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Life-Cycle Costing Manual for the Federal Energy Management Program

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U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

Prepared for
U.S. DEPARTMENT OF ENERGY
Federal Energy Management Program

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NBS HANDBOOK 135 (Rev. 1987)

Life-Cycle Costing Manual for the Federal Energy Management Program

A Guide for Evaluating the Cost Effectiveness of Energy Conservation and Renewable Energy Projects for New and Existing Federally Owned and Leased Buildings and Facilities

Prepared for

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ABSTRACT

The manual is a guide to understanding the life-cycle costing method and an aid to calculating the measures required for evaluating energy conservation and renewable energy investments in all Federal buildings. It expands upon the life-cycle costing criteria contained in the Program Rules of the Federal Energy Management Program (Subpart A of Part 436, Title 10, U.S. Code of Federal Regulations) and is consistent with those criteria. Its purpose is to facilitate the implementation of the Program Rules by explaining the life-cycle costing method, defining the measures, describing the assumptions and procedures to follow in performing evaluations, and giving examples. It provides worksheets, data tables, and other computational aids for calculating the required measures. It is the first of a three-volume set. The second volume is an update of energy price projections; the third is a User's Guide to the companion computer program, "FBLCC."

The life-cycle costing method and evaluation procedures set forth in the Federal Energy Management Program Rules and described in greater detail in this guide are to be followed by all Federal agencies for all energy conservation and renewable energy projects undertaken in new and existing buildings and facilities owned or leased by the Federal government, unless specifically exempted. The establishment of the methods and procedures and their use by Federal agencies to evaluate energy conservation and solar energy investments are required by Section 381(a)(2) of the Energy Policy and Conservation Act, as amended, 42 U.S.C. 6361(a)(2); by Section 10 of Presidential Executive Order 11912, amended; and by Title V of the National Energy Conservation Policy Act, 92 Stat. 3275, as amended by Section 405 of the Energy Security Act, 94 Stat. 611.

This updated edition of the manual replaces the 1982 edition. It adds three new sections: one on evaluating shared-energy-savings contracts, one on using the data tables and other computational aids to evaluate Federal building projects which are not primarily energy conservation or renewable energy projects, but which have a significant energy cost component, and one on issues which may complicate economic analyses. This updated edition also contains new examples, revised worksheets, and a section which provides guidance on problems frequently encountered in project evaluation.

The manual is used to provide instruction in two- and three-day life-cycle cost workshops which are conducted several times each year in different locations around the country.

Key words: building economics; capital investment decisions; economic analysis; energy economics; energy conservation; life-cycle costing; public buildings; renewable energy.

PREFACE

This manual amplifies the methodology and procedures for life-cycle cost analysis established by the Department of Energy (DoE) in Subpart A of Part 436 of Title 10 of the Code of Federal Regulations (10 CFR Part 436, Subpart A), which is entitled "Federal Energy Management and Planning Program" (FEMP). It is intended as an aid to implementing life-cycle cost evaluations of potential energy conservation and renewable energy investments in existing and new federally owned and leased buildings as required by Section 381(a)(2) of the Energy Policy and Conservation Act (EPCA), as amended, 42 U.S.C. 6361(a)(2); by Section 10 of Executive Order 11912, as amended by Executive Order 120003; and by Title V of the National Energy Conservation Policy Act (NECPA), 92 Stat. 3275, as amended by Section 405 of the Energy Security Act, 94 Stat. 611.

As called for by NECPA, the National Bureau of Standards has provided technical assistance to the Department of Energy in formulating the life-cycle costing methods and procedures for the FEMP Rules and has developed this manual as the first of a three-volume set of reports which together provide the methods, data, and computational tools for Federal LCC analysis of energy projects.

Included in the three-volume set are the following:

(1) Life-Cycle Cost Manual for the Federal Energy Management Program, National Bureau of Standards, Handbook 135 (revised 1987).

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

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

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

(3) A User's Guide to the Federal Building Life-Cycle Cost (FBLCC) Computer Program, National Bureau of Standards, NBS TN 1222 (Computer Program revised periodically).

This report is a user's guide to the computer program, "FBLCC." FBLCC, designed to run on an IBM PC/XT/AT, or compatible microcomputer, can be used to calculate the life-cycle costs, net savings, and savings-to-investment ratios of Federal energy projects, consistent with the procedures and assumptions described in Handbook 135 (see #1 above) and incorporating the energy price data of the most recent issue of NBSIR 85-3273 (see #2 above). FBLCC generates reports which summarize the assumptions and output in tabular form. Information for ordering the FBLCC computer program disk is provided in the User's Guide as well as in this Manual (see Appendix E).

The life-cycle costing methods and procedures set forth in 10 C.F.R., Part 436, Subpart A, are to be followed by all Federal agencies, unless specifically exempted, in evaluating the cost effectiveness of potential energy conservation and renewable energy investments in federally owned and leased buidings.

Though aimed specifically at supporting the economic evaluation of Federal building projects which are classified as energy conservation or renewable energy projects, the three-volume set can also be used to perform economic evaluations of Federal building projects which are not primarily energy conservation or renewable energy projects but which have an energy cost component. Both applications are explained in the three reports.

The Department of Energy was also directed by legislation and executive order to make available to the private sector the methods, procedures, and related aids developed for Federal use. In response to this directive, the National Bureau of Standards, under sponsorship by the Department of Energy, has published an additional life-cycle costing book for use by the private sector entitled Comprehensive Guide for Least-Cost Energy Decisions, NBS SP 709 (January 1987). The private sector book is also supported by the data provided in the most recent issue of NBSIR 85-3273 (see above), and by a special version of the computer program adapted to private sector analysis ("NBSLCC"). Information for ordering the NBSLCC computer disk is provided in NBS SP 709.

The author, through participation in the Building Economics Subcommittee of the American Society for Testing and Materials (ASTM), a voluntary consensus standards organization, has taken steps to ensure compatability between the Federal LCC Rule, the private sector guidelines set forth in SP 709, and the approaches to economic evaluation sanctioned by ASTM. References to applicable ASTM standards are provided in the text.

Further information on the Federal Energy Management Program can be obtained from the Federal Energy Management Program Staff, Office of the Assistant Secretary for Conservation and Renewable Energy, U.S. Department of Energy, Washington, D.C. 20234.

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Special acknowledgment and appreciation are extended to Mr. Dean Devine of the U.S. Department of Energy Federal Programs Office for his continued support and direction of this work.

The author is particularly indebted to the many persons who attended the series of Federal LCC Workshops held around the country for their valuable insights, suggestions, and field testing of this manual, as well as to Dr. Harold Marshall and Mr. Stephen Petersen, both of the National Bureau of Standards' Applied Economics Group, who joined the author in using the manual to provide instruction for the workshops.

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EXECUTIVE SUMMARY

In response to executive order and legislation, the U.S. Department of Energy (DoE) issued methods and procedures for all Federal agencies to follow in conducting life-cycle cost (LCC) analyses of energy conservation and renewable energy investments in Federal buildings. Intended to promote consistency and rationality in the energy-related investment decisions of Federal agencies, the methods and procedures are set forth in the Code of Federal Regulations under the title, "Federal Energy Management and Planning Program" (10 C.F.R., Part 436, Subpart A).

This manual was prepared to assist Federal agencies to implement the LCC Rule. It explains LCC concepts, provides a common glossary of terms, lists requirements for data and assumptions, and guides the making of the required calculations through provision of worksheets, reference to a computer program, sample problems solved step by step, and other aids for computation. (It also demonstrates how to use the data tables and other computational aids to evaluate Federal building projects which are not primarily energy conservation or renewable energy projects but which entail significant energy costs.)

The following is a capsulized summary of the key LCC requirements for Federal energy conservation and renewable energy projects:

PRINCIPAL APPLICATIONS

The LCC Rule applies to

° alternative building systems and designs for existing and new federally owned and leased buildings to reduce their consumption of nonrenewable energy,

° solar energy projects, and

° Federal photovoltaic utilization projects.

MAJOR LEGISLATIVE REQUIREMENTS

° Alternative building systems for proposed retrofit to existing Federal buildings should be determined to be life-cycle cost effective.

° The alternative Federal building design or building system design or size estimated to result in the lowest total life-cycle cost of the building should be selected, other things being equal.

° Cost-effective alternative retrofit systems competing for limited funds should be ranked in descending order of their savings-to-investment ratios and given priority on the basis of that ranking.

° In leasing buildings for Federal use, preference should be given to the building that uses solar energy or is otherwise life-cycle cost effective.

° All Federal buildings should be retrofitted to assure their minimum life-cycle cost by 1990.

KEY ELEMENTS OF THE LCC RULE

° Life-cycle cost evaluations should account for those investment costs, nonfuel operation and maintenance costs, repair and replacement costs, salvage values, energy costs, and other effects that are important to the long-term cost effectiveness of a decision.

° All future dollar amounts must be estimated in constant dollars, i.e., excluding the effects of general price inflation.

° A discount rate of 7 percent, also excluding inflation, must be used to adjust all dollar values to a present value in the year the analysis is made.

° As an adjustment for social benefits from saving nonrenewable energy that may not be fully reflected in the direct dollar savings, initial investment costs of the energy conserving features of a project are reduced to 90 percent of the actual amount for the purpose of estimating life-cycle costs. (This provision is currently under review.)

° The actual price of energy to a Federal Agency at the time the life-cycle cost evaluation is conducted (the "base year") should be used by that agency to establish base-year energy costs or savings. Regional averages of base-year prices estimated by DoE and given in Appendix C for 1985/86 (updated periodically in Energy Prices and Discount Factors for Life-Cycle Cost Analysis, NBSIR 85-3273) can be used if actual base-year prices are not available, but care should be taken to avoid mixing actual and DoE regional base-year prices.

° DoE-projected rates of change in energy prices must be used in estimating life-cycle energy costs or savings, with two exceptions: (1) component-specified escalation projections available from energy suppliers can be used in conjunction with time-of-day charges, demand charges, or other peak/off-peak price components (if such projections are not available from the energy supplier, the DoE-projections should be applied to each charge component); and (2) a Federal agency conducting a life-cycle cost analysis of a foreign Federal building should use energy price projections which are "reasonable under the circumstances," and may refer to the DoE "U.S. Average" price projections as a guide.

° The study period for a new building design or a building system retrofit should not exceed the lesser of 25 years or the period of intended use of the building; and for a leased building, the lesser of 25 years or the effective remaining term of the lease. For project designing and/or sizing where choices are mutually exclusive, all choices should be evaluated based on the same study period. SIR's based on varying study periods may be used for ranking nonmutually exclusive projects.

PRINCIPAL DEFINITIONS

Because the function of this manual is to amplify the LCC Rule, terminology and definitions used in the Rule are also used here. Definitions of additional economic terms are also provided. [Defined terms that appear in the definitions of other terms are capitalized.]

Alternative Building System - An installation or modification of an installation in a building intended primarily to reduce energy consumption or allow the use of renewable energy sources, or a primarily energy-saving Building System, including a renewable energy system, for consideration as part of the design for a New Federal Building.

Annually Recurring Costs - Those costs which are incurred each year in an equal, constant dollar amount throughout the Study Period.

Annual Value (Annual Worth) - Project costs or benefits amortized over the Study Period; that is, expressed as an annually recurring uniform amount, taking into account the Time Value of Money.

Annual Value (Annual Worth or Uniform Capital Recovery) Factor - A discount factor by which a present dollar amount may be multiplied to find its equivalent Annual Value, based on a given Discount Rate and a given period of time.

Base Case - The situation against which an Alternative Building System is compared.

Base Year - The first year of the study period, generally the year in which the life-cycle cost analysis is conducted.

Base-Year Energy Costs - The quantity of energy delivered to the boundary of a Federal Building in the Base Year, multiplied by the Base-Year Price of fuel.

Base-Year Energy Savings - For an Existing Federal Building, the positive difference between the existing building's Base-Year Energy Costs before the Retrofit and its estimated Base-Year Energy Costs after the Retrofit of a proposed Alternative Building System, taking into account all types of energy affected. For a New Federal Building, the positive difference between the estimated Base-Year Energy Cost of a building design or Building System design which is not primarily oriented towards energy conservation and the estimated Base-Year Energy Cost of an alternative building design or Building System design, taking into account all types of energy affected.

Base-Year Price - The price of a good or service as of the beginning of the first year of the study period.

Building - Any structure with a roof and walls designed for storage or human use.

Building System - A portion of the structure of the Building or of any energy-using system in the Building.

Cash Flow - The stream of costs and benefits (expressed for the purpose of this requirement in Constant Dollars) resulting from a project investment.

Compound Interest Factors or Formulas - See Discount Factors or Formulas.

Constant Dollars - Dollars of uniform purchasing power tied to a reference year (usually the Base Year) and exclusive of general price inflation or deflation.

Cost Effective - The condition whereby an Alternative Building System saves more than it costs over the Study Period, where all Cash Flows are assessed in Constant Dollars and discounted to reflect the Time Value of Money.

Current Dollars - Dollars of nonuniform purchasing power, including general price inflation or deflation, in which actual prices are stated. (With zero inflation or deflation, current dollars are identical to constant dollars.)

Demand Charge - That portion of the charge for electric service based on the plant and equipment costs associated with supplying the electricity consumed.

Differential Cost - The difference in the costs of an Alternative Building System and the Base Case.

Differential Energy Price Escalation Rate - The difference between a projected general rate of Inflation and the projected rate of price increase assumed for energy.

Discount Factors - Multiplicative numbers used to convert Cash Flows occurring at different times to correspondence at a common time. Discount factors are obtained by solving Discount Formulas based upon one dollar of value and an assumed Discount Rate and time.

Discount Formula - An expression of a mathematical relationship which enables the conversion of dollars at a given point in time to an equivalent amount at some other point in time.

Discount Rate - The rate of interest, reflecting the investor's Time Value of Money (or opportunity cost), that is used in Discount Formulas or to select Discount Factors which in turn are used to convert ("discount") Cash Flows to a common time. Real discount rates reflect time value apart from changes in the purchasing power of the dollar and are used to discount constant dollar cash flows; nominal discount rates include changes in the purchasing power of the dollar and are used to discount current dollar cash flows.

Discounted Payback Period - The time required for the cumulative savings from an investment to pay back the Investment Costs and other accrued costs, taking into account the Time Value of Money.

Discounting - A technique for converting Cash Flows occurring over time to time-equivalent values, adjusting for the Time Value of Money.

Economic Life - That period of time over which a Building or Building System is considered to be the lowest-cost alternative for satisfying a particular need.

Energy Conservation Measure - An installation or modification of an installation in a Building which is primarily intended to reduce energy consumption cost, or allow the use of a renewable energy source.

Existing Federal Building - A Federal Building, the construction of which was completed by November 9, 1978, or the design of which cannot feasibly be modified after the effective date of Subpart C of Part 436, 10 C.F.R.

Facility - Any group of closely located Buildings, none of which is individually metered for all energy sources and for which the actual rate of use of all energy sources can be determined.

Federal Agency - An Executive agency under 5 U.S.C. 105 (1970), the United States Postal Service, and each entity specified in 5 U.S.C. 5721 (1)(B)-(H) (1970).

Federal Building - Any Building, structure, or facility which is constructed, renovated, leased or purchased in whole or in part for use by the United States, and which includes a heating system, or cooling system, or both.

Inflation - A rise in the general price level, or, put another way, a decline in the general purchasing power of the dollar.

Internal Rate of Return - The compound rate of interest which, when used to discount Cash Flows of an Alternative Building System, will result in zero Net Savings (Net Benefits).

Investment Costs - The initial costs of design, engineering, purchase and installation, exclusive of "Sunk Costs," all of which are assumed to occur as a lump sum at the beginning of the Base Year for purposes of making the life-cycle cost analysis.

Life-Cycle Costing (LCC) - A method of economic evaluation that sums discounted dollar costs of initial investment (less Salvage Value), replacements, operations (including energy usage), and maintenance and repair of a Building or Building System over the Study Period (see Total Life-Cycle Cost). Also, as used in this report, a general approach to economic evaluation encompassing several related economic evaluation techniques, or "Modes of Analysis," including Total Life-Cycle Cost Analysis, Net Benefits or Net Savings Analysis, Savings-to-Investment Ratio Analysis, and Internal Rate of Return Analysis, all of which take into account long-run dollar impacts of a project.

Liquid Gas - Propane, butane, ethane, penetane, or natural gasoline.

Modes of Analysis - The various ways in which project cash flows can be combined and presented to describe a measure of project cost effectiveness. The Modes of Analysis used to evaluate FEMP projects are Total Life-Cycle Costs (TLCC), Net Savings (NS), and Savings-to-Investment Ratio (SIR). Simple Payback (SPB), a Mode of Analysis not fully consistent with the LCC method, is used as a supplemental measure for solar energy projects because of a specific legislative requirement.

Mutually Exclusive Projects - Projects where the acceptance of one precludes acceptance of the others. Examples are whether to use single-glazing, double-glazing or triple-glazing for a window, or R11, R19, or R30 levels of insulation in an attic.

Net Savings (Net Benefits) - Time-adjusted savings (or benefits) less time-adjusted differential costs taken over the Study Period, for an Alternative Building System relative to the base case.

New Federal Building - A Federal Building for which construction was not completed prior to November 9, 1978, and the design of which can be feasibly modified after the effective data of Subpart C of Part 436, 10 C.F.R.

Nonrecurring Costs - Costs that are not uniformly incurred annually over the Study Period.

Nonfuel Operation and Maintenance Costs - Labor and material costs required for routine upkeep, repair, and operation, exclusive of energy costs.

Nonmutually Exclusive Projects - Projects where the acceptance of one does not preclude the acceptance of the others. Examples are wall insulation and ceiling insulation. (For contrast, see Mutually Exclusive.)

Present Value (Present Worth) - The time-equivalent value of past, present or future cash flows as of the beginning of the Base Year.

Present Value (Present Worth) Factor - A discount factor by which a future dollar amount may be multiplied to find its equivalent Present Value as of the beginning of the Base Year. Single Present Value factors are used to convert single future amounts to Present Values. Uniform Present Value factors are used to convert Annually Recurring amounts to Present Values.

Replacement Costs - Future costs, included in the capital budget, to replace a Building System or a component during the Study Period.

Retrofit - The installation of an Alternative Building System in an Existing Federal Building.

Salvage Value - The residual value, net of any disposal costs, of any Building System removed or replaced during the Study Period, or remaining at the end of the Study Period, or recovered through resale or reuse at the end of the Study Period.

Savings-to-Investment Ratio (SIR) - A ratio computed from a numerator of discounted energy savings, plus (less) savings (increases) in Nonfuel Operation and Maintenance Costs, and a denominator of increased Investment Costs plus (less) increased (decreased) Replacement Costs, net of Salvage Value, for an Alternative Building System as compared with a Base Case.

Sensitivity Analysis - Testing the outcome of an evaluation to changes in the values of one or more system parameters from the initially assumed values.

Simple Payback Period (SPB) - A measure of the length of time required for the cumulative savings from a project to recover the Investment Cost and other accrued costs, without taking into account the Time Value of Money or the Differential Energy Price Escalation Rate.

Study Period - The length of the time period covered by the economic evaluation.

Sunk Costs - Costs which have been incurred prior to the life-cycle cost analysis and which therefore should not be considered in making a current project decision.

Time-of-Day Rate - The charge for service during periods of the day based on the cost of supplying the service at that particular time of the day.

Time Value of Money - The time-dependent value of money. If project cash flows are stated in constant dollars, their adjustment to a common time basis is necessary to take into account the real earning potential of investments over time. If project cash flows are stated in current dollars, their adjustment to a common time basis is necessary to take into account not only the real earning potential over time, but also price inflation or depletion.

Total Life-Cycle Cost (TLCC) - The total discounted dollar cost of owning, operating and maintaining a Building or Building System over the Study Period. (See Life-Cycle Costing.)

Useful Life - The period of time over which a Building or Building System continues to generate benefits or savings.

SYMBOLS AND ABBREVIATIONS

Btu - British Thermal Units

DoE - Department of Energy

DPB - Discounted Payback

FEMP - Federal Energy Management Programs

HVAC - Heating, Ventilation and Air Conditioning

IRR - Internal Rate of Return

kWh - Kilowatt Hours

LCC - Life-Cycle Costs or Life-Cycle Costing

MBtu - 10^6 x Btu or One Million Btu

NECPA - National Energy Conservation Policy Act

NS - Net Savings

O&M - Operation and Maintenance

OMB - Office of Management and Budget

PB - Payback Period

SFBP - Solar Federal Buildings Program

SIR - Savings-to-Investment Ratio

SPB - Simple Payback

SPW - Single Present Worth Factor

TLCC - Total Life-Cycle Costs

UPW - Uniform Present Worth Factor

UPW* - Modified Uniform Present Worth Factor

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1. INTRODUCTION

1.1 PURPOSE

This handbook is for use by Federal agencies in performing economic evaluations of energy conservation and renewable energy projects required by legislation and executive order and guided by the Life-Cycle Cost Rule (LCC Rule) for the Federal Energy Management Program (FEMP).[1] In its initial preparation, the handbook drew upon a number of existing Federal agency documents pertaining to LCC analysis, and reflected the consensus of an interagency task force regarding a set of consistent uniform methods and procedures for all Federal agencies to use.

This handbook describes the concepts and methods, outlines the procedures, defines the terms,[2] gives requirements for data and assumptions, and provides instructions, worksheets, data tables, and other computational aids for calculating the required measures. It may be used in any or all of the following ways: (1) as a general reference for performing or understanding life-cycle costing, (2) as a specific guide to the FEMP economic evaluation requirements, (3) as a tool for carrying out these requirements, and (4) as a guide for evaluating Federal building projects which are not primarily energy conservation or renewable energy projects but which entail significant energy costs. It is also used as a text for the series of life-cycle cost workshops conducted by the National Bureau of Standards and sponsored by the Department of Energy.

The handbook aims at assisting agencies to meet the following specific requirements (paraphrased) of legislation and Executive Order:

(1) In the construction or renovation of buildings, the cost of energy consumed over the building life must be considered.

(2) In the design of new Federal buildings, cost evaluations shall be made on the basis of life-cycle costs rather than initial costs.

(3) In designing new buildings, the lowest life-cycle cost design alternative that meets performance requirements of the building shall be selected.

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[1]The LCC Rule is set forth in the C.F.R., Part 436, Subpart A. The engineering and design of building retrofit and construction are not treated in the LCC Rule nor in this manual. For assistance in developing engineering costs and thermal data for energy conservation and solar projects, see U.S. Department of Energy, Architects and Engineers Guide to Energy Conservation in Existing Buildings, DOE/CS-0132. To determine available software, consult Government Institutes, Inc., Directory of Energy Software for Microcomputers.

[2]Specific terminology used in the Federal Regulation is used here for consistency. Definitions are given on pp. xviii through xxii.

(4) All energy conservation investments must be life-cycle cost effective.

(5) Funding should be allocated among available projects to maximize total net savings.

(6) On or before January 1, 1990, all cost-effective energy-conserving retrofits shall be implemented in Federal buildings.

(7) In leasing buildings, preference shall be given to buildings that utilize solar energy or otherwise minimize life-cycle costs to the Federal government over the remaining term of the lease.

1.2 ORGANIZATION

The remainder of this handbook is organized into nine sections and eight appendices. Section 2 provides a reference to basic concepts in life-cycle cost analysis for the convenience of the user who desires background. Section 3 discusses the data and assumptions that are to be followed in evaluating Federal projects. Sections 4 through 7 describe the calculation procedures that are to be used for each of the following applications: (a) evaluating energy conservation retrofit projects for existing Federal buildings, (b) evaluating alternative energy conservation designs for new Federal buildings, (c) evaluating the life-cycle costs of energy conservation or renewable energy projects for Federally leased buildings, and (d) evaluating solar energy systems for new and existing Federal buildings. Section 8 discusses economic analysis of shared energy savings contracts from both the standpoint of the private contractor and the Federal Agency. Section 9 describes the calculation procedures to be used for most other Federal building projects which entail significant energy costs but which are not primarily energy conservation or renewable energy projects. Section 10 provides guidance in dealing with selected problems which often arise in project evaluation. These include project interdependencies and problems in budget allocation. Instructions, worksheets,[1] and sample problems are provided.

Supporting information is given in the eight appendices. Appendix A contains 7 percent and 10 percent discount factors for finding the present values of nonfuel future amounts. Appendix B contains 7 percent and 10 percent discount factors for finding the present value of future energy costs based on 1985/86 projections. The 7 percent factors are needed for evaluating energy conservation and renewable energy projects, and the 10 percent factors for most other Federal building projects. Appendix C gives 1985/86 energy prices and projected energy price indices for 25 years. The data in Appendices B and C are provided to illustrate the procedures, but note that this data is

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[1]As an alternative to the worksheet computational approach, a computer program which is consistent with the methods and procedures described in this handbook can be used. The FBLCC computer program, described in Appendix E, is recommended.

updated yearly. The user should obtain the latest data for actual project evaluation. Appendix D contains blank worksheets that can be used for calculating the required measures of cost effectiveness. Appendix E describes the FBLCC computer program and gives information for ordering the computer diskette. Appendix F contains a graphical approach for converting simple payback to discounted payback. Appendix G provides a year-by-year, manual calculation method for evaluating life-cycle energy costs or savings that may be required when the quantity of energy changes over time. As a companion to section 9, Appendix H reproduces Circular A-94, Office of Management and Budget guidelines for evaluating most Federal projects which are <u>not</u> energy conservation or renewable energy projects.

2. BASIC CONCEPTS

This section provides an overview of concepts and methods of economic evaluation. An understanding of basic concepts is important for choosing appropriate economic evaluation methods for problem solving and for interpreting correctly the results of analyses. The user who has this understanding may wish to go directly to section 3, which discusses the specific requirements of the Federal LCC Rule for data and assumptions, and refer to this section only as needed.

2.1 METHODS OF ECONOMIC EVALUATION

There are a group of economic evaluation methods, or "modes of analysis," which are used to evaluate the economic performance of capital investment projects. These methods incorporate initial investment costs, including such items as design, engineering, and construction costs; replacement costs; operation, maintenance and repair costs; salvage values and disposal costs; and other significant effects which can be expressed in dollars.[1] Cash flows are adjusted to a consistent time basis and used to calculate a measure of economic performance. Because the methods take into account cash flows over time--not just initial costs--they are sometimes referred to as "life-cycle methods or approaches."

To evaluate the economic performance of energy conservation and renewable energy projects, economic evaluation methods are needed which incorporate current and future amounts. Economic evaluation is needed to determine which projects will save more than they cost (i.e., which are cost effective) and to select those projects that will provide the highest net return to the Federal energy conservation budget.

2.2 KEY STEPS

Table 2-1 lists 10 steps which are fundamental to most economic evaluations of capital investment projects. Each of these steps is discussed in turn below. The table is recommended as a general framework and checklist.

2.2.1 State the Objective

A clear statement of the specific objective to be accomplished by the economic evaluation is important in selecting a mode of evaluation and structuring the problem for solution. Examples of economic objectives are the following: to determine if an individual energy conservation or renewable energy project

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[1] Effects which are difficult or impossible to express in dollars may be crucial to a good decision and should not be ignored in the decision process. Several methods for taking into account effects omitted from cash flow estimates are discussed briefly in section 2.2.9.

Table 2-1. Steps in the Economic Evaluation Process

(1)	Define the problem and state the objective
(2)	Identify constraints
(3)	Identify technically sound strategies
(4)	Choose a mode (method) of economic analysis
(5)	Compile data and establish assumptions
(6)	Calculate measures of economic performance
(7)	Evaluate and compare alternatives
(8)	Perform sensitivity analysis
(9)	Take into account unquantified effects
(10)	Advise on the decision

meets Federal requirements for economic acceptablity; to determine which design, or what size, of a project is economically preferable; to determine which design of a new building will have the lowest overall owning and operating costs while fulfilling its functional requirements; to determine which combination of interrelated projects is most cost effective for a given facility; to determine what priority should be given to projects competing for limited funds.

Guidance is given in section 2.2.4 on selecting a mode of analysis for different problem applications, and numerical examples of problem solving to achieve different objectives are given in sections 4 through 10.

2.2.2 Identify Constraints

By identifying constraints which will cause certain energy conservation strategies to be infeasible (such as technical, physical, functional, budgetary, and building code requirements), the analyst can reduce the number of candidate strategies for which an economic evaluation must be performed. For example, the building location may preclude the use of solar energy; a supply of natural gas may not be available; the building may be a historic building with the need to preserve the original appearance; the budget may be too low to allow the acquisition of a project even if it is expected to be cost effective.

2.2.3 Identify Technically Sound Strategies

The economic evaluation, no matter how well done, can provide good solutions only if applied to potential capital investment projects which are technically sound.

2.2.4 Choose a Mode (Method) of Economic Analysis

For evaluating proposed capital investment projects under the Federal LCC Rule, the following modes of analysis are to be used: (1) Total Life-Cycle Costs (TLCC), (2) Net Savings (NS), (3) Savings-to-Investment Ratio (SIR), and (4) Payback Period (PB). A fifth, and closely related mode of analysis, often used in private sector evaluations and sometimes in Federal evaluations, but not required by the LCC Rule, is the Internal Rate of Return (IRR).

The first three of these, plus the fifth, are fully consistent with an LCC approach, in that they take into account all relevant values over the entire study period and discount them to a common time basis. The fourth, the payback period, is not fully consistent with an LCC approach because it includes only those values up to the time of payback, and, in its simple version, does not adjust them for time differences. It is used in the LCC Rule only as a supplementary measure to the life-cycle costing measures.

These five modes of analysis treat cash flows, including energy costs, in monetary terms. Since they are based on dollar values, the analysis modes do not distinguish between a dollar of energy cost and a dollar of nonenergy cost such as labor or materials. It is a strength of these modes of analysis that they take into account all project-related resource costs which are measurable in dollars, not just energy costs. However, this feature may mean the need for a project screening criterion to ensure that the energy conservation program is indeed supporting energy conservation projects. For example, an agency might wish to require that a specified percentage of project savings be energy savings. But the Federal LCC Rule makes no specific requirement for a screening criteron.

Table 2.2 provides a recommended guide for using the modes of analysis to solve different types of problems.[1] For further descriptions of the modes of analysis, their formulas, and guidance in using them, see section 2.3.

2.2.5 Compile Data and Establish Assumptions

Regardless of the mode of analysis that is used, it will be necessary to have estimates of the significant effects which are expected to result from each alternative strategy being evaluated. To the extent feasible, these effects should be quantified in dollars. Typical types of data which will be needed to evaluate energy conservation projects are the following: project acquisition costs; energy costs; non-energy operating and maintenance costs; repair and replacement costs; and resale or scrap value (less disposal costs). These types of data will also be needed for the base case, against which the energy conservation strategies are to be compared.

Estimates of the lives of the building(s) and building system(s), as well as the time period over which the decision maker is concerned with their economic performance, i.e., the study period, are additional parameters for which estimates will be needed.

For the duration of the study period, yearly estimates will be needed for each type of cash flow, and an assumption will be needed regarding the time of occurrence of the cash flows during the year. It is a well accepted convention in economic evaluations to use simplifying models of cash flows, rather than to attempt to reproduce their exact timing. Cash flows, for example, are sometimes assumed to occur in a lump sum at the end of the year in which they occur (end-of-year cash-flow model); in a lump sum at the beginning of the year (beginning-of-year cash-flow model); and sometimes, continuously throughout the year (continuous cash-flow model). For consistency among agencies in performing Federal energy conservation evaluations, the Federal LCC Rule requires that all capital investment costs be assumed to occur in a lump sum at the beginning of the first year of the study period, and that all other costs occur in lump sums at the end of the respective years in which they occur.

A cash-flow diagram, such as that illustrated in Figure 2-1, is useful in describing the timing of the various types of cash flows associated with a given project.

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[1] The IRR is not included in the table because it is not required by the Federal Rule. However, the IRR is analogous to the SIR in its appropriate use.

Table 2-2. FEMP LCC Rule Requirements: Modes of Analysis For Different Problem Applications

Type of Problem	Recommended Mode of Analysis[a]			
	TLCC	NS	SIR	PB
Determining Project Cost Effectiveness	√	√		
Choosing Among New Building Designs	√			
Choosing Among Alternative Designs for Building Systems	√	√		
Choosing Among Alternative Sizes for Building Systems	√	√		
Comparing and Ranking Nonmutually Exclusive Projects			√	
Evaluating Solar Energy Systems[b]	√	√	√	√

[a]For most types of problems, more than one method or mode of analysis is technically correct; however, only those required by the FEMP LCC Rule are indicated here.

[b]There are specific legislative requirements for evaluating solar energy systems, including computation of time to payback.

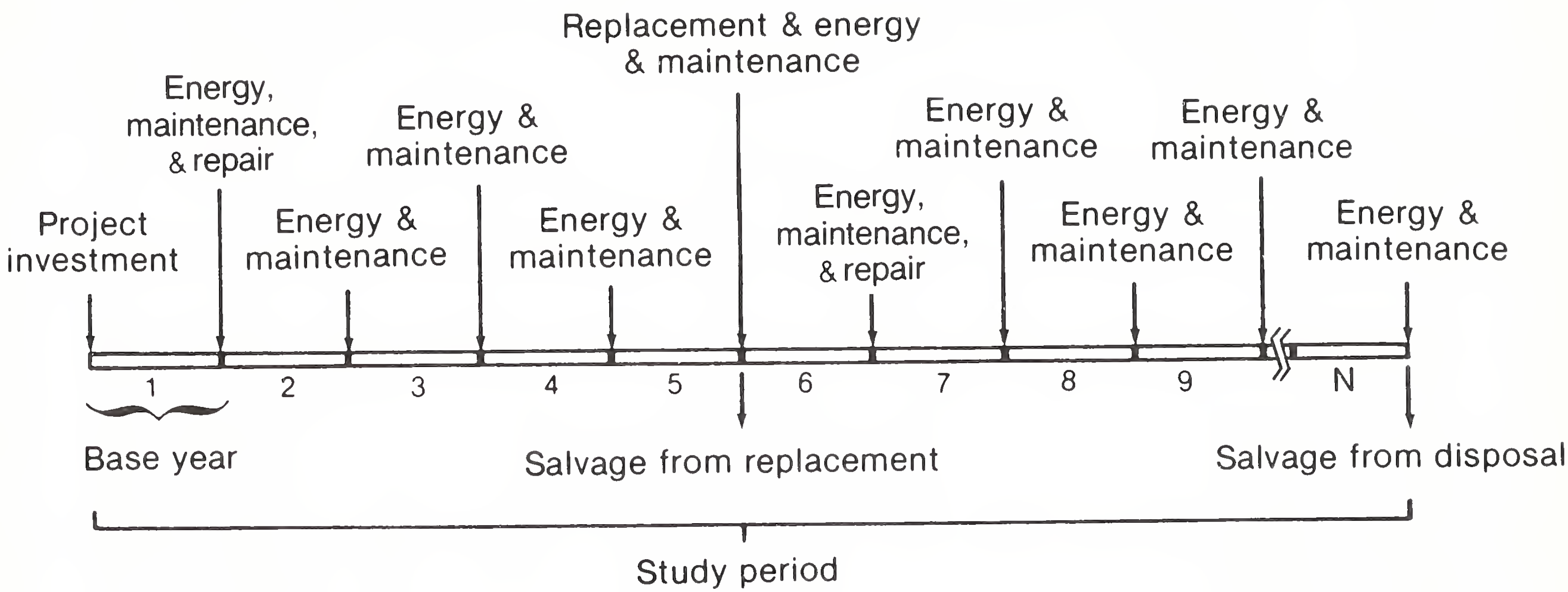

Figure 2-1. Cash Flow Diagram

2.2.6 Calculate Measures of Economic Performance

Each of the modes of analysis, given above in section 2.2.4 and described in more detail in section 2.3, provides a different measure of economic performance. The TLCC mode provides a measure in present value dollars of the life-cycle costs of a given energy conservation strategy; the NS mode, a measure in present value dollars of the difference in the life-cycle costs of one energy conservation strategy relative to another; the SIR mode, a dimensionless number expressing the ratio of savings to investment costs for one energy conservation strategy relative to another; and the PB mode, the number of years until initial investment costs are recouped through savings.

These measures can be calculated consistently with the requirements of the Federal LCC Rule in any of the following three ways:

(1) For the modes of analysis indicated in section 2.2.4, apply the formulas in section 2.3, adhering to the requirements of the Federal LCC Rule stated in section 3.
(2) Use the worksheets provided in Appendix D and illustrated in sections 4 through 7.
(3) Use the computer program "FBLCC," described in Appendix E and available from the sources listed there.

2.2.7 Evaluate and Compare Alternatives

In order for the measures of economic performance to improve building investment decisions, it is necessary that they be used correctly for the comparison of alternatives and that the results be correctly interpreted. See the guidelines in section 2.3 and the interpretations of the case illustrations in sections 4 through 7 and 9 for assistance in comparing alternatives and interpreting the results.

2.2.8 Perform Sensitivity Analysis

Sensitivity analysis is a useful technique for evaluating a project when there is uncertainty about the data and assumptions. There may be, for example, uncertainty about the life of a project, the quantity of energy it will save, or its future repair costs. The uncertainties may raise doubts about the project's likely cost effectiveness.

Sensitivity analysis is performed simply by repeating an evaluation using different input values. This technique can be used in the following three ways:

(1) By testing the percentage change in the output measure to specified percentage changes in input values, the analyst can identify those parameters that are likely to be most critical in determining the success of a project. This information can be useful in focusing further data gathering efforts.

(2) By calculating economic measures of performance based on upper and lower estimated values of input parameters, such as minimum and maximum estimated life or minimum and maximum estimated energy savings, the analyst can estimate a range within which the outcome is expected to fall. Expressing the answer

in terms of upper and lower boundaries may give a clearer picture of a project's potential cost effectiveness than a single point estimate.

(3) By anticipating "what if" questions, the analyst can calculate measures of economic performance based on different scenarios which a decision maker might pose. This can strengthen the reporting of evaluation results.

Although the LCC Rule sets no specific requirements for performing sensitivity analysis, it encourages the use of sensitivity analysis whenever

(a) substantial uncertainties cast doubt on project cost effectiveness, and

(b) there is a reasonable basis to estimate the variability of future costs and benefits.

The LCC Rule does not address the use of other techniques for taking into account uncertainty, but analysts should be aware of their existence. Two techniques, in addition to sensitivity analysis, which may be useful in evaluating energy conservation projects under uncertainty are break-even analysis and probability analysis, each of which is discussed briefly below:

Break-even analysis is a technique which allows us to estimate the input values for which a project's savings will just offset its costs. This is done algebraically by setting savings equal to costs, leaving the value of a designated parameter in the equation unspecified, and finding the solution value. By knowing the minimum or maximum value that a given input can have, beyond which the project will no longer be cost effective, the analyst can focus on estimating if the value in question will likely exceed or fall below the break-even value.

When probabilities of different conditions or occurrences affecting the outcome of an investment decision can be estimated, probability analysis can be used to estimate the weighted average, or expected value, of a project's outcome. If the outcome is expressed in terms of a probability distribution, statistical analysis of the variance can be performed to measure the degree of risk.[1]

2.2.9 Take into Account Unquantified Effects

If all the significant consequences of a project are not adequately captured in the numerical evaluation, the measure of economic performance taken alone can be misleading. It is important to take into account unquantified effects, as well as quantified effects, in making a decision. At a minimum, unquantified effects should be called to the attention of the decision maker in descriptive terms. In addition, it may be helpful to impute the maximum or minimum value which could be assigned the unquantified effects without reversing the decision. Break-even analysis (see section 2.2.8) can be used for this purpose.

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[1] For more on dealing with uncertainty, see L.M. Rose, Engineering Investment Decisions; Planning Under Uncertainty.

For example, assume that the economic evaluation of a building design in a cold climate shows that the life-cycle owning and operating costs of the building would be lower if the north wall were windowless. Assume also that a windowless wall will eliminate a view, the value of which is difficult to assess in dollar terms. If the value of the view is omitted from the LCC analysis, the net savings of the solid wall over the windowed wall is the maximum value the decision maker could impute to the view without choosing the windowed wall over the windowless wall, other factors being the same.

2.2.10 Advise on the Decision

The results of the economic evaluation should be an aid to improved decision making, not a substitute for good judgment.

2.3 MODES OF ANALYSIS

Section 2.2.4 provided a listing and an overview of the modes of analysis, and Table 2.2 showed their recommended uses. This section provides a description of each of the four modes of analysis used in FEMP evaluations, the formulas, and brief explanations of applications.[1]

2.3.1 Total Life-Cycle Cost Analysis

ABBREVIATION: TLCC

DESCRIPTION: TLCC is a mode of analysis which sums all significant time-equivalent dollar costs attributable to a given building design, system, or component. Positive cash flows, such as salvage values, are treated as negative costs which are time-adjusted and subtracted from the total.[2] (Adjusting cash flows to an equivalent time basis is explained in section 2.5.)

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[1]Descriptions of these and other economic evaluation methods are provided in most engineering economics texts, such as John A. White, Marvin H. Agee, and Kenneth E. Case, Principles of Engineering Analysis; and Tung Au and Thomas P. Au, Engineering Economics for Capital Investment Analysis; as well as in the version of this guide which was developed for use by the private sector, Ruegg and Petersen, Comprehensive Guide to Least-Cost Energy Decisions.

[2]The Federal definition and recommended usage of this method are consistent with the "Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems" published by the American Society for Testing and Materials (ASTM).

GENERAL FORMULA:

$$\overset{\text{Total Life-Cycle Costs}}{TLCC} = \overset{\text{Investment Costs}}{I} - \overset{\text{Salvage Value}}{S} + \overset{\text{Nonfuel O\&M \& Repair Costs}}{M} + \overset{\text{Replacement Costs}}{R} + \overset{\text{Energy Costs}}{E}, \qquad (2.1)$$

where all amounts are expressed as present value dollars. ("Present Value Dollars" is explained in section 2.5.5.)

FEMP USE: (1) Determination of project cost effectiveness.

To use this mode to determine project cost effectiveness, it is necessary to compute the TLCC for the alternative building system and the TLCC for the base case. A building design, system, or component that has a lower TLCC than the base case while meeting performance requirements can generally be held to be cost effective.[1]

(2) Comparison of new building designs.

To determine the most cost-effective building design, it is necessary to compute TLCC's for each of the alternative designs which meet the requirements for the building. The design alternative which has the minimum TLCC is the most cost-effective.[2]

(3) Comparison of design or size alternatives for a given building system in a given application, e.g., alternative thicknesses of insulation for a given wall or alternative designs of a heat pump.

To determine the most cost-effective design or size of a building system, it is necessary to compute TLCC's for each of the alternatives and for the base case, and to find which has the minimum TLCC.[3] This guideline of choosing the option with the lowest TLCC is appropriate for the Federal program which requires that by 1990 all Federal buildings be life-cycle cost effective in their design and retrofit. Stopping individual projects short of their lowest life-cycle cost design would mean potential savings opportunities foregone in the long run. (See further discussion in section 10.2.4.)

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[1]It should be noted that unquantified costs or benefits may alter cost effectiveness.

[2]See footnote 1.

[3]See footnote 1.

2.3.2 Net Savings Analysis

ABBREVATION: NS

DESCRIPTION: NS is a mode of analysis which extends TLCC analysis to calculate the time-equivalent dollar difference between the TLCC of the base case and the TLCC of the alternative building system. This approach to calculating NS is shown in equation 2.2 below.[1]

An equivalent way of defining NS is "the difference between the savings attributable to a project and the increase in costs attributable to it." This second approach to calculating NS, shown in equation 2.3 below, does not require the prior calculation of TLCC for the base case and the TLCC for the alternative building system, but rather works directly with the differences in individual cash flows.

GENERAL FORMULAS:

$$\overset{\text{Net Savings}}{NS} = \overset{\text{TLCC for the Base Case}}{TLCC_{BC}} - \overset{\text{TLCC for the Alternative Building System}}{TLCC_{A}}, \tag{2.2}$$

where all amounts are expressed in present value dollars and the subscript "BC" designates the base case and "A" designates the alternative building system. ("Present Value Dollars" is explained in section 2.5.5.)

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[1]The NS method, a variation of the Net Benefits method, is used when benefits occur primarily in the form of cost reductions. The Federal definition and recommended usage of this method are consistent with the "Standard Practice for Measuring Net Benefits for Investments in Buildings and Building Systems" published by ASTM.

$$\overset{\text{Net Savings}}{NS} = \overset{\text{Differential Energy Costs}}{\Delta E} - [\overset{\text{Differential Investment Costs}}{\Delta I} - \overset{\text{Differential Salvage Values}}{\Delta S} + \overset{\text{Differential Nonfuel O\&M \& Repair Costs}}{\Delta M} + \overset{\text{Differential Replacement Costs}}{\Delta R}], \qquad (2.3)$$

where all amounts are expressed in present value dollars, and the values in equation 2.3 are as defined below in equations 2.4 - 2.8.

The delta symbol, Δ, used above in equation 2.3 and below in equations 2.4 - 2.11 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: $\Delta E = (E_{BC} - E_A)$ (2.4)

Differential Present Value Investment Costs: $\Delta I = (I_A - I_{BC})$ (2.5)

Differential Present Value Salvage Value Realized, Net of Disposal Costs: $\Delta S = (S_A - S_{BC})$ (2.6)

Differential Present Value Nonfuel Operating and Maintenance (O&M) and Repair Costs: $\Delta M = (M_A - M_{BC})$ (2.7)

Differential Present Value Replacement Costs: $\Delta R = (R_A - R_{BC})$ (2.8)

where E, I, S, M, and R are as defined in equation 2.1. Note that it is important to preserve the appropriate signs when entering the resulting values in the equation for NS, SIR, and PB:

FEMP USE:[1] (1) Determination of the cost effectiveness of alternative building systems (i.e., same as for TLCC).

A positive NS can generally be held to mean an alternative building system is cost effective.[2] 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 required 7 percent return reflected in the discount rate, all other factors being equal between the alternative system and the base case.

(2) Comparison of design or size alternatives for a given building system in a given application, e.g., alternative thicknesses of insulation for a given wall, or alternative designs of a heat pump.

The alternative design or size of a building system which, when compared against the base case, has the maximum NS is the most cost-effective choice.[3] Expressed another way, it will usually pay to increase project investment up to the point that the last increment in costs is just exceeded by the increment in savings, such that the incremental net savings just exceeds zero. At this point, total net savings rise to their maximum value.

This guideline of choosing the project design or size with the highest NS is consistent with choosing the project design or size with the lowest TLCC. It is an appropriate guideline for the Federal program which requires that by 1990 all Federal buildings be life-cycle cost effective in their design and retrofit. Stopping individual projects short of their lowest life-cycle cost design and size to reflect short-term budget limitations might yield higher returns in the short run, but would mean potential savings opportunities foregone in the longer run. (See further discussion in section 10.2.4.)

(3) Evaluation of solar energy systems.

The NS mode meets a requirement of Title V, Part 2 of NECPA.

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[1]Note that NS is not recommended as a criterion for ranking individual projects, even though the objective in setting priority among nonmutually exclusive projects is to arrive at the set of projects that maximizes overall net savings. This is because the NS measure does not distinguish between a project that costs $1,000 and saves $6,000, and one that costs $10,000 and saves $15,000, although the first is clearly preferable to the second on economic grounds. Note further that the NS though technically correct for choosing among new building designs, is not required by the Federal LCC Rule.

[2]It should be noted that unquantified costs or benefits may alter cost effectiveness.

[3]See footnote 2.

2.3.3 Savings-to-Investment Ratio Analysis

ABBREVIATION: SIR

DESCRIPTION: The SIR is a mode of analysis which expresses savings as a ratio to costs. The numerator of the ratio is the reduction in energy costs, plus any decrease (or minus any increase) 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.[1]

GENERAL FORMULA:

$$\overset{\text{Savings-to-Investment Ratio}}{SIR} = [\overset{\text{Differential Energy Costs}}{\Delta E} - \overset{\text{Differential Nonfuel O\&M \& Repair Costs}}{\Delta M}] \div [\overset{\text{Differential Investment Costs}}{\Delta I} - \overset{\text{Differential Salvage Values}}{\Delta S} + \overset{\text{Differential Replacement Costs}}{\Delta R}], \qquad (2.9)$$

where all amounts are expressed as present value dollars. ("Present Value Dollars" is explained in section 2.5.5.)

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[1]The SIR method, a variation of the Benefit-to-Cost Ratio (BCR) method, is used when benefits occur primarily as cost reductions. For both SIR's and BCR's, there is some controversy regarding the placement of certain items in the numerator versus the denominator. Different formulations are sometimes used to reflect different investment objectives. The formulation used in conjunction with FEMP, and shown in equation 2.9, is designed to maximize the return to capital budgets. For a discussion of alternative formulations of the SIR, see Harold E. Marshall and Rosalie T. Ruegg, Recommended Practice for Measuring Benefit/Cost and Savings-to-Investment Ratios for Buildings and Building Systems, National Bureau of Standards, NBSIR 81-2397, November 1981.

FEMP USE:[1] (1) Comparison and ranking of nonmutually exclusive projects to determine their relative priorities.[2]

The SIR is recommended for setting priority among nonmutually exclusive projects. The approach is to rank projects in descending order of their SIR's (computed according to equation 2.9 above). 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. 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. (See in section 10.2 illustrations of and solutions to problems which may be encountered in using SIR's for budget allocation.)

(2) Comparison and ranking of proposed solar energy systems.

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[1]An SIR greater than one can generally be held to mean that an alternative building system is cost effective, but its use for determining cost effectiveness is not required by the FEMP LCC Rule.[3] The higher the ratio, the greater the average dollar savings per dollar spent. For example, an SIR of 4 computed for an alternative system relative to the base case can be interpreted to mean that the alternative building system is estimated to save $4 on the average for every $1 invested, over and above the required rate of return reflected in the discount rate.

It should be noted that the SIR mode cannot be reliably used to design and size alternative building systems unless the analysis is based on incremental SIR's. This is because SIR's 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 R19 versus 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.

[2]Another criterion for project ranking that was considered for use in this program was a measure of Btu per investment dollar. However, it is not required by the FEMP LCC guideline because it does not appear consistent with the requirements of the NECPA and the Executive Order for a life-cycle cost approach. It gives weight to the annual quantity of energy saved, but does not take into account the relative scarcities of different types of energy as reflected by their current and projected price differences. The Btu per investment dollar measure does not, for example, distinguish between savings of coal and savings of oil, or between savings of electricity in the northeast and in the northwest. Nor does the Btu per investment dollar measure account for the expected life of the project, the time value of money, and future nonenergy savings and costs. In the short run, it will yield the largest savings in terms of Btu's (if based on energy consumption at the source), but probably not the largest dollar energy savings. In the long run, it may not even yield the largest Btu savings, because of lower program efficiency and smaller dollar savings.

[3]It should be noted that unquantified costs or benefits may alter cost effectiveness.

2.3.4 Payback Period Analysis

ABBREVIATION: PB

DESCRIPTION: The PB mode of analysis finds how long it takes an alternative building system to just break even, in the sense of recovering investment costs. It is calculated as the elapsed time between the initial investment and the time at which cumulative savings are just sufficient to offset the initial investment and other accrued costs. If the cash flows are expressed as time-equivalent values, the mode is called "discounted payback" (DPB). If this is not done, that is, if the opportunity cost is assumed to be zero--generally a poor assumption--the mode is called "simple payback" (SPB).[1]

GENERAL FORMULA:

Find minimum value of y, years,

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 Value Discount Formula
Differential Investment Costs

for which $$\sum_{j=1}^{y} (\Delta\overline{E} - \Delta\overline{M} - \Delta\overline{R} + \Delta\overline{S})_j/(1+d)^j = \Delta I, \qquad (2.10)$$

where, $\Delta\overline{E}_j$, $\Delta\overline{M}_j$, $\Delta\overline{R}_j$, and $\Delta\overline{S}_j$ are constant dollar differential energy costs, nonfuel operating, maintenance and repair costs, replacement costs, and salvage value as defined in equations 2.4 through 2.8, except they are amounts in year j, <u>not</u> discounted prior to being entered into equation 2.10; d = the discount rate, and if d = 0, y = SPB.

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[1]The Federal definition, recommended usage, and statement about the limitations of this method are consistent with the "Standard Practice for Measuring Payback for Investments in Buildings and Building Systems" published by ASTM.

SIMPLIFIED SPB FORMULA: If future savings net of future costs are estimated to occur in an even amount from year to year, such that $(\Delta\bar{E}-\Delta\bar{M}-\Delta\bar{R}+\Delta\bar{S}) = AS$, a constant, the following simple formula can be used to determine SPB:

$$\overset{\text{Simple Payback}}{SPB} = \overset{\text{Differential Investment Costs}}{\Delta I} \div \overset{\text{Future Yearly Savings Net of Future Yearly Costs}}{AS} \qquad (2.11)$$

SIMPLIFIED METHOD OF APPROXIMATING DPB: Given that SPB has been estimated and that energy savings comprise most of the future cash flows, DPB can be approximated as follows:

(a) Go to the UPW* factor table based on a 7 percent discount rate and the appropriate DoE region (see Appendix B and latest update).

(b) Find in the column for the appropriate building type and energy type the UPW* factor that is closest in value to the value of the SPB.

(c) Read off the corresponding year in the left-hand column. (Interpolation may be used to obtain a closer approximation.)

The resulting year is the approximate DPB.

[For a non-energy conservation project for which energy savings do <u>not</u> comprise the major component of future cash flows, follow the above procedure, using UPW factors for a 10 percent discount rate from Appendix Table A-2 instead of the UPW* tables.]

FEMP USE:[1] (1) <u>Supplementary measure to the TLCC or NS modes to provide a rough indicator of cost effectiveness.</u>

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[1]The PB mode is not recommended for designing and sizing projects 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 R11 is the more cost-effective choice. 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 mode has limited usefulness in project evaluation.

Primary advantages of the PB mode 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.

Although not required by the Federal LCC Rule for non-solar project evaluations, the PB mode can be used as an indicator of the cost effectiveness of an alternative building system if properly interpreted. If an alternative building system is expected to recover its costs before the end of its life, taking into account the opportunity cost, and if there are no sizable costs expected after payback is achieved which might reverse payback, it is generally safe to consider the system to be cost effective. The PB mode must be used with caution, however, because a project with a shorter payback period is not necessarily a better investment than one with a longer payback period, and may well be a poorer investment.

(2) Supplementary measure to the TLCC or NS modes to test for minimum project life necessary for cost effectiveness, i.e., break-even life.

Although it is not required by the Federal LCC Rule, the time to PB can be a useful supplementary measure when there is uncertainty about project life.

(3) Evaluation of proposed solar energy systems as required by legislation.

A measure of payback is specifically required by Title V, Part 2 of NECPA for the evaluation of solar energy systems in the Solar Federal Buildings Program, in supplement to the NS measure. To meet this requirement, the Federal LCC Rule allows for the SPB mode to be used, with energy and other costs evaluated in base-year prices, and without differential price escalation or discounting. This can be done by using equation 2.10, where d is set equal to zero, or, if the net yearly cash flow is approximately uniform, by using equation 2.11.

2.4 ESTIMATING CASH FLOWS

The types of data generally needed to perform an economic evaluation are listed in section 2.2.5 in the overview, "Key Steps." The cash-flow diagram in Figure 2.1 illustrates that estimates are needed of both dollar amounts and their timing. This section provides guidance in estimating cash flows, with emphasis on how to work in "constant dollars."

2.4.1 Constant Versus Current Dollars

When future amounts are stated in actual prices as of the year in which they are expected to occur, they are said to be in "current dollars." Current dollars reflect any changes in the purchasing power of the dollar. Since it is in current dollars that future goods and services will be purchased, budget estimates must be stated in current dollars. But using current dollars to measure economic performance is equivalent to measuring the dimensions of a building or the quantity of energy with a redefined unit of measure each time a measurement is taken. A valid economic evaluation requires that all dollars have the same purchasing power. This means stating amounts in constant dollars. Constant dollars indicate what the same good or service would cost at different times if there were no inflation or deflation to change the purchasing power of the dollar.

The most direct way to express cash flows in constant dollars is to establish a reference year, for which the value of the dollar is set, and at the outset of the evaluation to state all past, present, and future amounts in dollars as of that reference year. (Guidance on how to estimate different kinds of cash flows in constant dollars is provided below in sections 2.4.1.1 and 2.4.1.2.)

Note that constant dollar cash flows must still be adjusted for the opportunity cost associated with their different times of occurrence. This adjustment for opportunity cost, called "discounting of cash flows," allows us to convert the constant dollar cash flows occurring at different times to a time-equivalent lump-sum amount evaluated as of the beginning of the base year, i.e., a present value. This is done using an interest rate, or "discount rate," which reflects the opportunity cost apart from any change in the purchasing power of the dollar, i.e., a "real discount rate." Present values are needed to compute the LCC, NS, SIR, and DPB modes of analysis described in section 2.3. (How to discount cash flows to present values is explained in section 2.5.5.)

A less direct way to express cash flows in constant dollars entails first estimating them in current dollars and then converting them to constant dollars. They can be converted to constant dollars either in the discounting operation or in a separate step prior to discounting. The conversion to constant dollars is performed as an integral part of the discounting operation simply by incorporating a projection of general price change in the discount rate, i.e., by using a market or "nominal" discount rate. Current dollars can be converted to constant dollars in a separate step from discounting by applying a price deflator to them, such as can be constructed from the Consumer Price Index (CPI) or the Producers Price Index (PPI).[1] If this second approach is followed, the discounting operation requires the use of a real discount rate, i.e., one which does <u>not</u> include a projection of general price change.

Any of these three approaches--(1) estimating cash flows in constant dollars and discounting them to present value using a real discount rate; (2) estimating cash flows in current dollars and discounting them to present value using a nominal discount rate; or (3) estimating cash flows in current dollars, converting them to constant dollars using a price deflator index, and then discounting them to present value using a real discount rate--will yield the same present value results provided consistent assumptions about the real rate of return and the rate of change in the overall price level are maintained.

<u>Federal agencies, however, are directed by the Office of Management and Budget (OMB) to follow the first approach when performing most economic evaluations. This means stating future prices in constant dollars at the outset.</u>[2] The constant dollar approach has the advantage of avoiding the need for Federal

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[1]CPI and PPI are published monthly by the U.S. Department of Labor in the <u>Monthly Labor Review</u>.

[2]U.S. Office of Management and Budget, Circular A-94, "Discount Rate to be Used in Evaluating Time-Distributed Costs and Benefits." (See Appendix H.)

agencies to project future price inflation or deflation, plus the additional computational advantage of simplifying the estimation of most types of cash flow.[1]

The price of a good or service stated in constant dollars remains unchanged from year to year provided it changes in current dollars at the same rate as prices in general. For example, if the price of a piece of equipment is $1000 today and the price of the identical equipment is $1005 at the end of a year, during a time that prices in general have risen at an annual rate of 5 percent, the price of the equipment in constant dollars continues to be $1000.

The current dollar price of a good or service may change at a different rate than prices in general if there are changes in its demand or supply relative to other goods and services. The constant dollar price estimate should reflect any differential change relative to prices in general. For example, if the price of a piece of equipment is $1000 today and the price of the identical equipment in current dollars is $1010 at the end of a year, while prices in general have risen at an annual rate of 5 percent, the differential rate of change is approximately 5 percent. The constant dollar price of the equipment reflects only the differential rate of change. Therefore, in constant dollars, the price of the equipment at the end of the year would be approximately $1005.[2]

If the current dollar price of a good fell, while prices in general increased, the differential rate of change would be negative, and the price of the good would fall even more in terms of constant dollars. Even if the current dollar price of a good increased, if the rate of increase were less than the rate of increase in prices in general, the differential rate of change would be negative, and in constant dollars the price would fall. On the other hand, if the current dollar price of a good increased faster than prices in general, the differential rate of change would be positive and the price of the good would also rise in constant dollars, though not as much as in current dollars. If the current dollar price of a good or service were fixed over time by contract, its constant dollar price would fall in the face of general price inflation, at a rate equal to the inflation rate.

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[1]The current dollar approach is often used in private sector evaluations because it offers a computational advantage in treating income tax effects and it entails using nominal discount rates which are in effect familiar market rates of interest. Again it should be noted that any of the three approaches will give the same present value results if consistently followed.

[2]The differential rate of change is said to be "approximately" 5 percent and the constant dollar price is said to be "approximately" $1005, because there is an interaction between the differential rate of change and the rate of price inflation which causes the total change not to be simply the sum of the two. (See equation 2.12.)

To state prices in constant dollars requires only an estimate of the difference in the rate at which the price of a good or service will change relative to prices in general, i.e., the "differential rate," rather than the actual rate of change in prices. If there is no sound basis for estimating the differential rate, it is accepted practice to assume that the differential rate is zero, i.e., that current dollar prices will change at about the same rate as prices in general. As we saw above, this means that the constant dollar price in each future year can simply be set equal to the reference-year price and multiplied times the quantity of the good or service in each future year to get an estimate of the future-year cash flow. This assumption greatly facilitates cash-flow estimation.

If there is a sound basis for estimating the differential rate, e, future prices can be estimated in constant dollars by inserting the estimated value of e in the following single compound-amount formula:

$$P_j = P_o \ (1+e)^j, \tag{2.12}$$

where P_j = a price in year j in constant dollars,
P_o = the reference year price,
e = the average annual differential rate of price change between the reference year and year j, and
j = the future year.

With estimates of the rate of change in actual prices, E, and the rate of general price inflation, I, the differential rate, e, can be derived by the following formula:

$$e = (E-I)/(1+I). \tag{2.13}$$

2.4.2 Estimating Energy Cash Flows

Following the Federal directive to perform economic evaluations in constant dollars, the first question we should ask is whether there is any basis for incorporating differential rates of change for energy prices. The answer is yes, because the Energy Information Administration (EIA) of the U.S. Department of Energy annually projects future prices of energy, by type, by region of the country, and by pricing classification: residential, commercial, and industrial, to support the Federal Energy Conservation Programs. The Federal LCC Rule requires Federal agencies to use these projections in evaluating the economic performance of energy conservation projects. (See section 3.4 for a discussion of the specific requirements.)

The Federal price projections are reported in several different formats to accommodate various computational needs:[1]

[1]In addition to the published tables of data described here, the EIA price projections are incorporated in data files of the FBLCC computer program described in Appendix F.)

(1) Modified uniform present worth (UPW*) discount factors of Appendix B incorporate EIA rates of differential price change. Multiplying a year's quantity of energy times the base-year price, and the product times the appropriate UPW* factor from Appendix B, will yield the lump-sum present value of the stream of constant dollar energy costs or savings over the study period, taking into account EIA's differential price projections. This is the set of data to use to perform an evaluation manually, using the Worksheets of Appendix D. (Note that this approach requires holding the quantity of energy constant over the study period.)

(2) Energy price indices are provided in Appendix C, Tables Ca-1 through Ca-11. These indices are for computing constant-dollar energy prices for future years, starting with the base-year price. If one wishes to show the estimated energy costs or savings in constant dollars year-by-year over the study period, this can be done by multiplying each year's quantity of energy times the base-year price, and the product times the appropriate price index for that year. It would then be necessary as a separate step to discount each year's amount to present value. The data in Tables Ca-1 through Ca-11 are used to perform an evaluation manually according to the procedure outlined in Appendix F, when the annual quantity of energy is expected to change each year. (Note that this approach does not require holding the quantity of energy constant over the study period as does the use of the UPW* factors.)

(3) Projected average differential rates of change in energy prices taken over five-year time intervals are provided in Appendix C, Tables Cb-1 through Cb-11. These are consistent with the format of energy price projections published in earlier editions of this handbook, and are provided for the convenience of the user who may wish to continue using that format.

With these projections and the prescribed procedures for using them, the major task in estimating energy cash flows is obtaining estimates of the <u>quantities</u> of energy required with and without the alternative building system. This task is primarily an engineering function and is not addressed by this handbook. Once quantity estimates are obtained, the economic evaluation of energy costs entails combining the quantity estimates with base-year energy prices and the applicable data from Appendix B or C.

2.4.3 Estimating Other Cash Flows

<u>Routine Maintenance and Repair Costs</u>: It is generally assumed that the <u>prices</u> attached to routine maintenance and repair costs will change at about the same rate as prices in general, which means that they will remain unchanged over the study period in constant dollars. If the quantity of routine maintenance and repair and the unit price are assumed to remain unchanged over the study period, then the <u>cost</u> in constant dollars also remains unchanged since it is the product of price and quantity. In this case, the routine maintenance and repair cash flow will consist simply of repetitions of the base-year cost. As section 2.5.5.1 demonstrates, a repeating uniform cash flow can be converted to present value simply by multiplying the base-year dollar amount times the uniform present worth (UPW) discount factor.

If, on the other hand, the annual quantity of maintenance and repair service is expected to change over time, this can be reflected by multiplying the base-year unit price times the quantity for each year, thereby generating a changing stream of cash flows. These can then be brought to present value by multiplying each individual amount times the single present worth (SPW) discount factor for that year, and summing the results.

Replacement Costs: Unless there is supporting evidence to the contrary, replacement costs are also usually assumed to change at the same rate as general price inflation. With this assumption, a future replacement cost would equal in constant dollars about the same amount as it would cost to make the replacement today. This is a helpful assumption because it is generally easier to obtain a reasonable estimate of what it would cost to replace a building system or component today than in the future, for example by calling manufacturers or suppliers or by consulting catalogs.

If there is a reasonable basis for estimating a differential rate of change in prices of replacement costs, the future cost can be estimated using equation 2.13 with estimates of the base-year cost, the estimated differential escalation rate, and the expected time of occurrence. A reasonable basis for estimating a differential rate of change in price might be a past record of change either consistently higher or lower than general price inflation, together with a forecast of demand and supply factors supporting a continuation of that trend.

Estimates of the quantities and times of occurrence of maintenance, repair, and replacements are usually based on statistical analysis of records if there has been previous experience with the type of system or component in question or with similar systems or components. Otherwise, estimates are generally based on published studies, product information in trade magazines, manufacturer product information, service life information from mechanical equipment and component surveys such as that given in ASHRAE handbooks, data bases such as the BOMA Experience Exchange Reports of the Building Owners and Managers Association, and advice of the engineering staff.

Salvage (Residual) Values: Estimates of future salvage value--which may include the value of items sold as used equipment or scrap, as well as that channeled to other uses--are also usually made in reference to base-year values. One way this is done is to prorate the starting value of the system or component over its estimated life assuming a constant or variable rate of decline, depending on which seems most reasonable, and to take the amount remaining at the end of the study period as the constant dollar salvage value.[1] Implicit in this approach is the assumption that the remaining value fully reflects any general price inflation or deflation. Another way to estimate salvage values is to base them on the prices at which similar, comparably aged property is selling in commercial markets in the base year. Implicit in this approach is the assumption that the remaining value will reflect any general price inflation or deflation plus any additional change to the same extent that similar equipment reflected such change in the past.

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[1]The value of buildings and other structures is assumed by the Federal government in its guidelines for lease/purchase evaluations to decline, due to decay and obsolescence, at a rate of 1.7 percent annually after inflation. U.S. Office of Management and Budget, Circular No. A-104, "Evaluating Leases of Capital Assets," Revised June 1, 1986, Appendix B, p. 2.

The constant dollar salvage value should be adjusted for any disposal costs necessary to realize the salvage. The disposal costs can be estimated on the basis of what it would cost in the base year to dispose of the item if it were in the condition expected at the end of the study period.

It should be noted that salvage values occurring at the end of a long study period tend to have relatively little weight in the analysis. This is because of the diminishing effect of the discounting operation, declines in value due to deterioration or obsolescence, and the offsetting effects of disposal costs. For example, assuming a straight-line decline in the constant dollar value of a component with a service life of 20 years, the required discount rate of 7 percent, and no disposal costs, the salvage value of the component after 10 years would have a present value equal to 25.5 percent of its base-year value.[1] This tendency often provides a rationale for devoting fewer resources to obtaining improved estimates of salvage values than of other cash flows needed for an evaluation.

These same guidelines for estimation will generally apply to other types of cash flows not covered here. The recommended procedure, in brief, is to start with base-year amounts whenever possible because of the greater ease in obtaining them and the greater confidence we usually have in their accuracy, and apply the approaches described above to derive a constant dollar future amount which can then be discounted to present value.

2.5 DISCOUNTING CASH FLOWS TO PRESENT VALUE

2.5.1 Opportunity Cost

With future amounts expressed in constant dollars, it remains necessary to adjust them to take into account the opportunity cost of money. The opportunity cost is the return that could have been realized if the funds were used for the best available alternative investment instead of the project being considered. This time adjustment can be accomplished by applying to the future amounts appropriate compound interest formulas, i.e., "discount formulas," or, alternatively, multiplicative "discount factors" which have been derived from the formulas and can be looked up in tables. The value of the discount factor depends on the discount rate and the period of time. The operation is often called "discounting cash flows."

2.5.2 Discount Rate

A "discount rate" is a rate of interest which reflects the investor's opportunity cost. Since it affects the present value of cash flows and, hence, whether or not a project will be acceptable, the value assigned to the discount rate is an important element in an economic analysis.

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[1]25.5% = 50.0% of initial value remaining after 10 years x 0.51, the SPW discount factor for a 7% discount rate and 10 years.

For evaluating most investments of the Federal government, the Office of Management and Budget (OMB) has specified that a real rate of 10 percent (not including inflation) be used.[1] Hence, the Appendix A and B data tables published in the January 23, 1980 Federal Register, as part of the original version of the LCC Rule, were based on a 10 percent discount rate.

This requirement, however, was superseded later in 1980 by passage of the Energy Security Act which required an annual discount rate of 7 percent for evaluating Federal energy conservation and renewable energy projects.[2] This rate, like the 10 percent rate, is interpreted as a real discount rate, not including the rate of inflation, and, hence, is appropriate for discounting future cash amounts that do not include inflation, i.e., that are given in constant dollars. (See section 2.4 for an explanation of constant dollars.)

The effect of discounting is to reduce the present value of future cash amounts. The higher the discount rate, the lower the present value equivalent of a future amount; the farther into the future the cash amount, the lower its present value equivalent.

2.5.3 Discount Formulas

The more commonly used discount formulas are shown in Table 2-3. Of these seven formulas, the following three are most used in evaluating the cost effectiveness of Federal energy conservation and renewable energy projects:

(1) Single Present Worth (SPW) Formula used to find the equivalent value at the present time of a single future amount, such as a replacement cost or a salvage value.

(2) Uniform Present Worth (UPW) Formula used to find the equivalent value at the present time of an annually recurring amount, such as routine maintenance cost.

(3) Modified Uniform Present Worth (UPW*) Formula[3] used to find the equivalent value at the present time of a future amount projected to change at specified rates over time, such as energy costs.

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[1]The 10 percent rate is specified in OMB Circular A-94 which is reproduced in Appendix H. Some Federal investment decisions are exempted from A-94, such as decisions regarding water projects and lease-or-purchase real property.

[2]Energy Security Act, Public Law 96-294, Sec. 405, 96th Congress, 94 Stat. 611 (1980).

[3]These formulas are also referred to as the Single Present Value (SPV), Uniform Present Value (UPV), and Modified Uniform Present Value (UPV*) formulas.

2.5.4 Discount Factors

Discounting is simplified by the use of discount factors, simple multipliers calculated from the discount formulas in Table 2-3 and displayed in tabular format. The factors, which are more convenient to use for manual computations and which give the same results as the formulas (aside from possible rounding errors), are emphasized in the LCC Rule.[1]

Appendix Tables A-1 and A-2 give the Single Present Worth (SPW) and Uniform Present Worth (UPW) discount factors, based on two discount rates: (1) the 7 percent discount rate now required for the analysis of Federal energy conservation and renewable energy projects, and (2) the 10 percent discount rate required for the analysis of most other Federal projects. These discount factors are appropriate for finding the present value of nonfuel costs or savings.

Appendix B Tables B-1a through B-11a give the Uniform Present Worth Modified (UPW*) discount factors, based on a 7 percent discount rate; and Tables B-1b through B-11b, on a 10 percent discount rate. These UPW* factors incorporate the official EIA-projected energy price escalation rates which Federal agencies are directed to use in making their LCC evaluations. The UPW* factors in Tables B-1a through B-11a are for evaluating energy costs and savings of projects which are primarily energy conserving or which use renewable energy; those in Table B-1b through B-11b are for evaluating energy costs and savings associated with most other Federal projects. Because the projected energy price escalation rates vary by region of the country, by fuel type, and by sector, a set of 11 tables (10 DoE regions plus the U.S. average) is necessary to provide these discount factors for each of the two discount rates.

2.5.5 Present Values

As indicated above, cash amounts that occur at different times should be discounted to a common time basis for a valid economic analysis. In general, that common time might be (1) the present, whereby all cash amounts are converted to an equivalent lump-sum value occurring now, i.e., a present value; (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, all Federal agencies are required to use a present value basis for evaluating energy conservation and renewable energy projects. Present values are used in preference to annual values because the present value conversions are needed to incorporate the escalation of energy prices. This results in the loss of computational advantages usually associated with the annual value basis.

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[1]The FBLCC computer program described in Appendix E performs the discounting operations. The FBLCC Diskette contains a separate program "DISCOUNT" which can be run to compute discount factors for specified input values of the discount rate, escalation rate, and time of occurrence.

Table 2-3. Discount Formulas

Name	Schematic Illustration	Application	Algebraic Form[a,b]
Single Compound-Amount (SCA) Equation	$\boxed{P} \longrightarrow \boxed{F?}$	To find F when P is known	$F = P \cdot [(1+d)^N]$
Single Present-Value (SPW) Equation	$\boxed{P?} \longleftarrow \boxed{F}$	To find P when F is known	$P = F \cdot \left[\frac{1}{(1+d)^N}\right]$
Uniform Sinking-Fund (USF) Equation	$\boxed{A?} + \boxed{A?} \cdots + \boxed{A?} \longleftarrow \boxed{F}$	To find A when F is known	$A = F \cdot \left[\frac{d}{(1+d)^N - 1}\right]$
Uniform Capital-Recovery (UCR) Equation	$\boxed{P} \longrightarrow \boxed{A?} + \boxed{A?} \cdots + \boxed{A?}$	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	$\boxed{A} + \boxed{A} \cdots + \boxed{A} \longrightarrow \boxed{F?}$	To find F when A is known	$F = A \cdot \left[\frac{(1+d)^N - 1}{d}\right]$
Uniform Present-Value (UPW) Equation	$\boxed{P?} \longleftarrow \boxed{A} + \boxed{A} \cdots + \boxed{A}$	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[c]	$\boxed{P?} \longleftarrow \boxed{A_1} + \boxed{A_2} \cdots + \boxed{A_n}$	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 $t = 1, \ldots, N$,
- 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, $A \doteq P/N$; UCA formula, $F \doteq A \cdot N$. The UPW* equation also yields an undefined answer when $e = d$. In this case, $P = A_0 \cdot N$.

[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 $F = P \cdot SCA$, $P = F \cdot SPW$, $A = F \cdot USF$, $A = P \cdot UCR$, $F \doteq UCA$, $P = A \cdot UPW$, and $P = A_0 \cdot UPW^*$.

[c] To find P when A_0 escalates at a different rate over each of K escalation periods,

$$P = \pi_{j=1} \left(\frac{1+e_i}{1+d}\right)^{n_i} = A_0 \sum_{j=1}^{n_1} \left(\frac{1+e_1}{1+d}\right)^j + \left(\frac{1+e_1}{1+d}\right)^{n_1} \sum_{j=1}^{n_2} \left(\frac{1+e_2}{1+d}\right)^j + \cdots$$

$$+ \left(\frac{1+e_1}{+d}\right)^{n_1} \left(\frac{1+e_2}{1+d}\right)^{n_2} \cdots \left(\frac{1+e_{K-1}}{1+d}\right)^{n_{K-1}} \sum_{j=1}^{n_K} \left(\frac{1+e_K}{1+d}\right)^j ,$$

where n_i = the number of interest or discounting periods over which a given escalation rate, e_i, is assumed to hold

$$\left(N = \sum_{i=1}^{K} (n_i)\right), \text{ and } \sum_{j=1}^{n_i} \left(\frac{1 = e_i}{1+d}\right)^j = \left(\frac{1+e_i}{d - ei}\right) \left[1 - \left(\frac{1+e_i}{1+d}\right)^{n_i}\right].$$

2.5.5.1 Using Discount Factors to Find the Present Value of Nonannually Recurring Amounts, Such as Replacement and Repair Costs and Salvage Values:

The present value (P) of a future amount that does not recur annually--such as a system replacement, repair, or salvage value--can be found by multiplying the future amount (F) by the SPW factor for the year (j) in which it occurs, i.e.,

$$P = F \times SPW_j. \tag{2.14}$$

For a Federal energy conservation or renewable energy project, SPW factors based on a 7 percent discount rate as given in Appendix Table A-1, 7 percent column, should be used.

For example, to find the present value of a replacement cost estimated in constant dollars at $1000 at the end of the 10th year, multiply $1000 by 0.51 (the SPW discount factor for the 10th year and 7 percent found in Table A-1), obtaining $510, i.e.,

$$P = \$1000 \times 0.51 = \$510. \tag{2.15}$$

This means, for example, that it would be worth raising initial investment costs by as much as $510 in order to avoid this future replacement.

In the same way, the present value of a future salvage amount can be found. For example, to find the present value of salvage estimated in constant dollars at $600 at the end of the 25th year, multiply $600 by 0.18 (the SPW discount factor for the 25th year and 7 percent found in Table A-1), as follows:

$$P = \$600 \times 0.18 = \$108. \tag{2.16}$$

[Note that for evaluating a Federal project which is <u>not</u> an energy conservation or renewable energy project and which is subject to OMB A-94, SPW factors based on a 10 percent discount rate as given in Appendix Table A-1, should be used for finding the present value of nonannually recurring amounts.]

2.5.5.2 Using Discount Factors to Find the Present Value of Uniform Annually Recurring Amounts Such as Routine Maintenance Costs:[1]

If a cash flow stated in constant dollars is expected to recur uniformly each year--as is typical of routine maintenance costs--its present value (P) over the study period (N years) can be found by multiplying the annually recurring amount (A) times by the UPW factor for N years, i.e.,

$$P = A \times UPW_N. \tag{2.17}$$

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[1]Initial investment costs can be assumed to be already in present value dollars and to require no discounting operation. (See sections 3.6 and 3.7 for further discussion of this assumption.)

For evaluating a Federal energy conservation or renewable energy project, UPW factors based on a 7 percent discount rate as given in Appendix Table A-2, 7 percent column, should be used. The annually recurring amount (A) is computed as the base-year price times the quantity required for one year.

For example, to find the present value of 15 years of maintenance costs of \$100 per year in base-year dollars, multiply \$100 by 9.11 (the UPW discount factor for 15 years and a 7 percent discount rate found in Table A-2), obtaining \$911, i.e.,

$$P = \$100 \times 9.11 = \$911. \tag{2.18}$$

The interpretation given to this result is that a Federal agency should regard the spending of \$100 per year for maintenance over 15 years as the economic equivalent of spending \$911 in a lump sum now, apart from uncertainty. This kind of equivalency measure can be useful in guiding cost tradeoffs, such as a tradeoff between higher initial investment costs and lower future maintenance costs, or vice versa. In this example, a Federal agency could justify spending up to \$911 in initial costs in order to avoid incurring the future maintenance costs of \$100 per year over 15 years.

[Note that for evaluating a Federal project which is <u>not</u> an energy conservation or renewable energy project and which is subject to OMB A-94, UPW factors based on a 10 percent discount rate should be used for finding the present value of uniform annually recurring costs. These are given in Appendix Table A-2, 10 percent columns.]

2.5.5.3 Using Discount Factors to Find the Present Value of Amounts Which are Projected to Recur Yearly but in Changing Amounts, Such as Energy Costs:

If a cash flow, stated in constant dollars, is expected to recur yearly but in a changing amount, and if there is a good basis for estimating the rates or amounts of change, UPW* factors which incorporate the specified changes can be constructed according to the appropriate formula of Table 2.3, and used to compute the present value of the cash flow.[1] To compute present value, multiply the initial quantity times the base-year price to get the base-year dollar amount (A_o), and then multiply A_o by the UPW* for the study period (N), i.e.,

$$P = A_o \times UPW_N^*. \tag{2.19}$$

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[1]Long-term price forecasts for specific industrial products and construction materials are generally unavailable. In most cases, the assumption that future prices will change at the same rate as prices in general, thereby remaining unchanged in constant dollar terms, is followed. This means that UPW rather than UPW* factors are used for finding the present value of most recurring amounts. But when there are long-term contractual agreements or prediction models which allow substantial analysis of market forces, as for energy prices, prices may be projected and UPW* factors constructed.

For evaluating the energy cost component of Federal energy conservation or renewable energy projects, use UPW* factors based on DoE energy price projections and a 7 percent discount rate. Demonstration UPW* factors, subject to annual update, are provided in Appendix Tables B-1a through B-11a.

The UPW* factors in Appendix B are useful for manual calculations of present value when the yearly quantity of energy is fixed. Use of the UPW* factors avoids the necessity for separate year-by-year calculations of present values using future prices and SPW factors. However, if the yearly quantity of energy--in addition to its price--is projected to change, the quantity change will not be reflected in the published UPW* factors. In this case, the year-by-year calculation procedure described in Appendix G is recommended.

The following example illustrates the use of UPW* factors from Appendix B to find the present value of energy costs. Consider a Federal office building in Wisconsin (DoE Region 5), which uses 5000 x 10^6 Btu of distillate oil annually, priced today at \$6.16 per 10^6 Btu (the DoE price in mid-1985 for DoE Region 5, Commercial Sector, Distillate Oil, as given in Appendix Table Ca-5). First find A_0, the base-year energy costs, by multiplying 5000 x 10^6 Btu x \$6.16/10^6 Btu. Then multiply the resulting amount, \$30,800 by 14.10 (the UPW* discount factor for DoE Region 5, Commercial Sector, Distillate, for 20 years found in Table B-5a), obtaining \$434,280. Thus

$$P = \$30,800 \times 14.10 = \$434,280. \qquad (2.20)$$

A reduction in the present value of energy costs can be compared with the present value costs of achieving the reduction. For example, an energy conservation project that would reduce the present value energy costs of the example building by, say, one-third, from \$434,280 to \$289,665--a savings of \$144,615--would be estimated to be cost effective if its present value costs were less than \$144,615.

[Note that for evaluating a Federal project which is not an energy conservation or renewable energy project and which is subject to OMB A-94, UPW* factors based on a 10 percent discount rate (given in Appendix Tables B-1b through B-11b) should be used for finding the present value of energy costs.]

3. REQUIREMENTS FOR DATA AND ASSUMPTIONS

The following is a list of requirements of the LCC Rule for establishing economic data and assumptions:[1]

3.1 CONSTANT DOLLARS

ESTIMATE ALL FUTURE AMOUNTS IN CONSTANT DOLLARS[2]

All monetary amounts should be stated in constant dollars in terms of the purchasing power of the dollar in the base year. For example, if an LCC evaluation were being made in 1986, a future cost expected to occur in 1990 should be stated in 1986 dollars without an estimate for the purely inflationary/deflationary trends that may cause the general level of prices in the economy to change between 1986 and 1990.

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.

The DoE-projected energy prices meet this requirement: they reflect only differential price changes and, hence, are in constant dollars. (For additional guidance and explanation, see section 2.4.)

3.2 QUANTITY OF ENERGY

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 or the DoE-estimated base-year electricity price (Appendix Tables C), the quantity of electricity generated should be used in the LCC evaluations, not the boundary purchases of fuel to produce the electricity. If, however,

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1 These requirements are based on the LCC Rule as set forth in C.F.R. Part 436, Subpart A.

2 OMB Circular A-104 requires that evaluation of leases be done in current dollars using a nominal discount rate.

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. (Also see section 3.3.)

3.3 BASE-YEAR ENERGY PRICES

> TO ESTIMATE INITIAL ENERGY COSTS OR SAVINGS, USE THE ACTUAL PRICE OF ENERGY TO THE AGENCY OR THE DoE-ESTIMATED BASE-YEAR REGIONAL AVERAGES OF ENERGY PRICES IF THE FORMER ARE NOT AVAILABLE

Federal agencies should use the actual prices of energy to them in the "base year" to establish base-year energy costs or savings if actual prices are available. If actual base-year prices are not readily available, the regional averages of base-year energy prices estimated by DoE and given in Appendix Tables C (subject to annual revision) can be used. The mixing of actual and DoE-estimated regional base-year prices in the same evaluation should be avoided if possible because differences in the nature of the data could affect the results.

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, or, if this price is not readily available, the appropriate DoE regional price of electricity from Appendix Tables C.

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 may be broken out separately in establishing base-year energy costs.

3.4 FUTURE ENERGY PRICES

> TO ACCOUNT FOR ANTICIPATED CHANGE IN FUTURE ENERGY PRICES, USE DoE-PROJECTED ENERGY PRICE ESCALATION RATES OR INDICES UNLESS SPECIFICALLY EXCEPTED

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 to vary by DoE region, by sector, by fuel type, and over time. The UPW* factors of Appendix Tables B reflect the projected differential escalation rates for energy prices, based on the price indices of Appendix Tables C (both sets of tables are subject to annual revision).

The DoE-projected rates of change in future energy prices can be incorporated into LCC evaluations in any of the three following ways:

(1) By using the UPW* factors of Appendix B in the Worksheet Approach described in sections 4 through 7 and 9.

(2) By applying the energy price indices of Appendix C to base-year prices, in the year-by-year approach described in Appendix G.

(3) By performing the evaluation using the companion FBLCC Computer Program described in Appendix E, 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 prices escalation rates:

(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 escalation rates are not available, but base-year utility prices are broken into demand and usage components, the DoE escalation rates 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 DoE-projected U.S. average escalation rates for guidance (UPW* Tables B-11a and B11b incorporate average escalation rates based on U.S. average price indices of Table Ca-11).

3.5 DISCOUNTING

> TO EVALUATE ENERGY CONSERVATION OR RENEWABLE ENERGY PROJECTS, DISCOUNT FUTURE AMOUNTS TO PRESENT VALUE USING A 7 PERCENT "REAL" DISCOUNT RATE. TO EVALUATE MOST OTHER FEDERAL PROJECTS (EXCEPT THOSE SPECIFICALLY EXEMPTED) DISCOUNT FUTURE AMOUNTS TO PRESENT VALUE OR ANNUAL VALUE USING A 10 PERCENT "REAL" DISCOUNT RATE

Consistent with the Energy Security Act, Federal agencies should use a discount rate of 7 percent, not including inflation, to find the present value equivalents of future constant dollar amounts associated with energy conservation or renewable energy projects. Use of the discounting factors given in Appendix A in the 7 percent columns and Appendix B, part a, all of which are based on a 7 percent rate, will meet this requirement.

Consistent with OMB Circular A-94, Federal agencies should use a discount rate of 10 percent, not including inflation, to find the present value equivalents of future constant dollar amounts associated with most other Federal projects, except those covered by other guidelines. Use of the 10 percent columns of Appendix A and the tables of part b of Appendix B will meet this requirement.

3.6 INVESTMENT COSTS

WITH THE EXCEPTION NOTED BELOW, TO EVALUATE ENERGY CONSERVATION OR RENEWABLE ENERGY PROJECTS, TREAT INVESTMENT COSTS, INCLUDING COSTS OF DESIGN, ENGINEERING, PURCHASE, AND INSTALLATION (EXCLUSIVE OF SUNK COSTS), AS A LUMP-SUM PRESENT VALUE AMOUNT OCCURRING AT THE BEGINNING OF THE BASE YEAR. FOR PURPOSES OF PROJECT EVALUATION, CONSIDER INVESTMENT COSTS 90 PERCENT OF ACTUAL INVESTMENT COSTS.(*) MOST OTHER FEDERAL PROJECTS ARE EVALUATED ON THE BASIS OF 100 PERCENT OF INVESTMENT COSTS WHICH MAY BE PHASED IN OVER A CONSTRUCTION PERIOD

*The provision which calls for a 10 percent reduction in investment costs for purposes of evaluating energy conservation and renewable energy projects is currently under review.

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 other cash flows, such as energy costs.

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, of course, 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 FEMP investment decisions, the difference in the results of a detailed cash flow analysis and of the simplified approach is expected generally not to be great. If a more detailed analysis is made, it is, in any case, necessary to convert all amounts to present value dollars as of the base year in order to compare alternative projects. A delay of project construction costs into the future generally means a corresponding delay in the commencing of energy savings. The present values of future investment costs, energy savings, and other costs will be reduced by delays in project completion. The reductions in costs and savings will tend to be somewhat offsetting, resulting in an LCC measure that tends to be quite close to that obtained by this simplified approach used for FEMP evaluation. (For a numerical example comparing the two approaches, see Table 3-1.)

An exception to treating investment costs as lump-sum present value amounts occurring at the beginning of the base year is the following: When making choices between mutually exclusive project alternatives which have as a primary difference their time required for implementation, a more detailed analysis of the timing of cash flows may be needed. 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 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). But the investment costs for the gas heating system would be treated as a future amount occurring at the end of the third year.

Reducing actual investment costs by 10 percent for use in the LCC evaluation is an adjustment designed to encourage Federal energy conservation. It is an adjustment intended to compensate for the use of average retail energy prices which are thought not to reflect the full value to the nation of conserving nonrenewable energy resources. The 10 percent reduction was modeled after the 10 percent tax credit allowed to business for energy conservation and renewable energy investments at the time this adjustment was designed.[1] The business tax credit for energy conservation has been eliminated, and this adjustment to investment costs by Federal agencies is currently under review.

3.7 ENERGY AND ANNUALLY RECURRING OPERATING AND MAINTENANCE COSTS

> ASSUME THAT ENERGY AND ANNUALLY RECURRING OPERATING AND MAINTENANCE COSTS BEGIN TO ACCRUE AT THE BEGINNING OF THE BASE YEAR, AND ARE EVALUATED AS LUMP-SUM AMOUNTS AT THE END OF EACH YEAR OVER THE STUDY PERIOD, STARTING WITH THE END OF THE BASE YEAR

To correspond with the treatment of investment costs as initially incurred expenses, energy and nonfuel annually recurring amounts are assumed to commence immediately, and are evaluated as of the end of each year, beginning with the end of the base year. Again, this is a simplifying assumption adopted to promote uniformity and practicality in the LCC Rule. (See the cash-flow diagram in section 2.2.5.)

3.8 NONANNUALLY RECURRING REPAIR AND REPLACEMENT COSTS AND SALVAGE VALUES

> ASSUME THAT FUTURE AMOUNTS NOT RECURRING ANNUALLY, SUCH AS REPAIR AND REPLACEMENT COSTS AND SALVAGE VALUES, OCCUR IN A LUMP SUM AT THE END OF THE YEAR IN WHICH THEY ARE ESTIMATED TO OCCUR

(See the cash-flow diagram in section 2.2.5.)

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[1]It is recognized that applying the 10 percent adjustment factor to investment costs is only a very rough proxy for the true value of social externalities not reflected in energy prices. For one thing, a more accurate adjustment would be linked to the type and amount of energy affected, not to the size of the investment cost.

Table 3-1. Treating Investment Costs as a Lump-sum Amount at the Beginning of the Base Year or as a Phased-in Cost Over a Construction Period

GIVEN ASSUMPTIONS:

Total Project Investment Cost = \$100,000 (Constant 1985 Dollars)

Annual Energy Savings (Evaluated at the Beginning of the Base Year) = \$15,000 [Note: This illustration is based on mid-1985 projections of U.S. average prices for natural gas, commercial buildings.]

Project Life = 20 years
Time of LCC Evaluation: mid-1985
Expected Investment Schedule (Constant 1985 Dollars):
mid-1986 - \$5,000 Design
late-1986 - \$5,000 Engineering
mid-1987 - \$20,000 Engineering
mid-1988 - \$70,000 Installation

Occupancy and Expected Onset of Energy Savings: mid-1988

SOLUTION BY LCC RULE, SIMPLIFIED METHOD:

$PV_{1985\$}$ Investment = \$100,000
$PV_{1985\$}$ Energy Savings = \$15,000 x 15.00 = \$225,000

Net Savings
NS = \$225,000 - \$100,000 = \$125,000

Savings-to-Investment Ratio
SIR = \$225,000/100,000 = 2.25

SOLUTION BY DETAILED METHOD, TAKING INTO ACCOUNT EXPECTED TIMING OF INVESTMENT COSTS AND ENERGY SAVINGS:[1]

Investment Costs

PV Investment Design	=	\$ 5,000 x .93	=	\$ 4,650
PV Investment Engineering	=	\$ 5,000 x .90	=	\$ 4,500
PV Investment Engineering	=	\$20,000 x .87	=	\$17,400
PV Investment Installation	=	\$70,000 x .82	=	\$57,400
$PV_{1985\$}$ Total Investment			=	\$83,950

Energy Savings

$PV_{1985\$}$ Energy Savings from mid-1988 through mid-2009:

1988-89	\$15,000 x 1.11 x .76 =	\$12,654
89-90	15,000 x 1.17 x .71 =	12,461
90-91	15,000 x 1.24 x .67 =	12,462
91-92	15,000 x 1.31 x .62 =	12,183
92-93	15,000 x 1.38 x .58 =	12,006
93-94	15,000 x 1.45 x .54 =	11,745
94-95	15,000 x 1.52 x .51 =	11,628
95-96	15,000 x 1.58 x .48 =	11,376
96-97	15,000 x 1.65 x .44 =	10,890
97-98	15,000 x 1.72 x .41 =	10,578
98-99	15,000 x 1.79 x .39 =	10,472
99-2000	15,000 x 1.86 x .36 =	10,044
2000-01	15,000 x 1.93 x .34 =	9,843
01-02	15,000 x 2.00 x .32 =	9,600
02-03	15,000 x 2.07 x .30 =	9,315
03-04	15,000 x 2.14 x .28 =	8,988
04-05	15,000 x 2.22 x .26 =	8,658
05-06	15,000 x 2.30 x .24 =	8,280
06-07	15,000 x 2.39 x .23 =	8,246
07-08	15,000 x 2.48 x .21 =	7,812
		199,440

Net Savings

NS = \$199,440 - \$83,950 = \$115,490

Savings-to-Investment Ratio

SIR = \$199,440/83,950 = 2.38

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[1]Note that NS and SIR calculated by this more detailed approach will vary relative to the NS and SIR calculated by the simplified approach depending on the exact scheduling of investment, the onset of energy savings, and the rate of escalation assumed in the price of energy.

3.9 RETROFIT STUDY PERIOD

> FOR EVALUATING OR RANKING AN ALTERNATIVE BUILDING SYSTEM RETROFIT FOR A FEDERALLY OWNED BUILDING, CHOOSE A STUDY PERIOD THAT IS THE LESSER OF (A) 25 YEARS, (B) THE ESTIMATED LIFE OF THE ALTERNATIVE BUILDING SYSTEM, OR (C) THE PERIOD OF INTENDED USE OF THE BUILDING[1]

Note that in selecting among mutually exclusive choices for a given retrofit project, it is important to use the same study period for evaluating all choices. (See section 3.10.)

3.10 STUDY PERIOD FOR DESIGNING AND SIZING NEW BUILDINGS AND BUILDING SYSTEMS

> 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, EXCEEDING NEITHER 25 YEARS NOR THE PERIOD OF INTENDED USE OF THE BUILDING

When present values are used, it is important 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--using the same study period. 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 or the period of intended use of the building, may be:

(a) The period of intended use of the building or 25 years, with appropriate replacements 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.

(c) The estimated life of one of the mutually exclusive alternatives with appropriate replacements and/or salvage values for the shorter- or longer-lived alternatives.

For example, consider that the problem is to decide whether it is more cost effective to retrofit a building that will be in use indefinitely with a heat-reflecting window film that costs $4.00/ft^2 to purchase and install and is estimated to last 5 years, or one that costs $10.00/ft^2 and is estimated to last 15 years. In this case, a study period of 15 years would be a good choice with the first alternative replaced twice and the second alternative not replaced.

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[1] An arbitrary cut-off for the study period of 30 years was originally adopted in Sec. A of Subpart 436, CFR 10, because of the great uncertainties regarding energy prices in the distant future. This limit is lowered from 30 years to 25 years by the provisions of the Energy Security Act of 1980.

3.11 LEASED BUILDING STUDY PERIOD

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.

3.12 PRESUMING COST EFFECTIVENESS

PRESUME THAT AN ALTERNATIVE BUILDING SYSTEM IS COST EFFECTIVE IF ITS INVESTMENT AND OTHER COSTS ARE INSIGNIFICANT

Investment and other costs may be considered insignificant when their total is less than the cost of performing the LCC evaluation. In other cases, the application of this guideline requires responsible judgment. It should be interpreted in a strict sense, and is intended to exempt from evaluation only those projects whose costs are trivial.

3.13 PRESUMING COST INEFFECTIVENESS

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 3 YEARS

4. EVALUATING ENERGY CONSERVING RETROFIT PROJECTS FOR EXISTING FEDERAL BUILDINGS

4.1 STRUCTURING PROBLEMS FOR SOLUTION

There are three main economic objectives to be achieved by an LCC evaluation of retrofit projects:

(1) to identify cost-effective projects;

(2) to design and size candidate projects for maximum cost effectiveness; and

(3) to identify the combination of candidate retrofit projects which will result in the greatest net savings for the limited Federal budget.

Consulting Table 2-2 to determine the modes of analysis required to achieve each of these objectives, we find that the TLCC or NS can be used to accomplish objectives (1) and (2) and the SIR, objective (3). A retrofit project is to be considered cost effective if, when compared with the base-case alternative, it lowers the building's TLCC or results in a positive NS. The alternative design or size of a project which is estimated to result in the lowest TLCC or highest NS is to be considered the most cost-effective choice. A candidate project having a higher SIR is to be given priority over other independent candidate projects having lower SIR's, when they are competing for a limited budget. (See section 10 for a discussion of problems which may be encountered in using SIR's for budget allocation.)

To assist the Federal facilities analyst in making the required evaluations for retrofit projects, a set of worksheets, entitled "RETROFIT WORKSHEETS" (Appendix D-1) are provided to guide the formatting of data and the operational computations for a hand calculation procedure.

The FBLCC computer program described in Appendix E can also be used to evaluate retrofit projects. The user must first run the "LCC" subprogram for the base case and for each alternative design or size of the retrofit program, and then run the "COMPARE" subprogram to generate the NS and SIR measures.

To help explain the LCC evaluation procedures for retrofit projects, two sample problems are solved below in sections 4.2 and 4.3, step by step, using the RETROFIT WORKSHEETS from Appendix D-1. The first illustrative problem is quite simple, involving the addition of insulation to bare hot water pipes. The only costs involved are the purchase and installation costs for the insulation; the savings result from a lower heat loss rate from the pipes. The second, slightly more complex, illustrative problem--replacement of a manual seasonal control system with an automatic control system--involves additional elements of cost.

4.2 SAMPLE RETROFIT PROBLEM #1: MODIFYING AN EXISTING BUILDING SYSTEM

4.2.1 Problem Statement

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:[1]

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: $\$7.00/10^6$ Btu
Plant Efficiency: .55
Remaining Building Life: Indefinite
Insulation Life: Indefinite
Study Period: 25 years
Available Insulation Choices: 1" or 2" of Fiberglass
Heat Loss Rates[2]--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[3]--1" Insulation: $3.47/ft installed cost
2" Insulation: $6.00/ft installed cost

The following questions are to be answered:

(1) Would it be cost-effective to add insulation?
(2) How much insulation should be added, 1 or 2 inches?
(3) What priority should this project receive relative to other projects?

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[1]For the purpose of demonstrating the basic procedures, this sample problem is kept simple. In actual practice, there would likely be other approaches to reducing the cost of hot water, such as reducing the water temperature or raising the efficiency of the water heating system, which would affect the cost effectiveness of the pipe insulation.

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

[3]Taken from R. S. Means Co., Inc., Mechanical Cost Data 1985.

4.2.2 Problem Solution

This problem can be solved by calculating the TLCC without the insulation to establish a base line, calculating the TLCC with 1" insulation, calculating the TLCC with 2" insulation and then comparing the three TLCC measures to see which is lowest. NS can be found by subtracting TLCC with the insulation (in each of the two sizes) from TLCC without the insulation. The SIR is calculated for the insulation thickness having the highest positive NS, using data from the TLCC calculations, to provide an index for ranking this project relative to other candidate projects.[1]

The RETROFIT WORKSHEETS from Appendix D-1 can be used to make these calculations. The first page of the worksheets describes the project and helps to organize background information necessary for the LCC evaluation. Following the project description are Parts A through E which are for estimating TLCC of the building or building system <u>without</u> the retrofit project, to provide a basis of comparison. Parts F through J are for estimating TLCC of the building or building system <u>with</u> the retrofit project. Part K is for calculating NS, and Part L, the SIR. When alternative designs and/or sizes for a given project--such as 1" versus 2" of pipe insulation--are being considered, it is necessary to repeat the calculations in Parts F through K for each alternative.

A set of RETROFIT WORKSHEETS completed for this problem is given in Exhibit 4-1. The calculations of NS for both choices of insulation thickness are shown on a single set of worksheets, with the calculations for the 2" thickness given in parentheses. Since this project entails no cost effects other than the estimated reduction in fuel costs, and the cost of the insulation, not all parts of the worksheets are needed to solve the problem. [Note that instructions accompany each page of the worksheets.]

From the evaluations, the following conclusions are drawn: insulating the pipes is estimated to be highly cost effective, reducing building costs by more than $24.0 thousand in present value dollars over 25 years. Based on the 1985 energy price projections, the additional investment required to increase insulation thickness from 1" to 2" is estimated not to be fully compensated by the additional savings, such that 1" of insulation is estimated to be the more cost-effective choice. The proposed project, insulating the laboratory pipes with 1" of insulation, is assigned priority for funding relative to other candidate projects on the basis of its SIR of 8.91.

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[1]For a discussion of designing and sizing projects when the budget is not sufficient to fund all that are cost effective, see section 10.2.3.

Exhibit 4-1. RETROFIT WORKSHEETS--COMPLETED FOR SAMPLE RETROFIT PROBLEM #1: MODIFYING AN EXISTING BUILDING SYSTEM

IDENTIFYING INFORMATION

AGENCY: Federal Science Agency

ADDRESS: Street Federal Street
City/County Boston
State Massachusetts
DoE Region 1

PROJECT CONTACT: Name L. C. C. Analyst
Position Facilities Engineer
Telephone

BUILDING OR FACILITY DESCRIPTION: Laboratory & Office Space

Classification for Energy Charges

[ ] Residential

[X] Commercial

[ ] Industrial

EXPECTED BUILDING/FACILITY LIFE Indefinite

PROJECT DESCRIPTION: Insulation of Hot Water Pipes in Basements of 10 Laboratory Buildings

EXPECTED PROJECT LIFE: Indefinite

STUDY PERIOD: From 1985 (Base Year) To 2010 (End Year)

LENGTH OF STUDY PERIOD: 25 Years

Instructions, Parts A-C

A. This part calculates the present value of energy costs before the retrofit. It is appropriate to use when (1) the annual physical quantity of energy required by the existing building or building system is expected to remain about constant over the study period, and (2) the types of energy are not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the retrofit:

(1) Annual quantity of energy to be purchased expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Ba table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs before the retrofit.

B. This part calculates the investment costs for the existing building or building system before the retrofit. It may be omitted if the existing system is to be left in place either "as is" or renovated at about the same cost whether or not the retrofit project is implemented.[4]

(1) If the existing system will be sold, scrapped, or redirected to a new use if the retrofit project is implemented, enter in (1) the estimated resale, salvage, or reuse value of the existing system in the base year.

(2) If the existing system is to be left in place, but will require an initial renovation or repair cost that will be different in amount without the retrofit project than with it, enter in (2) the amount of the initial renovation or repair cost in base-year dollars that will be required if the retrofit project is not implemented.

C. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs for the existing building or building system before the retrofit. If these costs are expected to be the same whether or not the retrofit project is implemented, this part may be omitted.[4]

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs for the existing building or building system, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) = Column (1) x Column (2).

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[1] Terms are defined in "Principal Definitions."

[2] Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$ Btu) only. If the quantity of energy in item A(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (= $\$20.00/10^6 \times 3412$ Btu/kWh).

[3] See Table 2-3 for the formula for calculating UPW* factors.

[4] Only those costs that will be affected by an investment decision need be considered in making that decision.

EXHIBIT 4-1. RETROFIT WORKSHEETS (Continued)

PARTS A-C

A. Calculating Energy Costs Before the Retrofit

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3) x (4)] PRESENT VALUE OF ENERGY COSTS
ELECTRICITY	______	$______	$______ BASE CHARGE = (1)X(2)	______	$______
			$______ DEMAND CHARGE	______	$______
			$______ TIME OF DAY CHARGE	______	$______
			$______ CONTRACT CAPACITY CHARGE	______	$______
			$______ OTHER CHARGE COMPONENT	______	$______
OIL	283.60×10^6 Btu[a]	$ 7.00/10^6 Btu	$ 1,985.20	16.17	$ 32,101
GAS		$	$		$
OTHER ______		$	$		$
TOTAL					$ 32,101

[a] 283.60×10^6 Btu/yr = [(150 Btu/hr/ft)(1,040 hrs/yr)(1,000 ft)] ÷ 0.55

B. Calculating Investment Costs for the Existing System Before the Retrofit

(1) Base-Year Resale, Salvage, or Reuse Value of the Existing System $ 0

(2) Base-Year Renovation Costs for the Existing System if the Retrofit Project is Not Implemented $ 0

C. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs Before the Retrofit

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
$ 0	X	-	=	$ 0

EXHIBIT 4-1. RETROFIT WORKSHEETS (Continued)

Instructions, Parts D & E

D. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values for the existing building or building system before the retrofit. If these amounts are expected to be about the same whether or not the retrofit project is implemented, this part may be omitted.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur.

(2) "Base-Year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur in any year during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs for the existing building or system.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs for the existing building or system.

(8) Column (8) = Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values for the existing building or system.

E. This part calculates the total life-cycle cost (TLCC) before the retrofit.

(1) Transcribe from Part A, Column (5) Total.

(2) Transcribe from Part B, item (1) or (2).

(3) Transcribe from Part C, Column (3).

(4) Transcribe from Part D, Column (6) Total.

(5) Transcribe from Part D, Column (7) Total.

(6) Transcribe from Part D, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

EXHIBIT 4-1. RETROFIT WORKSHEETS (Continued)

PARTS D & E

D. Calculating Nonannually Recurring, Nonfuel O&M and Repair Costs, Replacement Costs, and Salvage Value Before the Retrofit

(1) ELAPSED YEARS UNTIL OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
TOTAL					$ 0	$ 0	$ 0

E. Calculating TLCC Before the Retrofit

(1)	Present Value of Energy Costs: A(5) Total		$ 32,101
(2)	Present Value of Investment Costs: B(1) or B(2)	+	$ 0
(3)	Present Value of Annually Recurring, Nonfuel O&M Costs: C(3)	+	$ 0
(4)	Present Value of Nonannually Recurring, Nonfuel O&M & Repair Costs: D(6) Total	+	$ 0
(5)	Present Value of Replacement Costs: D(7) Total	+	$ 0
(6)	Present Value of Salvage Values: D(8) Total	-	$ 0
(7)	TLCC Before the Retrofit: (1)+(2)+(3)+(4)+(5)-(6)	=	$ 32,101

EXHIBIT 4-1. RETROFIT WORKSHEETS (Continued)

Instructions, Parts F & G

F. This part calculates the present value of energy costs after the retrofit. It is appropriate to use when (1) the annual physical quantity of energy requested by the existing building or building system is expected to remain about constant over the study period, and (2) the types of energy are not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the retrofit:

(1) Annual quantity of energy to be purchased expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Ba table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs after the retrofit.

G. This part calculates the investment costs attributable to the retrofit project.

(1) Costs of initial planning, design, engineering, purchase and installation, all in base-year dollars. If the existing system is to be left in place, but will require an initial renovation or repair cost that will be different with the retrofit project than without it, include in the initial investment costs the amount, in base-year dollars, of the initial renovation or repair costs required if the retrofit <u>is</u> performed.[4]

(2) Portion of amount in Line (1) which contributes to reducing energy consumption, in base-year dollars.

(3) Special adjustment to reduce energy conservation investment costs by 10%. It is intended to reflect estimated societal benefits from reducing the use of nonrenewable energy resources, not adequately reflected by market energy prices.

(4) Line (4) = Line (1) - Line (3).

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[1]Terms are defined in "Principal Definitions."

[2]Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$ Btu) only. If the quantity of energy in item F(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (= $\$20.00/10^6 \times 3412$ Btu/kWh).

[3]See Table 2-3 for the formula for calculating UPW* factors.

[4]Only those costs that will be affected by an investment decision need be considered in making that decision.

EXHIBIT 4-1. RETROFIT WORKSHEETS (Continued)

PARTS F & G

F. Calculating Energy Costs After the Retrofit

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3)X(4)] PRESENT VALUE OF ENERGY COST
ELECTRICITY	______	$______	$______ BASE CHARGE=(1)X(2)	______	$______
			$______ DEMAND CHARGE	______	$______
			$______ TIME OF DAY CHARGE	______	$______
			$______ CONTRACT CAPACITY CHARGE	______	$______
			$______ OTHER CHARGE COMPONENT	______	$______
OIL	37.80×10^6 Btu[a] (23.60×10^6 Btu)[b]	\$ $7.00/10^6$ Btu	\$ 264.60 (\$ 165.20)	16.17	\$ 4,279 (\$ 2,671)
GAS		$	$		$
OTHER ______		$	$		$
TOTAL					\$ 4,279 (\$ 2,671)

[a]37.80×10^6 Btu/yr = [(20 Btu/hr/ft)(1,040 hrs/yr)(1,000 ft)] ÷ 0.55, the annual quantity of oil to be purchased if 1" of insulation is added.

[b]23.60×10^6 Btu/yr = [(12.5 Btu/hr/ft)(1,040 hrs/yr)(1,000 ft)] ÷ 0.55, the annual quantity of oil to be purchased if 2" of insulation is added.

G. Calculating Investment Costs Attributable to the Retrofit

	1" Insulation	2" Insulation
(1) Estimated Actual Investment Costs for the Retrofit Project	\$ 3,470	\$ (6,000)
(2) Amount of Investment Comprising Energy Conservation Expenditure	\$ 3,470	\$ (6,000)
(3) Investment Cost Adjustment: Line (2) x 0.10	\$ 347	\$ (600)
(4) Adjusted Investment Costs attributable to the Retrofit Project: (1)-(3)	\$ 3,123	\$ (5,400)

Instructions, Parts H-J

H. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs after the retrofit. If these costs are expected to be the same whether or not the retrofit project is implemented and have not been included in Part C, omit this part.

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) - Column (1) x Column (2).

I. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values for the building or building system after the retrofit. If these amounts are expected to be about the same whether or not the retrofit project is implemented and have not been included in Part D, omit this part.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur, assuming end-of-year cash flows.

(2) "Base-year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur at any time during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs for the building or building system after the retrofit.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs for the building or building system after the retrofit.

(8) Column (8) = Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values for the building or building system after the retrofit.

J. This part calculates the TLCC after the retrofit.

(1) Transcribe from Part F, Column (5) Total.

(2) Transcribe from Part G, item (4).

(3) Transcribe from Part H, Column (3).

(4) Transcribe from Part I, Column (6) Total.

(5) Transcribe from Part I, Column (7) Total.

(6) Transcribe from Part I, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

EXHIBIT 4-1. RETROFIT WORKSHEETS (Continued)

PARTS H-J

H. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs After the Retrofit

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
$ 0	x	-	=	$ 0

I. Calculating Nonannually Recurring, Nonfuel O&M Costs and Repair Costs, Replacement Costs, and Salvage Value After the Retrofit

(1) ELAPSED YEARS BEFORE OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
TOTAL					$ 0	$ 0	$ 0

J. Calculating TLCC After the Retrofit Project

		1" Insulation		2" Insulation
(1) Present Value of Energy Costs: F(5) Total		$ 4,279		$ (2,671)
(2) Present Value of Adjustment Investment Costs: G(4)	+	$ 3,123	+	$ (5,400)
(3) Present Value of Annually Recurring, Nonfuel O&M Costs: H(3)	+	$ 0	+	$ 0
(4) Present Value of Nonannually Recurring, Nonfuel O&M and Repair Costs: I(6) Total	+	$ 0	+	$ 0
(5) Present Value of Replacement Costs: I(8) Total	+	$ 0	+	$ 0
(6) Present Value of Salvage: I(8) Total	-	$ 0	-	$ 0
(7) TLCC After the Retrofit Project (1) + (2) + (3) + (4) + (5) - (6)		$ 7,402		$ (8,071)

EXHIBIT 4-1. RETROFIT WORKSHEETS (Continued)

Instructions, Parts K & L

K. This part calculates the Net Savings (NS) (or Net Losses (-NS)) attributable to the retrofit project.

(1) Transcribe from Part E, item (7).

(2) Transcribe from Part J, item (7).

(3) Line (3) = Line (1) - Line (2).

L. This part calculates the Savings-to-Investment Ratio (SIR) for ranking the retrofit project.

(1) (a) Line (a) = (Part E, item (1)) - (Part J, item (1)).

(b) Line (b) = (Part E, Line (3) + Line (4)) - (Part J, Line (3) + Line (4)).

(c) Line (c) = Line (a) + Line (b). (Note that if O&M and repair costs are higher after the retrofit project than before it, Line (b) will be negative and will reduce the numerator.)

(2) (a) Line (a) = (Part J, Line (2)) - (Part E, Line (2)).

(b) Line (b) = (Part J, Line (5)) - (Part E, Line (5)).

(c) Line (c) = (Part J, Line (6)) - (Part E, Line (6)).

(d) Line (d) = Line (a) + Line (b) - Line (c). (Note that if replacement costs are lower after the retrofit than before it, Line (b) will be negative and will reduce the denominator, and if salvage value is lower, Line (c) will be negative and will increase the denominator.

(3) Line (3) = Line (1)(c) + Line (2)(d).

EXHIBIT 4-1. RETROFIT WORKSHEETS (Continued)

PARTS K & L

K. Calculating Net Savings or Net Losses of the Retrofit Project

		1" Insulation		2" Insulation
(1) TLCC Before the Retrofit: E(7)		$ 32,101		$ (32,101)
(2) TLCC After the Retrofit: J(7)	-	$ 7,402	-	$ (8,071)
(3) Net Savings (+) or Net Losses (-): (1)-(2)	=	$ 24,699	=	$ (24,030)

L. Calculating the SIR for Ranking the Retrofit Project

		1" Insulation[a]
(1) SIR Numerator		
(a) Energy Cost Savings Attributable to the Retrofit: E(1)-J(1)		$ 27,822
(b) Nonfuel O&M and Repair Cost Savings (+) or Cost Increase (-) Attributable to the Retrofit: E(3+4)-J(3+4)	+	$ 0
(c) SIR Numerator: (a) + (b)	=	$ 27,822
(2) SIR Denominator		
(a) Adjusted Increased Investment Cost Attributable to the Retrofit: J(2)-E(2)		$ 3,123
(b) Replacement Cost Increase (+) or Decrease (-) Attributable to the Retrofit: J(5)-E(5)	+	$ 0
(c) Salvage Value Increase (+) or Decrease (-) Attributable to the Retrofit: J(6)-E(6)	-	$ 0
(d) SIR Denominator: (a)+(b)-(c)	=	$ 3,123
(3) SIR for Ranking the Retrofit Project: (1c)÷(2d)		8.91

[a]The SIR is calculated only for the project size selected. Based on the comparison of Net Savings, 1" insulation is a more cost-effective choice than 2" insulation; therefore, the SIR is calculated for 1" insulation.

4.3 SAMPLE RETROFIT PROBLEM #2: REPLACING AN EXISTING BUILDING SYSTEM

4.3.1 Problem Statement

A new automatic control system is being considered for replacing the existing manual control system for the HVAC system in a Federal office complex located in Washington, D.C. The Federal complex has an indefinite life, and the facilities manager estimates that the new system would last at least 25 years. Would the replacement be cost effective? What priority should this retrofit project receive relative to other candidate projects?

Data and assumptions are as follows:

Existing System

Current (Immediate Salvage Value (Base-Year $): $260,000
Expected Remaining Life without Major Replacements: 10 years
Expected Salvage Value in 10 years without Major Replacements: 0
Salvage Value in 25 years with Necessary Replacements: 0
Annually Recurring (Nonfuel) O&M Costs (Base-Year$): $120,000
Nonannually Recurring (Nonfuel) O&M Costs (Base-Year $):

Year	Amount
5	$25,000
15	$25,000
20	$25,000

Replacement Cost (Base-Year $):

Year	Amount
10	$150,000

Energy Data:

Annual Quantity Electricity	$34,100 \times 10^6$ Btu
Annual Quantity Natural Gas	$433,600 \times 10^6$ Btu
Price of Electricity[1]	$\$21.42/10^6$ Btu
Price of Natural Gas	$\$5.99/10^6$ Btu

[1] In this example, the 1985 average prices from Appendix C, Table Ca-1, are used.

Retrofit System

Initial Investment Cost: \$1,500,000
Expected Life: 25 years or longer
Annually Recurring (Nonfuel) O&M Costs (Base-Year \$): \$145,000
Nonannually Recurring (Nonfuel) O&M Costs (Base-Year \$):

Year	Amount
10	\$40,000
20	\$40,000

Replacement Costs (Base-Year \$): 0
Salvage Value at End of 25 Years (Base-Year \$): 0

Energy Data:		
	Annual Quantity Electricity	$31,300 \times 10^6$ Btu
	Annual Quantity Natural Gas	$386,800 \times 10^6$ Btu
	Price of Electricity	\$21.42/10^6 Btu
	Price of Natural Gas	\$5.99/10^6 Btu

4.3.2 Problem Solution

Since only one alternative control system is being considered, this problem does not entail a design or sizing element. The TLCC, NS, and SIR are shown calculated in the RETROFIT WORKSHEETS in Exhibit 4-2.

From the evaluation, the following conclusions are drawn: Replacing the existing manual control system with the new automatic control system is estimated to reduce the relevant life-cycle costs of the office complex over 25 years by \$4.0 million. This project is assigned priority for funding according to its SIR of 4.99.

Exhibit 4-2. RETROFIT WORKSHEETS--COMPLETED FOR SAMPLE RETROFIT PROBLEM #2: REPLACING AN EXISTING BUILDING SYSTEM

IDENTIFYING INFORMATION

AGENCY: National Administration

ADDRESS: Street Federal Street
City/County Washington, D.C.
State
DoE Region 3

PROJECT CONTACT: Name L. C. C. Analyst
Position Facilities Engineer
Telephone

BUILDING OR FACILITY DESCRIPTION: Offices

Classification for Energy Charges

[ ] Residential

[X] Commercial

[ ] Industrial

EXPECTED BUILDING/FACILITY LIFE Indefinite

PROJECT DESCRIPTION: Replacement of HVAC Manual Control System with Automatic Control System

EXPECTED PROJECT LIFE: 25 Years or Longer

STUDY PERIOD: From 1985 (Base Year) To 2010 (End Year)

LENGTH OF STUDY PERIOD: 25 Years

EXHIBIT 4-2. RETROFIT WORKSHEETS (Continued)

Instructions, Parts A-C

A. This part calculates the present value of energy costs before the retrofit. It is appropriate to use when (1) the annual physical quantity of energy required by the existing building or building system is expected to remain about constant over the study period, and (2) the types of energy are not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the retrofit:

(1) Annual quantity of energy to be purchased expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Ba table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs before the retrofit.

B. This part calculates the investment costs for the existing building or building system before the retrofit. <u>It may be omitted if the existing system is to be left in place either "as is" or renovated at about the same cost whether or not the retrofit project is implemented.</u>[4]

(1) If the existing system will be sold, scrapped, or redirected to a new use if the retrofit project is implemented, enter in (1) the estimated resale, salvage, or reuse value of the existing system in the base year.

(2) If the existing system is to be left in place, but will require an initial renovation or repair cost that will be different in amount without the retrofit project than with it, enter in (2) the amount of the initial renovation or repair cost in base-year dollars that will be required if the retrofit project is <u>not</u> implemented.

C. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs for the existing building or building system before the retrofit. If these costs are expected to be the same whether or not the retrofit project is implemented, this part may be omitted.[4]

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs for the existing building or building system, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) = Column (1) x Column (2).

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[1]Terms are defined in "Principal Definitions."

[2]Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$ Btu) only. If the quantity of energy in item A(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (= $\$20.00/10^6 \times 3412$ Btu/kWh).

[3]See Table 2-3 for the formula for calculating UPW* factors.

[4]Only those costs that will be affected by an investment decision need be considered in making that decision.

EXHIBIT 4-2. RETROFIT WORKSHEETS (Continued)

PARTS A-C

A. Calculating Energy Costs Before the Retrofit

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3) x (4)] PRESENT VALUE OF ENERGY COSTS
ELECTRICITY	$34,100 \times 10^6$ Btu	\$ $21.42/10^6$ Btu	\$ 730,422 BASE CHARGE = (1)X(2)	11.79	\$ 8,611,675
			\$ ____ DEMAND CHARGE	____	\$ ____
			\$ ____ TIME OF DAY CHARGE	____	\$ ____
			\$ ____ CONTRACT CAPACITY CHARGE	____	\$ ____
			\$ ____ OTHER CHARGE COMPONENT	____	\$ ____
OIL		\$	\$		\$
GAS	$433,600 \times 10^6$ Btu	\$ 5.99	\$2,597,264	16.54	\$ 42,958,747
OTHER ____		\$	\$		\$
TOTAL					\$ 51,570,422

[a] $283/60 \times 10^6$ Btu/yr = [(150 Btu/hr/ft)(1,040 hrs/yr)(1,000 ft)] ÷ 0.55

B. Calculating Investment Costs for the Existing System Before the Retrofit

(1) Base-Year Resale, Salvage, or Reuse Value of the Existing System \$ 260,000

(2) Base-Year Renovation Costs for the Existing System if the Retrofit Project is Not Implemented \$ 0

C. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs Before the Retrofit

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
\$ 120,000	X	11.65	=	\$ 1,398,000

Instructions, Parts D & E

D. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values for the existing building or building system before the retrofit. If these amounts are expected to be about the same whether or not the retrofit project is implemented, this part may be omitted.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur.

(2) "Base-Year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur in any year during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs for the existing building or system.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs for the existing building or system.

(8) Column (8) - Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values for the existing building or system.

E. This part calculates the total life-cycle cost (TLCC) before the retrofit.

(1) Transcribe from Part A, Column (5) Total.

(2) Transcribe from Part B, item (1) or (2).

(3) Transcribe from Part C, Column (3).

(4) Transcribe from Part D, Column (6) Total.

(5) Transcribe from Part D, Column (7) Total.

(6) Transcribe from Part D, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

PARTS D & E

D. Calculating Nonannually Recurring, Nonfuel O&M and Repair Costs, Replacement Costs, and Salvage Value Before the Retrofit.

(1) ELAPSED YEARS UNTIL OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
5	$ 25,000			0.71	$ 17,750		
10		$15.000		0.51		$ 76,500	
15	$ 25,000			0.36	$ 9,000		
20	$ 25,000			0.26	$ 6,500		
TOTAL					$ 33,250	$ 76,500	$ 0

E. Calculating TLCC Before the Retrofit

(1)	Present Value of Energy Costs: A(5) Total		$ 51,570,422
(2)	Present Value of Investment Costs: B(1) or B(2)	+	$ 260,000
(3)	Present Value of Annually Recurring, Nonfuel O&M Costs: C(3)	+	$ 1,398,000
(4)	Present Value of Nonannually Recurring, Nonfuel O&M & Repair Costs: D(6) Total	+	$ 33,250
(5)	Present Value of Replacement Costs: D(7) Total	+	$ 76,500
(6)	Present Value of Salvage Values: D(8) Total	-	$ 0
(7)	TLCC Before the Retrofit: (1)+(2)+(3)+(4)+(5)-(6)	=	$ 53,338,172

Instructions, Parts F & G

F. This part calculates the present value of energy costs after the retrofit. It is appropriate to use when (1) the annual physical quantity of energy requested by the existing building or building system is expected to remain about constant over the study period, and (2) the types of energy ares not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the retrofit:

(1) Annual quantity of energy to be purchased expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Ba table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs after the retrofit.

G. This part calculates the investment costs attributable to the retrofit project.

(1) Costs of initial planning, design, engineering, purchase and installation, all in base-year dollars. If the existing system is to be left in place, but will require an initial renovation or repair cost that will be different with the retrofit project than without it, include in the initial investment costs the amount, in base-year dollars, of the initial renovation or repair costs required if the retrofit _is_ performed.[4]

(2) Portion of amount in Line (1) which contributes to reducing energy consumption, in base-year dollars.

(3) Special adjustment to reduce energy conservation investment costs by 10%. It is intended to reflect estimated societal benefits from reducing the use of nonrenewable energy resources, not adequately reflected by market energy prices.

(4) Line (4) = Line (1) - Line (3).

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1 Terms are defined in "Principal Definitions."

2 Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$ Btu) only. If the quantity of energy in item F(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (= $\$20.00/10^6 \times 3412$ Btu/kWh).

3 See Table 2-3 for the formula for calculating UPW* factors.

4 Only those costs that will be affected by an investment decision need be considered in making that decision.

EXHIBIT 4-2. RETROFIT WORKSHEETS (Continued)

PARTS F & G

F. Calculating Energy Costs After the Retrofit

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3)X(4)] PRESENT VALUE OF ENERGY COST
ELECTRICITY	31,300 x 10^6 Btu	\$ 21.42/10^6 Btu	\$ 670,446 BASE CHARGE=(1)X(2)	11.79	\$ 7,904,558
			\$ ____ DEMAND CHARGE	____	\$ ____
			\$ ____ TIME OF DAY CHARGE	____	\$ ____
			\$ ____ CONTRACT CAPACITY CHARGE	____	\$ ____
			\$ ____ OTHER CHARGE COMPONENT	____	\$ ____
OIL		\$	\$		\$
GAS	386,800 x 10^6 Btu	\$ 5.99/10^6 Btu	\$ 2,316,932	16.54	\$ 38,322,055
OTHER ____		\$	\$		\$
TOTAL					\$ 46,226,613

G. Calculating Investment Costs Attributable to the Retrofit

(1)	Estimated Actual Investment Costs for the Retrofit Project	\$ 1,500,000
(2)	Amount of Investment Comprising Energy Conservation Expenditure	\$ 1,500,000
(3)	Investment Cost Adjustment: Line (2) x 0.10	\$ 150,000
(4)	Adjusted Investment Costs Attributable to the Retrofit Project: (1)-(3)	\$ 1,350,000

EXHIBIT 4-2. RETROFIT WORKSHEETS (Continued)

Instructions, Parts H-J

H. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs after the retrofit. If these costs are expected to be the same whether or not the retrofit project is implemented and have not been included in Part C, omit this part.

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) - Column (1) x Column (2).

I. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values for the building or building system after the retrofit. If these amounts are expected to be about the same whether or not the retrofit project is implemented and have not been included in Part D, omit this part.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur, assuming end-of-year cash flows.

(2) "Base-year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur at any time during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs for the building or building system after the retrofit.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs for the building or building system after the retrofit.

(8) Column (8) = Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values for the building or building system after the retrofit.

J. This part calculates the TLCC after the retrofit.

(1) Transcribe from Part F, Column (5) Total.

(2) Transcribe from Part G, item (4).

(3) Transcribe from Part H, Column (3).

(4) Transcribe from Part I, Column (6) Total.

(5) Transcribe from Part I, Column (7) Total.

(6) Transcribe from Part I, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

EXHIBIT 4-2. RETROFIT WORKSHEETS (Continued)

PARTS H-J

H. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs After the Retrofit

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
$ 145,000	x	11.65	=	$ 1,689,250

I. Calculating Nonannually Recurring, Nonfuel O&M Costs and Repair Costs, Replacement Costs, and Salvage Value After the Retrofit

(1) ELAPSED YEARS BEFORE OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
10	$40,000			0.51	$20,400		
20	$40,000			0.26	$10,400		
TOTAL					$30,800	$ 0	$ 0

J. Calculating TLCC After the Retrofit Project

(1)	Present Value of Energy Costs: F(5) Total		$ 46,226,613
(2)	Present Value of Adjustment Investment Costs: G(4)	+	$ 1,350,000
(3)	Present Value of Annually Recurring, Nonfuel O&M Costs: H(3)	+	$ 1,689,250
(4)	Present Value of Nonannually Recurring, Nonfuel O&M and Repair Costs: I(6) Total	+	$ 30,800
(5)	Present Value of Replacement Costs: I(8) Total	+	$ 0
(6)	Present Value of Salvage: I(8) Total	-	$ 0
(7)	TLCC After the Retrofit Project (1) + (2) + (3) + (4) + (5) - (6)		$ 49,296,663

EXHIBIT 4-2. RETROFIT WORKSHEETS (Continued)

Instructions, Parts K & L

K. This part calculates the Net Savings (NS) (or Net Losses (-NS)) attributable to the retrofit project.

(1) Transcribe from Part E, item (7).

(2) Transcribe from Part J, item (7).

(3) Line (3) = Line (1) - Line (2).

L. This part calculates the Savings-to-Investment Ratio (SIR) for ranking the retrofit project.

(1) (a) Line (a) = (Part E, item (1)) - (Part J, item (1)).

(b) Line (b) = (Part E, Line (3) + Line (4)) - (Part J, Line (3) + Line (4)).

(c) Line (c) = Line (a) + Line (b). (Note that if O&M and repair costs are higher after the retrofit project than before it, Line (b) will be negative and will reduce the numerator.)

(2) (a) Line (a) = (Part J, Line (2)) - (Part E, Line (2)).

(b) Line (b) = (Part J, Line (5)) - (Part E, Line (5)).

(c) Line (c) = (Part J, Line (6)) - (Part E, Line (6)).

(d) Line (d) = Line (a) + Line (b) - Line (c). (Note that if replacement costs are lower after the retrofit than before it, Line (b) will be negative and will reduce the denominator, and if salvage value is lower, Line (c) will be negative and will increase the denominator.

(3) Line (3) = Line (1)(c) + Line (2)(d).

EXHIBIT 4-2. RETROFIT WORKSHEETS (Continued)

PARTS K & L

K. Calculating Net Savings or Net Losses of the Retrofit Project

(1)	TLCC Before the Retrofit: E(7)		$ 53,338,172
(2)	TLCC After the Retrofit: J(7)	-	$ 49,296,663
(3)	Net Savings (+) or Net Losses (-): (1)-(2)	=	$ 4,041,509

L. Calculating the SIR for Ranking the Retrofit Project

(1)	SIR Numerator		
(a)	Energy Cost Savings Attributable to the Retrofit: E(1)-J(1)		$ 5,343,809
(b)	Nonfuel O&M and Repair Cost Savings (+) or Cost Increase (-) Attributable to the Retrofit: E(3+4)-J(3+4)	-	$ 288,800
(c)	SIR Numerator: (a) + (b)	=	$ 5,055,009
(2)	SIR Denominator		
(a)	Adjusted Increased Investment Cost Attributable to the Retrofit: J(2)-E(2)		$ 1,090,000
(b)	Replacement Cost Increase (+) or Decrease (-) Attributable to the Retrofit: J(5)-E(5)	-	$ 76,500
(c)	Salvage Value Increase (+) or Decrease (-) Attributable to the Retrofit: J(6)-E(6)	-	$ 0
(d)	SIR Denominator: (a)+(b)-(c)	=	$ 1,013,500
(3)	SIR for Ranking the Retrofit Project: (1)(c) (2)(d)		4.99

5. EVALUATING ENERGY CONSERVING BUILDING DESIGNS AND SYSTEMS FOR NEW FEDERAL BUILDINGS

5.1 STRUCTURING PROBLEMS FOR SOLUTION

In evaluating and choosing new building designs, the overriding factor is the functional use of the building. Economic evaluation of energy conservation features is useful for determining the most cost effective of alternative designs for a given building that will satisfy the functional use requirements. It is not the purpose of the evaluation to determine if a given building should be built.

The TLCC mode of analysis is appropriate for identifying the design that will meet the functional and other requirements of a building at the lowest total life-cycle costs, emphasizing in this process the life-cycle costs of the energy components of the building. The approach is to sum (1) the present value of investment costs less salvage value net of disposal costs, (b) the present value of future nonfuel operating, maintenance, and repair costs, (c) the present value of replacement costs, and (d) the present value of energy costs for each alternative design. The design whose energy-related components result in the lowest TLCC for the building will be preferred, other things being equal.[1]

A set of worksheets entitled "NEW BUILDING DESIGN WORKSHEETS" (Appendix D-2), has been prepared to assist in calculating the TLCC of alternative building designs. The items and the calculation procedures given in these worksheets are essentially the same as those given in Parts A through D of the Retrofit Worksheets. (NS and SIR are not required.) Instructions for completing the worksheets are found on the pages facing the worksheets.

The FBLCC computer program described in Appendix E also can be used to evaluate new building designs. The user must run the program for each alternative building design and compare TLCC's.

To help explain the evaluation procedures for new building designs, a sample problem and step-by-step solution are given below, using the NEW BUILDING DESIGN WORKSHEETS from Appendix D-2.[2] The problem compares two alternative designs for

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[1]As in the case of evaluating retrofit projects, it is important that any significant differences in the benefits associated with alternative designs of a new building be taken into account. If quantifiable, these differences in benefits can be incorporated into the TLCC measure as negative costs; if unquantifiable, a verbal description should be provided to supplement the numerical TLCC evaluation.

[2]A set of blank worksheets is provided in Appendix D-2.

a given building, A and B, both of which are assumed to meet the functional requirements in approximately an equal way, but one of which is more energy conserving than the other.

5.2 SAMPLE BUILDING DESIGN PROBLEM

5.2.1 Problem Statement

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 (DoE region 5).[1] 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 (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 design is 25 percent of the wall area and most of that is located on the south side; in the conventional building, it is 40 percent and distributed equally on all sides. The energy-conserving design has more massive exterior surfaces and increased insulation which reduces 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 its summer cooling load. Its earth-bermed north wall on the first floor reduces both the heating and cooling loads. Either design is expected to last at least 25 years, and neither is assumed to have salvage value remaining at the end of the 25-year study period. The question to be answered is which design is estimated to have the lowest life-cycle cost.

Following is a listing of the major relevant costs for each design:

	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.)	$100,000	

[1]The designs are purely hypothetical and are solely for the purpose of illustrating the evaluation process.

	Energy-Conserving Design (A)	Conventional Design (B)
(b) Architectural and Engineering Design Fees and Construction Costs:	\$9,780,000	\$9,130,000
(c) Annual Energy Consumption:		
Natural Gas	$2,290 \times 10^6$ Btu	$4,980 \times 10^6$ Btu
Electricity	$3,886 \times 10^6$ Btu	$7,277 \times 10^6$ Btu
(d) Energy Prices:[1]		
Natural Gas	\$ $5.49/10^6$ Btu	\$ $5.49/10^6$ Btu
Electricity	\$$21.21/10^6$ Btu	\$$21.21/10^6$ Btu
(e) Nonfuel O&M Costs:		
Recurring Annual Cost:	\$70,000	\$90,000
Repairs to External Surfaces Every 10 Years:	\$60,000	\$100,000

5.2.2 Problem Solution

This problem can be solved by calculating the TLCC for each of the two designs being considered to determine which is estimated to be lower.[2] The NEW BUILDING DESIGN WORKSHEETS shown in Exhibit 5-1 are used to carry out the evaluations. For ease of comparison, both design alternatives are shown evaluated on the same worksheets with amounts for the energy conserving design labeled (A) and those for the conventional design labeled (B).

From the evaluation, the following conclusion can be drawn: The additional investment costs required for the energy conserving design are more than offset by the estimated lower energy costs, such that the TLCC of the energy conserving design is estimated to be lower than the TLCC of the conventional design: \$11.8 million versus \$12.5 million.

In reviewing the results, it might be pointed out that the differences in the TLCC measures obtained are small relative to the magnitude of the total building cost. However, the reduction in the building's TLCC attributable to the energy-conserving design is significant relative to the incremental investment costs required for the energy-conserving features. Estimated energy savings plus reductions in other costs total \$1,342,043, compared with an estimated increase in actual investment costs of \$750,000.

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[1]In this example, the 1985 average fuel prices from Appendix C, Table C-1 are used.

[2]Any number of possible designs for a given building can be evaluated in this same way.

EXHIBIT 5-1. NEW BUILDING DESIGN WORKSHEETS--COMPLETED FOR TWO ALTERNATIVE BUILDING DESIGNS

IDENTIFYING INFORMATION

AGENCY: National Defense

ADDRESS: Street Federal Street

City/County Madison

State Wisconsin

DoE Region ______

PROJECT CONTACT: Name I. R. Designer

Position Facilities Architect

Telephone ______

BUILDING, FACILITY, OR SYSTEM DESCRIPTION: Office Building of 176,000 ft^2

Classification For Energy Charges

[ ] Residential

[X] Commercial

[ ] Industrial

Expected Building Facility, or System Life: 25+

STUDY PERIOD: From 1985 (Base Year) To 2010 (End Year)

LENGTH OF STUDY PERIOD: 25 years

Instructions, Parts A & B

A. This part calculates the present value of energy costs. It is appropriate to use when (1) the annual physical quantity of energy required for the design is expected to remain about constant over the study period, and (2) the type(s) of energy are not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the choice of designs:

(1) Total annual quantity of energy to be purchased, expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Appendix Ba table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs.

B. This part calculates the investment costs for the building or system.

(1) Costs of initial planning, site acquisition, design, engineering, purchase and installation, all in base-year dollars.

(2) Portion of amount in Line (1) which contributes to reducing energy consumption, in base-year dollars.

(3) Special adjustment factor to reduce energy conservation investment costs by 10%. It is intended to reflect estimated societal benefits from reducing the use of nonrenewable energy resources not adequately reflected by market energy prices.

(4) Line (4) = Line (1) - Line (3).

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[1]Terms are defined in "Principal Definitions."

[2]Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$) only. If the quantity of energy in item A(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton of steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (=$\$20.00/10^6$Btu x 3,412 Btu/kWh).

[3]See Table 2-3 for the formula for calculating UPW* factors.

EXHIBIT 5.1. NEW BUILDING DESIGN LCC WORKSHEETS (Continued)

PARTS A & B

A. Calculating Energy Costs

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3)x(4)] PRESENT VALUE OF ENERGY COST
ELECTRICITY	(A) 3,886 x 10^6 Btu (B) 7,277 x 10^6 Btu	\$ 21.21/10^6 Btu	(A) \$ 82,422.06 (B) \$ 154,345.17 BASE CHARGE=(1)x(2)	11.31	(A) \$ 932,193 (B) \$1,745,644
			\$ ____ DEMAND CHARGE	____	\$ ____
			\$ ____ TIME OF DAY CHARGE	____	\$ ____
			\$ ____ CONTRACT CAPACITY CHARGE	____	\$ ____
			\$ ____ OTHER CHARGE COMPONENT	____	\$ ____
OIL		\$	\$		\$
GAS	(A) 2,290 x 10^6 Btu (B) 4,980 x 10^6 Btu	\$5.49/10^6 Btu	(A) \$12,572.10 (B) \$27,340.20	17.93	(A) \$225,418 (B) \$490,210
OTHER ____		\$	\$		\$
TOTAL					(A) \$1,157,611 (B) \$2,235,854

B. Calculating Investment Costs for the New Building Design

	(A)	(B)
(1) Estimated Actual Investment Costs for the New Building Design	\$9,880,000[1]	\$9,130,000
(2) Part of Investment Comprising Energy Conservation Expenditure	\$ 750,000	0[2]
(3) Investment Cost Adjustment: Line (2) x 0.10	\$ 75,000	0
(4) Adjusted Investment Costs for the New Building Design	\$9,805,000	\$9,130,000

[1]Includes \$100,000 site acquisition cost, plus \$9,780,000 architectural and engineering design fees and construction costs.

[2]Investment Costs of the conventional design are not eligible for the investment cost adjustment; the adjustment applies only to energy conservation or renewable energy investment costs.

EXHIBIT 5-1. NEW BUILDING DESIGN WORKSHEETS (Continued)

Instructions, Parts C-E

C. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs.

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) = Column (1) x Column (2).

D. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur, assuming end-of-year cash flows.

(2) "Base-Year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur in any year during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs.

(8) Column (8) = Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values.

E. This part calculates the total life-cycle cost (TLCC).

(1) Transcribe from Part A, Column (5) Total.

(2) Transcribe from Part B, item (4).

(3) Transcribe from Part C, Column (3).

(4) Transcribe from Part D, Column (6) Total.

(5) Transcribe from Part D, Column (7) Total.

(6) Transcribe from Part D, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

PARTS C-E

C. Calculating Annually Recurring, Nonfuel Operating, Maintenance (O&M), and Repair Costs

(1) Amount of Annually Recurring Costs in Base Year Dollars	X	(2) UPW Factor	=	(3) Present Value of Annually Recurring Costs
(A) $ 70,000				(A) $ 815,500
(B) $ 90,000		11.65		(B) $1,048,500

D. Calculating Nonannually Recurring, Nonfuel O&M and Repair Costs, Replacement Costs, and Salvage Values

(1) ELAPSED YEARS BEFORE OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M AND REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COST (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUE (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)x(5)] PRESENT VALUE OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
10	(A) 60,000 (B) 100,000			0.51	(A) 30,600 (B) 51,000		
20	(A) 60,000 (B) 100,000			0.26	(A) 15,600 (B) 26,000		
TOTALS					(A)$ 46,200 (B)$ 77,000	$ 0	$ 0

E. Calculating the TLCC

	(A)	(B)
(1) Present Value of Energy Costs: A(5) Total	$ 1,157,611	$ 2,235,854
(2) Present Value of Adjusted Investment Cost: B(4)	+ $ 9,805,000	+ $ 9,130,000
(3) Present Value of Annually Recurring, Nonfuel O&M Costs: C(3)	+ $ 815,500	+ $ 1,048,500
(4) Present Value of Nonannually Recurring, Nonfuel O&M and Repair Costs: D(6) Total	+ $ 46,200	+ $ 77,000
(5) Present Value of Replacement Costs: D(7) Total	+ $ 0	+ $ 0
(6) Present Value of Salvage Values: D(8) Total	- $ 0	- $ 0
(7) TLCC of the New Building or System Design: (1)+(2)+(3)+(4)+(5)-(6)	$11,824,311	$12,491,354

6. EVALUATING ENERGY CONSERVATION DECISIONS FOR FEDERALLY LEASED BUILDINGS

The National Energy Act directs Federal agencies to give preference in leasing buildings to those "which use solar heating and cooling equipment or other renewable energy sources or which otherwise minimize life-cycle costs."

This section describes those specific life-cycle costing assumptions and procedures which pertain to the evaluation of energy conservation and renewable energy decisions for leased Federal buildings. The focus is on the special requirements for evaluating leased buildings that differ from those for owned buildings.

6.1 COST ASSUMPTIONS

Only those costs actually incurred or those savings actually realized by the Federal government are to be included in the life-cycle cost evaluation of a project for a leased building. At the one extreme--usually when an entire building is leased--the Federal government may directly pay all energy and nonfuel operating and maintenance costs. In this circumstance, the kinds of costs to be included in the evaluation are identical to the costs which would be included if the building were owned by the Federal government with the probable exception of salvage value at the end of the life of the investment.

At the other extreme, usually when a small part of a privately owned building is leased, the Federal government may directly pay no energy or nonfuel operating and maintenance costs. These costs may be paid entirely by the building owner and incorporated into the rent. In this circumstance, no energy savings are realized by the Federal government unless lease renegotiations are held to reduce the rent following energy-conserving retrofits. If there are no savings to be realized by the government occupant either by reduced utility bills or by lower rent, energy conservation investments are deemed under the program rules not to be cost effective and specific life-cycle cost evaluation is unnecessary.

Between the two extremes, the Federal government may directly pay some, but not all, of the energy and nonenergy operating and maintenance costs. The life-cycle cost evaluation should include the part of the costs that are directly paid by the Federal government. In this case, the cost effectiveness to the Government of a project for a leased building may vary markedly, depending upon the particular way in which energy and other costs are shared between the building owner and the Federal lessee.

6.2 STUDY PERIOD ASSUMPTIONS

The study period for leased buildings is the lesser of 25 years or the effective remaining term of the lease. If appropriate, the study period may include renewal options that are likely to be exercised. The cost effectiveness and priority ranking of a project for a leased building is therefore likely to be quite sensitive to the remaining effective term of the lease.

The LCC Rule allows a Federal agency to presume that a retrofit is <u>not</u> cost effective when a Federal building is occupied under a short-term (2 years or less) lease without a renewal option or with a renewal option which is not likely to be exercised. No evaluation is required under this condition.

6.3 LCC EVALUATIONS OF PROJECTS FOR LEASED BUILDINGS

The modes of analysis, the evaluation procedures as reflected in the worksheets, the computer program, and those assumptions not specifically changed for leased buildings, apply to evaluations for leased buildings. However, in using the worksheets and computer program, it is important to observe the special cost and study period assumptions for leased buildings that are described above in section 6.1 and 6.2, as well as any other regulations governing Federal expenditures in leased buildings. Additionally, special attention is directed to the treatment of salvage values when evaluating projects for leased buildings. The lease, or the nature of the retrofit project, may require that ownership of certain kinds of capital assets retrofitted into a leased building be transferred from the Federal government to the building owner upon termination of the lease. If ownership transfers to the building owner, care should be taken to include only those salvage values that are actually likely to be recovered by the Federal government.

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7. EVALUATING FEDERAL SOLAR ENERGY PROJECTS[1]

7.1 STRUCTURING PROBLEMS FOR SOLUTION

Evaluating the economic performance[2] of solar energy systems is very similar to evaluating energy conservation investments. And the economic objectives to be achieved by LCC evaluations of solar energy projects are essentially the same:

(1) to determine if a proposed project is estimated to be cost effective;

(2) to identify which system designs and sizes are likely to be most cost effective, in what locations, against which fuel types, in which types of buildings, and for what applications; and

(3) to assign priority to candidate solar energy projects relative to other projects.

Consulting Table 2-2 to determine the modes of analysis for evaluating solar energy systems, we find that they all are used. The TLCC method is appropriate for estimating if a solar energy system will reduce the long-run owning and operating costs of a building. It is also useful for determining the economically preferred design and size of a solar energy system, by showing the impact of changes in investment on lifetime building costs. If TLCC is lower with a combined solar energy/auxiliary energy system than with the most cost-effective nonsolar alternative, the solar energy system is considered cost effective. If a solar energy system of one design results in a lower TLCC than another, it is considered the more cost-effective design. As long as TLCC continues to decline as the size of the solar energy system is increased, it pays to increase the size. A measure of NS is easily derived from the TLCC measures. To assign priority of solar energy projects relative to other independent projects, the SIR method is used. Because it is called for in legislation, the PB method (simple payback) is used to provide a supplementary measure of economic performance.

To illustrate how to perform an economic evaluation of a solar energy system, a sample problem is provided below. The SOLAR ENERGY WORKSHEETS from Appendix D-3 are used to organize the data, guide the discounting operations, and compute TLCC, NS, SIR, and PB.[1] The example, though hypothetical, is based on performance and costs of actual systems monitored under the Department of Energy's "Solar in Federal Buildings Program." Cost-saving features are pointed out where appropriate.

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[1]Although this part is written specifically for solar energy, the methods and procedures presented here can be adapted to the economic evaluation of most other kinds of renewable energy systems.

[2]For information on other aspects of solar design and evaluation, see Solar Energy Research Institute, Solar Design Workbook for the Solar Federal Buildings Program, ed. Gregory Franta, et al., SERI/SP-62-308, May 1980.

7.2 SAMPLE SOLAR ENERGY PROBLEM

7.2.1 Problem Statement

A Federal agency is considering a solar energy system for retrofit to an existing Federal office building located at a Marine Corps Air Station in the southwest corner of Arizona, and wishes to know if it is expected to be cost effective. The latitude is 32.7°N and the longitude is 114.7°W. The climate is warm and dry and the insolation characteristics are favorable for solar applications. The monthly average ambient temperature varies from a low of 55.4°F in January to a high of 93.7°F in July. The monthly average insolation of the horizontal ranges from 999 Btu/day·ft^2 in December to 2812 Btu/day·ft^2 in July.

The solar energy system, a retrofit design, is intended to supply 50 percent of the hot water load for a 5000 ft^2 launderette/PX now met entirely by an electric water heater. The electric water heater will serve as auxiliary to the solar energy system. The load exists seven days a week and totals approximately 1750 million Btu over the year. The daily load profile closely matches the solar profile so the need for storage is reduced.

The closed-loop drainback system has 2500 ft^2 of collector area and stores energy in a single 750 gallon storage tank. A highly effective external plate heat exchanger is used to transfer heat between the collector loop and the storage tank. When a draw of water by the launderette occurs, city water is forced into the storage tank replacing the solar-heated water which is delivered to the electric auxiliary water heater where its temperature is boosted.

There are 84 collectors in the array, broken into 14 banks of 6 collectors each. Two rows of seven banks are mounted directly on the roof which is oriented toward true south with a pitch of 33° from the horizontal. Integration of the collectors into the roof is a good technique for reducing support structure cost and it allows improved performance of the collectors due to the insulating effect of the roof. The single glazed, black chrome, flat plate collectors have internal manifolds and are approximately 3' wide by 8' long.

The copper distribution piping is plumbed in a reverse return fashion and run in the attic space to provide weather proofing and to reduce pipe losses. All lines are well insulated to an R-7 value. Because the mechanical room is directly below the collectors, piping costs are kept to a minimum.

The mechanical room houses the small drainback tank, the plate heat exchanger, the collector and storage pumps, the storage tanks, the delta temperature controller and the auxiliary water heater. Those components which can lose

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[1]For a more indepth treatment of the economic evaluation of solar energy systems for both Federal and private buildings, see Rosalie Ruegg and Thomas Sav, "Microeconomics of Solar Energy," Solar Energy Handbook, ed. J.F. Kreider and F. Kreith (New York, New York: McGraw-Hill Book Company, 1981).

energy are well insulated (e.g., the storage tank is insulated to R-25). Because the water quality at the site is good, a costly tank lining is not required. Electrical installation costs are low since power was already run into the mechanical room.

This solar water heating system is expected to deliver 45 percent of the solar energy incident on collectors to the load. The remaining portion of the load will be handled by the electric auxiliary heater which will boost the temperature of the solar-heated water to 135°F. The efficiency of the electric unit is rated at 100%. Both the solar energy system and the auxiliary unit are expected to have a lifetime of 20 years.

The data for evaluating the solar water heating system are presented below:

Bare Construction Costs for Material and Labor

	Cost	Cost/ft^2 Collector (gross area)
Collectors	\$22,500	\$ 9.00
Roof Modification & Supports	6,875	2.75
Tanks	3,750	1.50
Piping and Pumps	12,500	5.00
Insulation	2,250	.90
Controls and Instrumentation	2,500	1.00
Electrical	375	.15
	\$50,750	\$20.30

Multiplier for freight, workers compensation, social security, unemployment tax, sales tax, contingency, G&A, profit, bonds and permits and liability insurance:

1.37

Total Construction Cost

\$69,527 $\quad$ \$27.81/ft^2

Design Cost (10% of Total Construction Cost)

\$ 6,953

Energy Data

Price of Electricity, 1985	\$19.83 x 10^6 Btu
Annual Water Heating load	1,750 x 10^6 Btu
Solar Fraction	0.5 x Load
Annual Operating Energy for Pump Electricity, etc.) (.02% of Annual Solar Energy Delivered)	.02 x (1,750 x 10^6 Btu x 0.5) = 17.5 x 10^6 Btu
Efficiency of Electric Auxiliary Heater	100%

Annual Maintenance Cost

2% of Initial Construction Cost

.02 x \$69,527 = \$1,391

Equipment Replacement Costs

Assume no major equipment failures during the life of the system.

Salvage Value

Assume that the demolition value of the project is equal to any salvage value. Therefore, the effective salvage value is zero.

Assume that the maintenance costs for the auxiliary hot water heater are unaltered by the use of the solar system.

7.2.2 Problem Solution

The SOLAR ENERGY WORKSHEETS from Appendix D-3 are used to organize the data for this problem, as illustrated in Exhibit 7-1.

The following conclusions can be drawn from the evalution: The combined solar energy/electric auxiliary water heater is estimated to reduce life-cycle energy costs by more than \$100,000. The project's priority will be based on an SIR of 2.69. The project is expected to recover its costs in four to five years.

EXHIBIT 7-1. SOLAR ENERGY WORKSHEETS--COMPLETED FOR A SAMPLE PROBLEM

IDENTIFYING INFORMATION

AGENCY: U.S. Marine Corps

ADDRESS: ______

PROJECT TITLE: Solar Energy/Electric Auxiliary Hot Water System for Base Launderette and PX

PROJECT CONTACT PERSON: J. Smith

BUILDING DESCRIPTION: [ ] NEW [X] EXISTING

Functional Use: ______

Classification for Energy Charges [ ] Residential

[X] Commercial

[ ] Industrial

EXPECTED BUILDING/FACILITY LIFE: Indefinite

SOLAR APPLICATION (Check All Appropriate): Domestic Hot Water [X], Space Heating [ ], Space Cooling [ ], Industrial Process Heat [X]. If Process Heat,

Briefly Explain: Process hot water is supplied to a launderette and domestic hot water to a PX.

G. TYPE SOLAR ENERGY SYSTEM: [X] Active [ ] Passive [ ] Combined Active/Passive

Briefly Describe: Closed-loop drainback system with 2500 ft^2 of collector area and 750 gallon storage tank, used with an electric auxiliary water heater.

EXPECTED PROJECT LIFE: 20 Years

STUDY PERIOD: FROM 1985 (Base Year) TO 2005 (End Year)

LENGTH OF STUDY PERIOD: 20 Years

EXHIBIT 7-1. SOLAR ENERGY WORKSHEETS

Instructions, Parts A-C

In order to evaluate the cost effectiveness of a solar energy system, it is necessary to estimate a base-line against which to compare it. The purpose of this part is to estimate those base-line costs for the non-solar energy system that would be used if the solar energy project were not undertaken. This system may be identical to or different from the system that would be used as a backup to the solar energy system.

A. This part calculates the present value of fuel costs without solar. It should be completed for the type(s) of fuel(s) that solar will be displacing. Indicate in the appropriate columns:

(1) Annual quantity of energy to be purchased expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Appendix Ba table should be applied to the sum of the separate charge components in Column (3). Use a study period of 20 years unless (1) more accurate number for the particular system is available, or (2) the remaining life of the building is less than 20 years, in which case the study period should equal the remaining building life. Do not exceed a study period of 25 years.

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs if solar is not used.

B. This part gives the investment costs for the non-solar energy system which would be used in lieu of the solar energy system. It should be completed only if the energy system which would be used in lieu of solar energy (1) differs from the system that would be used as a backup to the solar energy system, or (2) would require renovation costs to keep it in service that differ in amount if used without the solar energy system versus with it.

(1) For a new building, enter the costs of purchasing and installing the non-solar energy system, in base-year dollars.

(2) For an existing building, with an existing energy system which would be continued in use if the solar energy project were not undertaken, enter any renovation costs necessary to keep it in service.

(3) For an existing building whose existing energy system would not be continued in use regardless of the solar energy project, enter the costs of purchasing and installing the new non-solar energy system to be used in lieu of solar energy less any net proceeds from the existing system.

C. This part calculates the present value of annually recurring, nonfuel operating and maintenance (O&M) costs of the nonsolar energy system which would have been used in lieu of the proposed solar energy system. It should be completed only if the O&M costs of the non-solar energy system are expected to differ from the O&M costs of the backup system.

(1) Self-explanatory.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) = (Column (1) x Column (2).

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[1] Terms are defined in "Principal Definitions."

[2] Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$) only. If the quantity of energy in item A(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton of steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $20.00/$10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is $0.068/kWh (=$20.00/10^6Btu x 3,412 Btu/kWh).

[3] See Table 2-3 for the formula for calculating UPW* factors.

EXHIBIT 7-1. SOLAR ENERGY WORKSHEETS (Continued)

PARTS A-C

A. Calculating Fuel Costs Without Solar

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3) x (4)] PRESENT VALUE OF ENERGY COSTS
ELECTRICITY	$1,750 \times 10^6$ Btu	\$ $19.83/10^6$ Btu	\$ 34,703 BASE CHARGE = (1)X(2)	11.76	\$ 408,101
			\$____ DEMAND CHARGE	____	\$____
			\$____ TIME OF DAY CHARGE	____	\$____
			\$____ CONTRACT CAPACITY CHARGE	____	\$____
			\$____ OTHER CHARGE COMPONENT	____	\$____
OIL		\$	\$		
GAS		\$	\$		\$
OTHER ____		\$	\$		\$
TOTAL			\$ 34,703		\$ 408,101

B. Calculating Investment Costs Without Solar

(1) For New Building Only, Base-year Investment Costs for the Non-solar Energy System \$ -

(2) For Existing Building/Existing System Only, Base-year Renovation Costs for the Existing System if the Solar Energy Project is Not Implemented. \$ -

(3) For Existing Building/New System Only, Base Year Investment Cost for the New Non-solar Energy System (Less Resale for Old System) \$ -

C. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs Before the Retrofit

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
\$ -	X	-	=	\$ -

Instructions, Parts D & E

D. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values for the non-solar system which would have been used in lieu of the proposed solar energy system. It should be completed only if these types of costs for the non-solar energy system are expected to differ from these same types of costs for the auxiliary system.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur, assuming end-of-year cash flows.

(2) "Base-Year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur in any year during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs for the non-solar energy system.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs for the non-solar energy system.

(8) Column (8) - Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values for the non-solar energy system.

E. This part calculates the total life-cycle cost (TLCC) without solar.

(1) Transcribe from Part A, Column (5) Total.

(2) Transcribe from Part B, item (1) or (2), or (3).

(3) Transcribe from Part C, Column (3).

(4) Transcribe from Part D, Column (6) Total.

(5) Transcribe from Part D, Column (7) Total.

(6) Transcribe from Part D, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

EXHIBIT 7-1. SOLAR ENERGY WORKSHEETS (Continued)

PARTS D-E

D. Calculating Nonannually Recurring, Nonfuel O&M and Repair Costs, Replacement Costs, and Salvage Values Without Solar.

(1) ELAPSED YEARS BEFORE OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
TOTALS					$ ---	$ ---	$ ---

E. Calculating TLCC Without Solar

(1)	Present Value of Energy Costs: A(5) Total	+	$ 408,101
(2)	Present Value of Investment Costs: B(1), (2), or (3)	+	$ ______
(3)	Present Value of Annually Recurring, Nonfuel O&M Costs: C(3)	+	$ ______
(4)	Present Value of Nonannually Recurring, Nonfuel O&M & Repair Costs: D(6) Total	+	$ ______
(5)	Present Value of Replacement Costs: D(7) Total	+	$ ______
(6)	Present Value of Salvage Values: D(8) Total	-	$ ______
(7)	TLCC Without Solar: (1)+(2)+(3)+(4)+(5)-(6)	=	$ 408,101

Instructions, PARTS F-H

F. This part identifies the types of fuel affected by the solar energy system, and the data needed to compute fuel quantities in Part G.

G. This part calculates the present value of fuel costs with solar.

(1) Annual Quantity of Energy Purchased = [(Annual Energy Load/Efficiency of Auxiliary System) x (1 - Solar Fraction] + [Annual Energy for Operating Solar Pumps, etc.].

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Ba table should be applied to the sum of the separate charge components in Column (3). Use a study period of 20 years unless (1) a more accurate number for the particular system is available, or (2) the remaining life of the building is less than 20 years in which case the study period should equal the remaining building life.

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs if solar is used.

H. This part calculates the investment costs attributable to the solar energy system.

(1) Total of Site Planning, Design and Construction Costs.

(2) Complete this line only if an entry was made in Part B for the costs of the NON-SOLAR energy system to be used in lieu of solar energy. Enter the cost of purchase and installation or of renovation, whichever is applicable, of the non-solar energy system.

(3) Line (3) = Line (1) + Line (2).

(4) Portion of amount in Line (3) which contributes to reducing nonrenewable energy consumption, in base-year dollars.

(5) Special adjustment to reduce investment costs for conservation of nonrenewable energy cost by 10%. The factor is intended to reflect estimated societal benefits from reducing the use of nonrenewable energy resources not adequately reflected by market energy prices.

(6) Line (6) = Line (3) - (Line (5).

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[1] Terms are defined in "Principal Definitions."

[2] Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$ Btu) only. If the quantity of energy in item F(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (= $\$20.00/10^6 \times 3412$ Btu/kWh).

[3] See Table 2-3 for the formula for calculating UPW* factors.

EXHIBIT 7-1. SOLAR ENERGY WORKSHEETS (Continued)

PARTS F-H

F. Calculating Fuel Costs with Solar

(1)	Type of Fuel	Electricity			
(2)	Annual Energy Load (10^6 Btu)	1,750			
(3)	Efficiency of Auxiliary System	100%			
(4)	Solar Fraction	0.5			
(5)	Annual Energy for Operating Solar Pumps, etc. (10^6 Btu)	17.5			

G. Calculating Fuel Costs with Solar

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3)X(4)] PRESENT VALUE OF ENERGY COST
ELECTRICITY	892.5 x 10^6 Btu[a]	\$ 19.83/10^6 Btu	\$ 17,698 BASE CHARGE=(1)X(2)	11.76	\$ 208,132
			\$ ____ DEMAND CHARGE	____	\$ ____
			\$ ____ TIME OF DAY CHARGE	____	\$ ____
			\$ ____ CONTRACT CAPACITY CHARGE	____	\$ ____
			\$ ____ OTHER CHARGE COMPONENT	____	\$ ____
OIL		\$	\$		\$
GAS		\$	\$		\$
OTHER ____		\$	\$		\$
TOTAL			\$ 17,698		\$ 208,132

[a] 892.5 x 10^6 Btu = [1,750/1.00 x (1 - 0.5)] + 17.5

H. Calculating Investment Costs with Solar

(1)	Investment Costs of the Solar Energy System	\$ 76,480
(2)	Investment Costs of the Non-Solar Energy Backup System	\$ -
(3)	Total Investment Costs Attributable to the Solar Energy System and its Backup	\$ 76,480
(4)	Portion of Total Investment Cost Comprising Energy Conservation Expenditure	\$ 76,480
(5)	Investment Costs Adjustment: Line (4) x 0.10	\$ 7,648
(6)	Adjusted Investment Costs Attributable to the Solar Project: (3) - (5)	\$ 68,832

EXHIBIT 7-1. SOLAR ENERGY WORKSHEETS (Continued)

Instructions, PARTS I & K

I. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs (O&M) with the solar energy system. These are the total O&M costs associated with the solar energy system including the O&M costs of the auxiliary system. If the nonfuel O&M costs of the auxiliary system are assumed the same as those of the non-solar energy system used alone and are omitted in section C, they should also be omitted in this section. (For the solar system, typical O&M costs are between 1 and 4 percent of the system investment costs.)

(1) Self explanatory.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) - Column (1) x Column (2).

J. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values with the solar energy system. Included are amounts for the auxiliary system. If these amounts for the auxiliary system are assumed the same as those of the non-solar energy system used alone and are omitted from section D, they should be omitted for the auxiliary system in this section.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur.

(2) "Base-year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values for the solar energy system should be set equal to 0 unless more definitive information is available.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs with the solar energy system.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs with the solar energy system.

(8) Column (8) = Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values with the solar energy system.

K. This part calculates the total life-cycle cost (TLCC) with the solar energy system.

(1) Transcribe from Part G, Column (5) Total.

(2) Transcribe from Part H, item 6.

(3) Transcribe from Part I, Column (3).

(4) Transcribe from Part J, Column (6) Total.

(5) Transcribe from Part J, Column (7) Total.

(6) Transcribe from Part J, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

EXHIBIT 7-1. SOLAR ENERGY WORKSHEETS (Continued)

PARTS I-K

I. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs With Solar

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
$ 1,391	x	10.59	=	$ 14,731

J. Calculating Nonannually Recurring, Nonfuel O&M Costs and Repair Costs, Replacement Costs, and Salvage Values with Solar

(1) ELAPSED YEARS BEFORE OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
TOTALS					$ ---	$ ---	$ ---

K. Calculating TLCC with Solar

(1)	Present Value of Energy Costs: G(5) Total		$ 208,132
(2)	Present Value of Adjusted Investment Costs: H(6)	+	$ 68,832
(3)	Present Value of Annually Recurring, Nonfuel O&M Costs: I(3)	+	$ 14,731
(4)	Present Value of Nonannually Recurring, Nonfuel O&M and Repair Costs: J(6) Total	+	$ -
(5)	Present Value of Replacement Costs: J(7) Total	+	$ -
(6)	Present Value of Salvage Values: J(8) Total	-	$ -
(7)	TLCC With Solar (1) + (2) + (3) + (4) + (5) - (6)		$ 291,695

EXHIBIT 7-1. SOLAR ENERGY WORKSHEETS (Continued)

Instructions, PARTS L & M

L. This part calculates the Net Savings or Net Losses of the solar energy system as a measure of its cost effectiveness.

(1) Transcribe from Part E, item (7).

(2) Transcribe from Part K, item (7).

(3) Line (3) = Line (1) + Line (2).

L. This part calculates the Savings-to-Investment Ratio (SIR) for ranking the solar energy project relative to other projects.

(1) (a) Line (a) = (Part E, item (1)) - (Part K, item (1)).

(b) Line (b) = (Part K, Lines (3) + Line (4)) - (Part E, Lines (3) + Line (4)).

(c) Line (c) = Line (a) + Line (b). (Note that if O&M and repair costs are higher with the solar energy project than without it Line (b) will be negative and will reduce the numerator.)

(2) (a) Line (a) = (Part K, item (2)) - (Part E, item (2)).

(b) Line (b) = (Part K, item (5)) - (Part E, item (5)).

(c) Line (c) = (Part K, item (6)) - (Part E, item (6)).

(d) Line (d) = Line (a) + Line (b) - Line (c). (Note that if replacement costs are lower with the solar energy project than without it, Line (b) will be negative and will reduce the denominator, and if salvage value is lower, Line (c) will be negative and will increase the denominator.

(3) Line (3) = Line (1)(c) + Line (2)(d).

PARTS L-M

L. Net Savings or Net Losses of the Solar Project

(1) TLCC without Solar: E(7)		$ 408,101
(2) TLCC with Solar: K(7)	-	$ 291,695
(3) Net Savings (+) or Net Losses (-): (1)-(2)	=	$ 116,406

M. SIR Calculation

(1) SIR Numerator		
(a) Energy Cost Savings Attributable to Solar: E(1)-K(1)		$ 199,969
(b) Nonfuel O&M and Repair Cost Savings (+) or Cost Increase (-) Attributable to Solar: K(3+4)-E(3+4)	-	$ 14,731
(c) SIR Numerator (a)+(b)	=	$ 185,238
(2) SIR Denominator		
(a) Adjusted Increased Investment Cost with Solar: K(2)-E(2)		$ 68,852
(b) Replacement Cost Increase (+) or Decrease (-) Attributable to Solar: K(5)-E(5)	+	$ -
(c) Salvage Value Increase (+) or Decrease (-) Attributable to Solar: K(6)-E(6)	-	$ -
(d) SIR Denominator: (a)+(b)-(c)	=	$ 68,832
(3) SIR for Ranking the Retrofit Project: (1)(c)÷(2)(d)		2.69

Instructions, PART N

N. This part describes two methods of calculating simple payback for the solar project, based on the types of cash flow anticipated. All applicants should complete either: (1) for uniform cash flow, or (2) for nonuniform cash flows.

(1) (a) Transcribe from Part M, item (2)(a).

(b) Line (b) = (Part A, Column (3) Total) - (Part G, Column (3) Total).

(c) Line (c) = (Part I, item (1)) - (Part C, item (1)).

(d) Line (d) = Line (b) - Line (c).

(e) Line (e) = Line (a) + Line (d).

(2) (a) Beginning with year 0 (at which time investment costs are entered) and progressing one year at a time, enter the number of elapsed years in the study period.

(b) Column (b) = (Part A, Column (3) Total) - (Part G, Column (3) Total x (number of years accumulated).

(c) Column (c) = [Part I, item (1) + (Part J, item (2) + (3) - (4)][1] - [Part C, item (1) + (Part D, items (2) + (3) - (4)].[1] This should be accumulated by year.

(d) Column (d) = Column (b) - Column (c).

(e) Column (e) = Part M, item (2)(a).

(f) Column (f) = Column (d) - Column (e).

(g) Simple payback (SPB) occurs in the year indicated in Column (a) for which Column (f) changes from negative to positive.

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[1]Items 2, 3, and 4 of Parts D and J refer to nonannually recurring costs which only have to be included in those years in which they occur.

N. Simple Payback (SPB)

(1) Calculating SPB when annual cash flows are uniform.[a]

(a) Adjusted Increased Investment Cost With Solar: M(2a)	(b) Base-Year Fuel Cost Savings With Solar: A(3)Total-G(3) Total	(c) Change in Base Year Nonfuel O&M Costs With Solar: I(1)-C(1)	(d) Net Yearly Savings: (b) - (c)	(e) SPB (Years): (a) ÷ (d)
$ 68,832	$ 17,005	$ 1,391	$ 15,614	4.4

(2) Calculating SPB when annual cash flows are not uniform.

(a) CUMULATIVE YEAR	(b) CUMULATIVE ENERGY SAVINGS	(c) CUMULATIVE CHANGE IN NONFUEL O&M, REPAIR, REPLACEMENT, AND SALVAGE VALUE WITH SOLAR	(d) CUMULATIVE SAVINGS	(e) ADJUSTED INCREASED INVESTMENT COSTS WITH SOLAR	(f) CUMULATIVE SAVINGS MINUS INVESTMENT COST	(g) SPB (Value of Col. (a) When Col. (f) Becomes Positive)

[a]To provide a quick-to-compute, though rough, measure of simple payback, it is assumed that cash flows are uniform even though this ignores annual changes in energy prices.

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8. EVALUATING SHARED ENERGY SAVINGS CONTRACTS

8.1 DESCRIPTION

The National Energy Conservation Policy Act (42 U.S.C. 8201) was amended in 1986 by P.L. 99-272 to authorize Federal agencies to enter into contractual arrangements with private organizations for privately funded energy conservation projects in Federal facilities.[1] Contracts negotiated under provisions of the amendment would have private contractors incur the costs of implementing energy conservation in Federal facilities in return for a share of the resulting savings.

Costs to be incurred by the contractor would include costs incurred in making energy audits, acquiring and installing equipment, and training personnel. Savings to be shared would be energy savings directly resulting from implementation of such conservation measures during the term of the contract.

Energy savings are to be calculated as a reduction in the cost of energy from a base cost established through a methodology set forth in the contract. Energy savings may result from "(A) the lease or purchase of operating equipment, improvements, altered operation and maintenance, or technical services; or (B) the increased efficient use of existing energy sources by cogeneration or heat recovery." Contracts for shared savings may be negotiated for "an existing Federally owned building or buildings or other Federally owned facilities."

8.2 REQUIREMENTS FOR ECONOMIC EVALUATION

Because shared-savings projects are privately funded, they are evaluated somehwat differently from the standpoint of the government than Federally funded projects. First, there are no investment costs to the Federal agency. Second, the benefits (savings) to the government depend not only on the performance of the project, but on the specific terms of the contract, which may vary from one instance to another. Despite these differences, the economic analysis methods presented in this Handbook are useful for addressing economic issues arising in conjunction with shared-savings projects. The purpose of this section is to discuss briefly requirements for economic analysis by contractors and Federal agencies.

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[1]Consolidatd Omnibus Budget Reconciliation Act of 1985, Title VII--Energy and Related Programs, Subtitle C--Federal Energy Conservation Shared Savings, P.L. 99-272.

8.2.1 Evaluating Shared-Savings Projects from the Standpoint of the Private Contractor

The economic questions faced by the private contractor are similar to those asked by a Federal agency considering a Federally funded project: Does the project offer an acceptable return to the investor? What project or set of projects (including project design and size alternatives) offers the best return to the investor for the available budget?

The economic evaluation methods needed by the private contractor are also essentially the same as those needed by a Federal agency evaluating a Federally funded project, with two exceptions: The private contractor requires that the economic evaluation methods include tax treatment. And, the private contractor may prefer a rate-of-return method, which is not required for Federal evaluations. Both of these requirements are provided for in Comprehensive Guide for Least-Cost Energy Decisions, the private-sector version of this Handbook.[1]

There are important differences in data which a private contractor would use in a project evaluation as compared with data which a Federal agency would use to evaluate a Federally funded project. Differences include the following: (1) Private contractors may use a discount rate different from the 7 percent mandated rate used for Federal analyses, because the private investor's minimum acceptable rate of return on the investment may differ from 7 percent. (2) Private contractors may respond to risk differently than Federal agencies, and this may be reflected in cash flow estimates, as well as in the discount rate. (3) Private contractors will be concerned with that share of energy savings which is revenue to them, whereas a Federal agency would be concerned with all of the energy savings accruing from a Federally funded project. (4) Private contractors may have a different time horizon than a Federal agency. (5) A private investor may choose to use energy price projections different from those used by Federal agencies. (6) Prices of labor, materials and the relative efficiencies with which resources are used may differ. (7) All benefits and costs to the private contractor are dependent on the specific terms of the contractural agreement. For example, if the contract calls for vesting of capital equipment to the government at a specified time, this will affect the capital costs to the contractor, as well as the contractor's time horizon. For these reasons, it is unlikely that a private contractor would arrive at the same investment recommendations or decisions for retrofitting a given government facility as would the Federal agency.

8.2.2 Evaluating Shared-Savings Projects from the Standpoint of the Federal Agency

As authorized legislatively, shared-savings projects entail no investment costs to the government, and offer lower future costs. Hence, they are by

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[1]Rosalie T. Ruegg and Stephen R. Petersen, Comprehensive Guide for Least-Cost Energy Decisions.

definition "cost effective" from the government's perspective, in the sense of saving more than they cost.[1] They offer a clear advantage to Federal agencies over the alternative of making no energy conservation investment.

A further question is as follows: Is a given shared-savings contract more advantageous to the government than a Federally funded solution to the same energy consumption problem? To answer this question, a comparison is needed of the estimated net savings to the government from a specific Federally funded energy conservation project and the contractural alternative. The comparison should take into account any differences in the expected timing with which the two approaches could be implemented. For example, if the contractural approach could be implemented immediately, but the in-house approach would be delayed until a future year's budget cycle, this difference in timing should be reflected in a comparative analysis.

Where a comparison of the economic advantages to the government of the two approaches is desired, it is recommended that Federal agencies use the Net Savings Method described in section 2.2.2. In order to reflect delays in Federal funding, it will be necessary to relax the assumption that all investment costs occur as a lump-sum amount at the beginning of the base year (see section 3.6).

If budgetary or other constraints preclude a Federally funded approach, the contractural approach offers clear advantages. If a private organization can undertake an energy conservation project in a Federally facility, recoup its investment plus a profit, and turn the capital equipmment (and subsequent savings) over to the Federal agency before the time the agency could implement and recover costs on the same project, the private contractural arrangement will be advantageous to the government for long-lived projects. Entering into a privately shared savings contract may be a way to avoid either delay or inaction.

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[1]For purposes of this discussion, it is presumed that the methodology for establishing the baseline for computing energy savings and other aspects of the contractural arrangement can be successfully negotiated to provide savings to the government.

9. EVALUATING FEDERAL PROJECTS WHICH ARE NOT PRIMARILY FOR ENERGY CONSERVATION

This section demonstrates how to use the computational aids and data developed for the Federal Energy Management Program (FEMP) to evaluate certain "non-energy projects." First, the types of "non-energy projects" which can be treated are identified. Then, differences in the requirements for evaluating "non-energy projects" as compared with "energy projects" are listed. Limitations on using the FEMP computational aids and data for evaluating "non-energy projects" are pointed out, and, where feasible, techniques for overcoming the limitations are noted. Next, two problems are presented to illustrate the use of the FEMP computational aids and data in evaluating "non-energy projects." The first problem presented is quite simple and can easily be treated using the FEMP worksheets and data based on a 10 percent discount rate. The second problem entails a planning/construction period which delays the onset of energy and other operational costs, and extends past the 25 year study period. Several manipulations are required to use the FEMP worksheets and data to solve the second problem.

9.1 TYPES OF "NON-ENERGY PROJECTS" TREATED

Many projects, though not primarily energy conservation or renewable energy projects, have an energy cost component which should be included in their economic evaluation.[1] With several exceptions, such as water resources projects and capital asset leasing which have their own evaluation guidelines, most "non-energy" projects are subject to the guidelines of OMB Circular A-94, a copy of which is provided in Appendix H.[2] (Circular A-94 lists other types of decisions exempted from its scope.) The Federal LCC Rule, while largely compatible with the A-94 guideline, adds some specific requirements not found in A-94. These departures from A-94 are sufficient to warrant special attention when applying the FEMP computational aids and data to non-eneregy projects.

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[1] The Federal LCC Rule does not define exactly which projects are, and are not, primarily energy conservation or renewable energy projects, and, hence, subject to the Federal LCC Rule. Some Federal agencies, e.g., the U.S. Air Force, have defined conditions under which a project is to be considered an energy project; some agencies have left it to the discretion of the organizational unit performing the evaluation.

[2] Guidance for evaluating the economic performance of water resources projects are contained in Water Resources Principles and Standards, and capital asset leasing, in OMB Circular A-104, Evaluating Leases of Capital Assets, revised June 1, 1986.

9.2 DIFFERENCES IN REQUIREMENTS OF OMB CIRCULAR A-94 AND THE FEDERAL LCC RULE

Principal differences in the assumptions and options called for by Circular A-94 and those presented in this Handbook for evaluating Federal energy projects are listed below:

* The A-94 specified discount rate is 10% real (i.e., net of general price inflation), instead of the 7% real rate required by the Federal LCC Rule.

* A-94 does not specify a limit to the allowable study period, while the Federal LCC Rule limits it to 25 years.

* Since A-94 does not address use of DoE-energy price projections, their use is considered optional, whereas the Federal LCC Rule requires that these projections be used.

* Where there is a "reasonable basis for estimating such changes," A-94 allows inclusion of projected changes in the relative prices of any type of cost and/or benefit component, whereas the Federal LCC Rule applies this option only to the energy component.

* Circular A-94 does not specifically exclude treatment of a planning/ construction period which delays the onset of energy costs and other post-occupancy costs and benefits. Inclusion of a planning/construction period is ruled out of most analyses by the Federal LCC Rule, which calls for the assumption that investment costs occur as a lump sum at the beginning of the base year and that energy and other costs begin accruing at the end of the base year. An exception to this assumption may be needed to choose among mutually exclusive project alternatives with different implementation times, and to evaluate shared-savings contracts.

* Circular A-94 uses the full investment cost in calculating measures of economic performance, while the Federal LCC Rule provides for a 10 percent reduction in investment cost to reflect societal benefits of energy conservation not fully captured by market energy prices. (The 10 percent adjustment is currently under review.)

* Circular A-94 allows the discounting of cash flows to annual value, as well as present value, using mid-year discount factors, as well as end-of-year discount factors. The Federal LCC Rule requires discounting to present value, using end-of-year discount factors.

These are the key differences. Otherwise their requirements are essentially the same: Circular A-94, like the Federal LCC Rule, requires that all future costs be entered in constant dollars. Likewise, they are in agreement as to the time to which all future values should be discounted to present value--i.e., the beginning of the study period--and for both sets of guidelines, the year in which the evaluation is conducted is designated "the beginning of the study period." Circular A-94 refers to the beginning of the study period as the "time of the decision," while the Federal LCC Rule refers to it as the "base year, the year in which a life-cycle cost analysis is conducted." Since the purpose in conducting a life-cycle cost analysis is to make a decision, and since it is generally not sound practice to conduct an analysis now upon which to base a decision at some time significantly in the future, these two definitions are in agreement.

9.3 LIMITATIONS IN APPLYING FEMP COMPUTATIONAL AIDS AND DATA TO "NON-ENERGY PROJECTS"

As a result of the differences listed in section 9.2, there are some limitations in applying the FEMP computational aids and data to "non-energy projects." Four limitations (and how to overcome certain of them) are noted below:

Limitation (1): The worksheets (Appendix D) and UPW* discount factor tables (Appendix Tables B-1b through B-11b) do not provide explicitly for a planning/construction period and delayed occupancy.

This limiation can be overcome by modifying the calculation of energy costs, investment costs, and nonfuel annually recurring costs in the following ways:

(a) Present value energy costs. If the annual quantity of energy in the post-occupancy period is assumed constant, a delayed occupancy can be taken into account using the UPW* factors as follows: Subtract the UPW* factor for the end of the planning/construction period from the UPW* factor for the end of the study period, and use the difference as the UPW* factor in the sections of the worksheet for calculating present value energy costs. (Remember to use 10 percent UPW factors.) This technique is illustrated by sample problem #2, section 9.4.

If the annual quantity of energy in the post-occupancy period is expected not to be constant, a delayed occupancy can be taken into account by substituting the year-by-year energy calculation procedure described in Appendix G for the energy sections of the worksheets. In this case, the energy price indices and SPW factors should be matched with the years in which energy costs are expected to be incurred.

(b) Investment Costs. Compute present value investment costs by multiplying the scheduled amount in each year by the SPW factor for that year. (Remember to use 10 percent SPW factors.) Enter the total in line 1 of the investment cost section of the worksheets. This technique is illustrated in sample problem #2, section 9.4.

(c) Annually Recurring Costs (O&M). Subtract the UPW factor for the end of the planning/construction period from the UPW factor for the end of the study period, and use the difference as the UPW factor for computing the present value of annually recurring costs. (Remember to use UPW factors based on a 10 percent discount rate.) This technique is illustrated in sample problem #2, section 9.4.

(Note that the FBLCC computer program, described in Appendix E, allows for incorporation of a planning/construction period and delayed occupancy when run in its Circular A-94 mode.)

Limitation (2): DoE-energy price projections are limited to a 25-year period.

To allow extension of the study period to 30 years, the UPW* factors based on a 10 percent discount rate in Appendix B, Tables B-1b through B-11b, have been extrapolated an additional 5 years. The extension is based on the assumption that the average annual price escalation rate for years 20 through 25 will continue for years 25 through 30. (The SPW and UPW discount factors given for a 10 percent discount rate in Appendix Tables A-1 and A-2, respectively, are also extended to cover a 30-year study period to match the extended UPW* series.)

To extend the study period beyond 30 years, there are several approaches possible, none of which are supported by DoE energy price projection:

(a) SPW, UPW, and UPW* factors for the extended period can be obtained from another source and used as called for in the worksheets.[1]

(b) UPW* factors from Appendix B can be used to calculate present value energy costs over the part of the study period they cover (thereby using the DoE price projections), and UPW factors can be used to calculate present value energy costs in the remaining period. This can be done in either of two ways:

(1) Subtract the UPW factor for the last year covered by a UPW* factor from the UPW factor for the last year in the study period. By adding the difference to the UPW* factor for the preceding portion of the study period, a factor for the entire period is derived.

(2) Alternatively, derive the factor for the remaining years by multiplying the SPW factor for the 30th year times the UPW factor for the elapsed number of years beyond 30. This factor for the remaining years is then added to the UPW* factor for the preceding portion of the study period to derive a factor for the entire study period. For example, if the study period is 35 years, find the UPW factor for 5 years, multiply it times the SPW factor for year 30, and add the result to the UPW* factor for 30 years.

Implicit in this use of UPW factors to calculate present value energy costs in the period past 30 years is the assumption that energy prices in the extended period will change at about the same rate as prices in general. (This technique is illustrated in sample problem #2, section 9.4.)

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[1]Tables of SPW and UPW discount factors can be found in most engineering economics or financial analysis textbooks. An extensive set of SPW, UPW, and UPW* factors is published by the American Society for Testing and Materials (ASTM), Discount Factor Tables, Adjunct to ASTM Practice E 917. However, the UPW* factors published by ASTM are constructed for a range of constant integer escalation rates which are not consistent with the DoE projections. The ASTM Adjunct provides no guidance on trends in future energy prices. Their use constitutes a total departure from the FEMP energy data.

(Note that the FBLCC computer program run in its Circular A-94 mode allows the user to specify a study period of up to 50 years for "non-energy projects." Run in this mode, the program gives the user two options regarding future energy prices: (1) the option of using the DoE-projected rates of energy price change through the 25-year projection period and thereafter yearly rates of change specified by the user, or (2) the option of user-specified rates of change over the entire study period.)

Limitation (3): "Non-energy projects" may entail categories of costs and/or benefits, such as rental income or user fee revenue, not provided for by the worksheets or the FBLCC computer program. The worksheets and the computer program focus on the following categories: investment costs, energy costs, operating and maintenance cost, repair and replacement costs, and salvage values.

To use the worksheets to evaluate projects having categories of costs or benefits not included in the worksheets, it is necessary to prepare supplementary worksheets or attachments. To use the FBLCC computer program to evaluate projects having categories of costs or benefits not explicitly designated in the program, enter costs in the cost category with the most similar pattern of cash flows, and enter benefits as negative costs in the cost category with the most similar pattern of cash flows.

Limiation (4): The worksheets are designed to discount cash flows to present value, assuming end-of-year cash flows. Present values are used because they entail fewer computations and promote uniformity among agencies in the expression of results. An end-of-year cash flow model is used also to promote uniformity. (When price escalation is factored in, computation of present values is necessary before annual values can be calculated.)

Annual values can be easily computed from the present value results of the worksheets by applying a Uniform Capital Recovery factor (UCR) for the length of the study period and the 10 percent discount rate, to the present value amount.[1] If some other cash flow model is desired, this can be accommodated by substituting other discount factors for the end-of-year factors provided in Appendices A and B.[2]

(Note that the FBLCC computer program (Appendix E) computes both present values and annual values, with both based on the assumption of end-of-year cash flows.)

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[1]UCR discount factors are found in most engineering economics or financial analysis textbooks and also in the ASTM Discount Factor Tables.)

[2]See Circular A-94 (Appendix H) for an explanation of mid-year discount factors.

9.4 SAMPLE PROBLEM #1: SELECTING FLOOR COVERING FOR A NEW BUILDING DESIGN

9.4.1 Problem Statement

The facilities manager at a Federal facility in a mid-Atlantic state has identified two types of floor covering for employee lounges, either of which is expected to meet requirements for appearance and comfort: carpet and quarry tile. The desire is to select the covering which will be most cost-effective over the 30-year assumed life of the building. The coverings are expected to differ primarily in their service lives and in their maintenance requirements. A small difference is expected in their thermal qualities because the insulated floors are over an unheated space.

Data and assumptions are as follows:[1]

	Carpet	Quarry Tile
Floor Area to be Covered:	1,000 ft^2	1,000 ft^2
Installed Cost	\$3.20/ft^2	\$6.50/ft^2
Yearly Maintenance Cost	\$1.70/ft^2	\$0.85/ft^2
Quantity of Natural Gas for Space Heating (cooling is not required)	90,000 ft^3/yr	100,000 ft^3/yr
Base-year Price of Natural Gas	\$0.006/ft^3	\$0.006/ft^3
Expected Service Life	10 years	30 years

9.4.2 Problem Solution

The solution to this problem is shown in Exhibit 9.1. The problem is solved using the New Building Design Worksheets from Appendix D; SPW factors from Appendix A, Table A-1, 10 percent column; a UPW factor from Appendix A, Table A-2, 10 percent column, for 30 years; and a UPW* factor from Appendix B, Table B-4b, for 30 years. Since this is not an energy conservation project, investment costs are not subject to the 10 percent adjustment.

Quarry tile is found to be a more cost-effective choice for floor coverings than carpet. Over the 30-year study period, the quarry tile, with its estimated present value cost of \$23,444, is expected to cost \$5,550 less in present value dollars than the carpet, with its estimated present value cost of \$28,994. The savings from the quarry tile are due to its lower expected O&M costs, which are offset somewhat by higher expected investment costs and energy costs.

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[1]This is a hypothetical problem intended to demonstrate the use of the FEMP worksheets and data to solve a "non-energy project" extending past 25 years, rather than to suggest generalizable data or results.

EXHIBIT 9-1. NEW BUILDING DESIGN WORKSHEETS COMPLETED FOR TWO ALTERNATIVE BUILDING DESIGNS

IDENTIFYING INFORMATION

AGENCY: 1 Federal Agency

ADDRESS: Street Flag Court

City/County Charlotte

State North Carolina

DoE Region 4

PROJECT CONTACT: Name J. Cox

Position Facilities Manager

Telephone

BUILDING, FACILITY, OR SYSTEM DESCRIPTION: Office Building Complex Employee Lounges

Classification For Energy Charges

[ ] Residential

[X] Commercial

[ ] Industrial

Expected Building Facility, or System Life: 30 years

STUDY PERIOD: From 1985 (Base Year) To 2015 (End Year)

LENGTH OF STUDY PERIOD: 30 years

EXHIBIT 9-1. NEW BUILDING DESIGN WORKSHEETS

Instructions, Parts A & B

A. This part calculates the present value of energy costs. It is appropriate to use when (1) the annual physical quantity of energy required for the design is expected to remain about constant over the study period, and (2) the type(s) of energy are not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the choice of designs:

(1) Total annual quantity of energy to be purchased, expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1 through B-11. (Remember to use the 10% tables, B-1b through B-11b, for projects which are <u>not</u> primarily energy conserving.) For electricity only, if Agency prices are used and there are separate charge components <u>with</u> component escalation rates provided by the energy supplier, UPW* factors can be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Appendix B table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs.

B. This part calculates the investment costs for the building or system.

(1) Costs of initial planning, site acquisition, design, engineering, purchase and installation, all in base-year dollars. (Remember that Lines 2-4 below are not applicable to projects which are <u>not</u> primarily energy conserving.)

(2) Portion of amount in Line (1) which contributes to reducing energy consumption, in base-year dollars.

(3) Special adjustment factor to reduce energy conservation investment costs by 10%. It is intended to reflect estimated societal benefits from reducing the use of nonrenewable energy resources not adequately reflected by market energy prices.

(4) Line (4) = Line (1) - Line (3).

---

[1] Terms are defined in "Principal Definitions."

[2] Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$) only. If the quantity of energy in item A(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton of steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh ($=\$20.00/10^6$Btu x 3,412 Btu/kWh).

[3] See Table 2-3 for the formula for calculating UPW* factors.

EXHIBIT 9-1. NEW BUILDING DESIGN WORKSHEETS (Continued)

PARTS A & B

A. Calculating Energy Costs

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3)x(4)] PRESENT VALUE OF ENERGY COST
ELECTRICITY	______	$ ______	$ ______ BASE CHARGE=(1)x(2)	______	$ ______
			$ ______ DEMAND CHARGE	______	$ ______
			$ ______ TIME OF DAY CHARGE	______	$ ______
			$ ______ CONTRACT CAPACITY CHARGE	______	$ ______
			$ ______ OTHER CHARGE COMPONENT	______	$ ______
OIL		$	$		$
GAS	Carpet: 90,000 ft3 Quarry Tile: 100,000 ft^3	$ 0.006/ft^3	Carpet $540 Quarry Tile: $600	14.88	Carpet $8,035 Quarry Tile: $8,928
OTHER ______		$	$		$
TOTAL					Carpet: $8,035 Quarry Tile: $8,928

B. Calculating Investment Costs

	Carpet	Quarry Tile
(1) Estimated Investment Costs for the Building or System	$ 3,200	$ 6,500
(2) Amount of Investment Comprising Energy Conservation Expenditure	$ n.a.	$ n.a.
(3) Investment Cost Adjustment: Line (2) x 0.10	$ n.a.	$ n.a.
(4) Adjusted Investment Costs: (1) - (3)	$ n.a.	$ n.a.

n.a. = not applicable

EXHIBIT 9-1. NEW BUILDING DESIGN WORKSHEETS (Continued)

Instructions, Parts C-E

C. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs.

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2. (Remember to use a UPW factor for a 10% discount rate from Appendix Table A-2 for projects which are not primarily energy conserving.)

(3) Column (3) = Column (1) x Column (2).

D. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur, assuming end-of-year cash flows.

(2) "Base-Year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur in any year during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1). (Remember to use an SPW factor from Appendix Table A-1 for a 10% discount rate for projects which are not primarily energy conserving.)

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs.

(8) Column (8) = Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values.

E. This part calculates the total life-cycle cost (TLCC).

(1) Transcribe from Part A, Column (5) Total.

(2) Transcribe from Part B, item (4). (Item (1) will be used for projects which are not primarily energy conserving.)

(3) Transcribe from Part C, Column (3).

(4) Transcribe from Part D, Column (6) Total.

(5) Transcribe from Part D, Column (7) Total.

(6) Transcribe from Part D, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

EXHIBIT 9-1. NEW BUILDING DESIGN WORKSHEETS (Continued)

PARTS C-E

C. Calculating Annually Recurring, Nonfuel Operation and Maintenance (O&M) Costs

(1) Amount of Annually Recurring Costs in Base Year Dollars	X	(2) UPW Factor	=	(3) Present Value of Annually Recurring Costs
Carpet: $1,700 Quarry Tile: $ 850		9.43		Carpet: $16,031 Quarry Tile: 8,016

D. Calculating Nonannually Recurring, Nonfuel O&M and Repair Costs, Replacement Costs, and Salvage Values

(1) ELAPSED YEARS UNTIL OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M AND REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COST (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUE (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)x(5)] PRESENT VALUE OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
Carpet: 10		$3,200	0	0.39		$ 1,248	
Carpet: 20		$3,200	0	0.15		$ 480	
TOTALS					$ -	$ 1,728	$ -

E. Calculating the TLCC

		Carpet		Quarry Tile
(1) Present Value of Energy Costs: A(5) Total		$ 8,035		$ 8,928
(2) Present Value of Investment Cost: B(1)	+	$ 3,200	+	$ 6,500
(3) Present Value of Annually Recurring, Nonfuel O&M Costs: C(3)	+	$ 16,031	+	$ 8,016
(4) Present Value of Nonannually Recurring, Nonfuel O&M Repair Costs: D(6) Total	+	$ -	+	$ -
(5) Present Value of Replacement Costs: D(7) Total	+	$ 1,728	+	$ -
(6) Present Value of Salvage Values: D(8) Total	-	$ -	-	$ -
(7) TLCC of the New Building or System Design: (1) + (2) + (3) + (4) + (5) - (6)	=	$ 28,994	=	$ 23,444

9.5 SAMPLE PROBLEM #2: SELECTING DOORS FOR A NEW BUILDING DESIGN

9.5.1 Problem Statement

Construction on a new Federal office building in Los Angeles is planned to begin in 1988, with occupancy scheduled early in 1990. Approximately 50 percent of construction costs will be incurred in 1988 and 50 percent in 1989. Several design options are now being reconsidered, including the selection of the type of door to be used for four sets of entry doors. (The present, the time the design options are to be reevaluated, is assumed to be early 1987.) The building, once constructed, is expected to be used indefinitely.

The choice of doors is between automatic sliding doors, the type originally included in the design plans, and revolving doors. The automatic sliding doors are tempered glass with a bronze, 3/4" frame and a photo-electric control, powered by a 2 horsepower motor. The revolving doors are also tempered glass in a bronze frame. The choice is not expected to affect significantly the space conditioning requirements of the building. However, there is an energy cost associated with operating the photo-electric control system of the sliding doors, but none for operating the revolving doors.

Data and assumptions are as follows:[1]

	Automatic Sliding Door	Revolving Door
Number of Exterior Doors	4	4
Installed Cost	$65,000	$85,000
Yearly Maintenance		
Cleaning-labor	25	40
-materials	5	5
-equipment	5	5
Service*-labor	175	100
-materials	20	10
-equipment	10	5
Energy Consumption	3,000 kWh/yr	0
Base-year (1987) price of electricity	$0.06/kWh	-
Expected Life (without major replacement)	15 years	30 years
Replacements/timing	$32,500/15 years	$85,000/30

*Service for the automatic sliding doors consists of removing obstructions, cleaning track, and adjusting operating functions and servicing all moving parts every 6 months; and for the revolving doors, inspecting and cleaning pivot points every 6 months.

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[1]This is a hypothetical problem intended to demonstrate the use of the FEMP worksheets and data to solve a "non-energy project," rather than to suggest generalizable data or results.

A study period of 33 years is selected to accommodate a common multiple of the expected lives of the two types of doors of 15 and 30 years, respectively, plus the 3 year delay until construction is completed and the doors are installed.

9.5.2 Problem Solution

The solution to this problem is shown in Exhibit 9.2. The New Design Worksheets from Appendix D are used. Both door types are evaluated on the same worksheet, with the distinguishing labels "Sliding" and "Revolving."

Because this example entails several of the features which the FEMP worksheets and data tables were not designed to handle, techniques described in section 9.3 are used to facilitate the solution. The two features added to this example are a planning/construction period which delays occupancy, and a study period in excess of 30 years. An additional problem which arises if the DoE energy price projections are not updated annually is illustrated.

The 8.01 derived discount factor in Column (4) of Exhibit 9.2, Part A, is an estimate of the UPW* factor, derived as follows: First, to enable use of the sample UPW* factors from Appendix B, it is assumed that the energy price escalation rates from 1987 through 2017 are identical to those from 1985 through 2015. (Note that this problem only arises if up-to-date tables of UPW* factors are not available.) Second, to account for the 3-year delay, the UPW* factor for year 3, 2.63 is subtracted from the UPW* factor for year 30, 10.50, the residual, 7.87, being the estimated UPW* factor for the 27-year period 1990-2017 (i.e., 10.50 - 2.63 = 7.87). To complete coverage of the study period from 2017 to 2020, the simplifying assumption is made that over the last three years, energy prices will change at the same rate as prices in general, such that they will remain unchanged in constant dollars. This assumption enables the use of UPW factors. To treat the last three years, the UPW factor for year 30, 9.43, is subtracted from the UPW factor for year 33, 9.57, and the residual, 0.14, is added to the UPW* factor, 7.87. The resulting sum, 8.01, is a multiplier for finding the present value of energy costs beginning to accrue in 1990 and terminating in 2020.

To account for the delay in the on-set of annually recurring O&M costs, the UPW factor required in section C of the worksheet, 7.08, is derived as the residual of the UPW factor for 33 years, 9.57, and the UPW factor for 3 years, 2.49. (UPW factors for years in excess of 30 were obtained from the ASTM publication, Discount Factor Tables.)

The planning/construction period is also reflected in the calculation in section D, Columns (3) and (7), of replacement costs. The SPW factor for year 18, not 15, is used to discount the replacement cost because of the 3-year delay before the doors are placed in use.

EXHIBIT 9-2. NEW BUILDING DESIGN WORKSHEETS--Completed for Sample Problem #2: Selecting Doors

IDENTIFYING INFORMATION

AGENCY: General Services Administration

ADDRESS: Street Federal Center

City/County Los Angeles

State California

DoE Region 9

PROJECT CONTACT: Name B. E. Tripp

Position Architect

Telephone ______

BUILDING, FACILITY, OR SYSTEM DESCRIPTION: Federal Office Building -- Selection of Exterior Doors

Classification For Energy Charges

[ ] Residential

[X] Commercial

[ ] Industrial

Expected Building/Facility, or System Life: Indefinitely

STUDY PERIOD: From 1987 (Base Year) To 2020 (End Year)

LENGTH OF STUDY PERIOD: 33 Years

BEGINNING OF OCCUPANCY 1990

EXHIBIT 9-2. NEW BUILDING DESIGN WORKSHEETS

Instructions, Parts A & B

A. This part calculates the present value of energy costs. It is appropriate to use when (1) the annual physical quantity of energy required for the design is expected to remain about constant over the study period, and (2) the type(s) of energy are not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the choice of designs:

(1) Total annual quantity of energy to be purchased, expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1 through B-11. (Remember to use the 10% tables, B-1b through B-11b, for projects which are not primarily energy conserving. See footnote a, section A of the Worksheet, for an explanation of the derivation of UPW* for a period greater than 30 years.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors can be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Appendix B table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs.

B. This part calculates the investment costs for the building or system.

(1) Costs of initial planning, site acquisition, design, engineering, purchase and installation, all in base-year dollars. (Remember to discount future scheduled construction costs to present value before entering the amount in Line (1). Also recall that Lines 2-4 below are not applicable to projects which are not primarily energy conserving.)

(2) Portion of amount in Line (1) which contributes to reducing energy consumption, in base-year dollars.

(3) Special adjustment factor to reduce energy conservation investment costs by 10%. It is intended to reflect estimated societal benefits from reducing the use of nonrenewable energy resources not adequately reflected by market energy prices.

(4) Line (4) = Line (1) - Line (3).

---

[1]Terms are defined in "Principal Definitions."

[2]Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$) only. If the quantity of energy in item A(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton of steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (=$\$20.00/10^6$Btu x 3,412 Btu/kWh).

[3]See Table 2-3 for the formula for calculating UPW* factors.

EXHIBIT 9-2. NEW BUILDING DESIGN WORKSHEETS (Continued)

PARTS A & B

A. Calculating Energy Costs

TYPE	(1) ANNUAL QUANTITY OF ENERCY PURCHASED	(2) BASE-YEAR ENERCY PRICE PER UNIT	(3) BASE-YEAR ENERCY COSTS	(4) UPW* FACTOR	(5) [=(3)x(4)] PRESENT VALUE OF ENERGY COST
ELECTRICITY	Sliding: 3000 kWh Revolving: 0 kWH	$ 0.06/kWh	Sliding: $180 Revolving: $ 0 BASE CHARGE=(1)x(2)	(10.50-2.63) + (9.57-9.43)=8.01[a]	Sliding: $1,442 Revolving: 0
			$ ____ DEMAND CHARCE	____	$ ____
			$ ____ TIME OF DAY CHARCE	____	$ ____
			$ ____ CONTRACT CAPACITY CHARCE	____	$ ____
			$ ____ OTHER CHARCE COMPONENT	____	$ ____
OIL		$	$		$
CAS		$	$		$
OTHER ____		$	$		$
TOTAL					Sliding: $1,442 Revolving: 0

[a]UPW* for N = 30, from Table B-9b, is 10.50; UPW* for N = 3, from Table B-9b, is 2.63; the difference is the UPW* factor for a 27-year period, taking into account the 3-year delay in the on-set of energy costs. UPW for N = 33, from engineering economics text table, is 9.57; UPW for N = 30 is 9.43; the difference, 0.14, is the UPW factor for the last three years of the study period for which the UPW* table does not cover. See further discussion in text.

B. Calculating Investment Costs

	Present Value[a] Sliding	Revolving
(1) Estimated Investment Costs for the Building or System	$ 56,550	$73,950
(2) Amount of Investment Comprising Energy Conservation Expenditure	$ n. a.	n. a.
(3) Investment Cost Adjustment: Line (2) x 0.10	$ n. a.	n. a.
(4) Adjusted Investment Costs: (1) - (3)	$ n. a.	n. a.

[a]50% of construction costs are incurred in 1988 and 50% in 1989. $56,550 = ($32,500 x 0.91) + ($32,500 x 0.83); $73,950 = ($42,500 x 0.91) + ($42,500 x 0.83). n. a. = not applicable.

EXHIBIT 9-2. NEW BUILDING DESIGN WORKSHEETS (Continued)

Instructions, Parts C-E

C. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs.

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2. (Remember to use a UPW factor for a 10% discount rate from Appendix Table A-2 for projects which are not primarily energy conserving. See footnote a, section C of the Worksheet, and the text in section 9.5.2 for an explanation of the derivation of the UPW factor.)

(3) Column (3) = Column (1) x Column (2).

D. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur, assuming end-of-year cash flows.

(2) "Base-Year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur in any year during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1). (Remember to use an SPW factor from Appenix Table A-1 for a 10% discount rate for projects which are <u>not</u> primarily energy conserving.)

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs.

(8) Column (8) = Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values.

E. This part calculates the total life-cycle cost (TLCC).

(1) Transcribe from Part A, Column (5) Total.

(2) Transcribe from Part B, item (4). (Item (1) will be used for projects which are <u>not</u> primarily energy conserving.)

(3) Transcribe from Part C, Column (3).

(4) Transcribe from Part D, Column (6) Total.

(5) Transcribe from Part D, Column (7) Total.

(6) Transcribe from Part D, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

EXHIBIT 9-2. NEW BUILDING DESIGN WORKSHEETS (Continued)

PARTS C-E

C. Calculating Annually Recurring, Nonfuel Operation and Maintenance (O&M) Costs

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
Sliding: $240 Revolving: $165	X	(9.57-2.49)=7.08[a]	=	Sliding: $1,699 Revolving: $1,168

[a]The UPW factor for 33 years, 9.57, was taken from ASTM Discount Factor Tables.

D. Calculating Nonannually Recurring, Nonfuel O&M and Repair Costs, Replacement Costs, and Salvage Values

(1) ELAPSED YEARS UNTIL OCCURRENCE	(2) AMOUNT OF INVESTMENT COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COST (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUE (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)x(5)] PRESENT VALUE OF INVESTMENT & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
18[a]		Sliding: $32,500 Revolving: 0		0.18		Sliding: $5,850 Revolving 0	
TOTALS						Sliding: $5,850 Revolving 0	$

[a]Replacement is required after 15 years of use; hence, taking into accunt 3 years delay between beginning of study period and occupancy, the replacement is 18 years from beginning of study period.

E. Calculating the TLCC

		Sliding Doors		Revolving Doors
(1) Present Value of Energy Costs: A(5) Total		$ 1,442		$ 0
(2) Present Value of Investment Cost: B(1)	+	$ 56,550	+	$ 73,950
(3) Present Value of Annually Recurring, Nonfuel O&M Costs: C(3)	+	$ 1,699	+	$ 1,168
(4) Present Value of Nonannually Recurring, Nonfuel O&M Repair Costs: D(6) Total	+	$ -	+	$ -
(5) Present Value of Replacement Costs: D(7) Total	+	$ 5,850	+	$ 0
(6) Present Value of Salvage Values: D(8) Total	-	$ 0	-	$ 0
(7) TLCC of the New Building or System Design: (1) + (2)+ (3) + (4) + (5) - (6)	=	$ 65,541	=	$ 75,118

10. ISSUES TO CONSIDER

The purpose of this section is to address several issues which often arise in performing economic evalutaions, but which are not addressed by the Federal LCC Rule. These issues are (1) how to take into account interdependencies among building systems, which may arise if projects are partial substitutes for one another or complementary to one another, or if one is prerequisite to another; (2) what to do when selecting projects in order of their SIR's is incompatible with the budget; and (3) what to do when choices must be made among projects of variable design/size. The purpose of this section is to alert the analyst to these factors and to explain how to deal with them.

10.1 PROJECT INTERDEPENDENCIES

When selecting projects for a given building or facility, it is important to take into account possible interdependencies among the projects. Projects are interdependent if selecting one will affect the cost effectiveness of the other. Failing to take into account project interdependencies can result in poor decisions. Projects may be selected which appear to be cost effective but are not. Projects may be rejected which appear not to be cost effective but are. Projects may be oversized or undersized. More specifically, failure to take into account substitutability among projects can result in selection of projects which are not cost effective and which are oversized. Failure to take into account complementarity among projects can cause rejection or undersizing of cost-effective projects. Failure to account for the fact that some projects may not be cost effective when taken alone but may be prerequisite to projects which are cost effective, can result in over-or under-estimating of project cost effectiveness.

10.1.1 Project Substitutability

Substitutability exists among projects when having more of one project means needing less of another.[1] Projects may be direct substitutes in that they are alternatives for accomplishing the same task, or they may be indirect substitutes in that they are alternatives for accomplishing the same objective, but in different ways.

An example of direct substitutes is caulking to reduce draft around window frames versus applying well-fitted storm windows which also reduce draft around window frames. Either will reduce the building's energy load. But,

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[1]The distinction between substitutability and mutual exclusion is that some or all of substitutable alternatives may be taken whereas only one of mutually exclusive alternatives may be taken.

though they are substitute methods of reducing draft around window frames, they are not substitutes in other respects, and it is possible, and may be desirable, to have both.

An example of indirect substitutes is increasing the efficiency of the HVAC system versus improving the thermal integrity of the building envelope. The former lowers the requirement for purchased energy to meet the existing load. The latter lowers the existing load. Both contribute to the objective of reducing the building's energy consumption. Both may be selected. However, the energy savings from the higher efficiency system will be diminished if the thermal resistance of the exterior envelope is increased, and the energy savings of the more resistive envelope will be diminished if the higher efficiency system is installed.

The problem is to recognize when projects are to some extent substitutable, determine whether each remains cost effective if the other is selected, and, where there are size/design choices, determine which combination is most cost effective.

A straight-forward solution to the problem is to compute the building's TLCC for alternative combinations of substitutable projects which fit within the budget, adjusting for their interactions. The combination with the lowest TLCC, or, alternatively, with the highest aggregate NS, is most cost effective. Because of the number of repetitious computations entailed, this approach is facilitated by using a computer program. (The FBLCC computer program, at the time of this update, does not automatically adjust for interdependencies, but is helpful in performing multiple evaluations. The capability to adjust for project interdependencies is being added to the FBLCC program. Mathematical programming techniques can be applied to problems such as these which require simultaneous solutions across projects.)

Project SIR's can also be used as a guide to putting together combinations of suitable projects. Using the SIR approach, each project SIR is first computed as though each is independent of the others. In the first selection round, the project with the highest SIR is tentatively selected, and the SIR's on the remaining projects are recomputed taking into account acceptance of the first. In the second round, the project with the next highest SIR is tentatively selected, and the SIR's on the remaining projects are recomputed taking into account acceptance of the second project. In addition, the SIR on the first selected project is recomputed to make sure it doesn't fall below the acceptance point as subsequent projects are added. In the third round, the project with the next highest SIR is tentatively selected, and the SIR's on the remaining projects and on the previously selected projects are recomputed. This process goes on until there are no more substitutable projects (or increments to interdependent projects) having an adjusted SIR greater than 1.0 or until the budget has been exhausted.

The SIR approach is most useful and reliable when there are a limited number of projects. This is because accepting each successive project may change not only the SIR's for all the remaining projects or project sizes, but also the SIR's for preceding projects or project sizes which have already been tentatively accepted. If there are many substitutable projects being considered, having previously selected projects drop out of the selection sometimes requires substantial recomputations and can become confusing. In this case, the preceding approach--computing and comparing aggregate TLCC or NS for each alternative combination of substitutable projects--is recommended.

There follows an illustration of finding the optimal combination of substitutable projects, using first the aggregate TLCC approach and then the SIR approach. The problem is to find the combination of envelope modifications and heating system retrofits which will minimize the life-cycle costs of owning and operating a building, given the specified data and assumptions.

The retrofit options include three different kinds of envelope modifications: attic insulation, storm windows, and caulking the existing windows. There are four size alternatives for the attic insulation: R0-R11, R0-R19, R0-R30, and R0-R38, which by increments are: R0-R11, R11-R19, R19-R30, and R30-R38.[1] It is assumed that the degree of interdependence between the storm windows and caulking is strong. Storm windows are assumed to substitute completely for caulking, such that the benefits of caulking are lost if storm windows are added. Storm windows are assumed to provide additional benefits beyond those provided by caulking, such that storm window benefits are reduced, but not lost, if the windows are first caulked.

The retrofit options include only one option for the heating system: replacing the existing electric resistance heating system (efficiency = 1.0) with a heat pump (coefficient of performance (COP) = 2.0), where only one size and design option for the heat pump is considered. There is interdependence between this option and all of the envelope options.

It is assumed that the budget is sufficient to fund all of the options. The base price of electricity is $\$20/10^6$ Btu and the UPW* factor is 10.

The proposed modification and data (hypothetical) needed to determine the optimal combination is presented in Table 10-1, Part A. Each of the options is presented independent of the other options.

<u>Aggregate TLCC Approach:</u>

As described above, this approach calls for computing the aggregate TLCC of possible project combinations within the budget to find the one which will minimize the overall TLCC of the building.[2] The TLCC'S for some of the selection possibilities--each modification used alone--are already given in Table 10-1, Part A. To these are added the combinations of interest, in Table 10-1, Part B. (Note that it is possible at the outset by inspection of the data in Part A of the table to rule out certain possible combinations as not providing minimum TLCC. For example, since insulation is cost effective up to R30 and its cost effectiveness is not significantly affected by caulking or storm windows, we know we can eliminate from further consideration examining the sizes R11 and R19 in combination with storm windows and/or caulking. Since R38 is not cost effective used alone, it will not be cost effective used in combination with other modifications, and can also be eliminated.)

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[1]R = resistance level.

[2]Only those components of building LCC which will be affected by the decision need be included in the analysis.

Table 10-1, Part A. Combining Interdependent Projects: Data and Assumptions

Proposed Modifications	Annual Energy Purchased[a] (10^6 Btu) (1)	Incremental Investment Cost($)[b] (2)	Present Value Energy Costs($)[c] (3)	TLCC[d] (4)	Incremental SIR[e] (5)
None	50	0	10,000	10,000	-
Envelope					
R11 Attic Insulation	37.0	300	7,400	7,700	8.7
R19 " "	35.0	150	7,000	7,450	2.7
R30 " "	34.0	180	6,800	7,430	1.1
R38 " "	33.5	150	6,700	7,480	0.7
Storm Windows	47.0	200	9,400	9,600	3.0
Caulking Existing Windows	49.0	25	9,800	9,825	8.0
Heating System					
Heat Pump (COP = 2.0)	25	3,500	5,000	8,500	1.4

[a]Annual space heating load/heating system efficiency = annual energy purchased.

[b]The additional cost of having the specified modification versus not having it.

[c]50×10^6 Btu · \$20/10^6 Btu · 10 (UPW*) = \$10,000; 37×10^6 Btu · \$20/10^6 Btu · 10 (UPW*) = \$7,400, etc.

[d]TLCC need include only those building costs affected by the investment design under evaluation. TLCC = Present Value Energy Costs + Total Investment Costs required to achieve a given envelope modification. Because R11 is prerequisite to R19, total investment costs associated with R19 is the sum \$300 + \$150 = \$450. TLCC associated with R19 = \$7,000 + \$450 = 7,450.

[e]The SIR must be based on incremental savings and costs, not totals, when used to guide project decisions regarding size/design choices, because SIR's based on totals cannot be relied upon to signal cost-effective project increments. The incremental SIR for R19, for example, is computed as follows: SIR = $\$\Delta$ Energy Costs/$\$\Delta$Investment Costs = \$400/\$150 = 2.7.

Table 10-1, Part B. Combining Interdependent Projects: Minimization of Aggregate TLCC Approach

Proposed Modifications	Annual Energy Purchased (10^6 Btu) (1)	Incremental Investment Cost (2)	Present Value Energy Costs (3)	TLCC (4)
R30 Attic Insul./Storm Windows	31	830	6,200	7,030[a]
R30 Attic Insul./Caulking	33	655	6,600	7,255
R30 Attic Insul./Storm Windows/ Caulking	31	855	6,200	7,055
Caulking/Storm Windows	47	225	9,400	9,625
R11 Attic Insul./Heat Pump	18.5	3,800	3,700	7,500
R19 Attic Insul./Heat Pump	17.5	3,950	3,500	7,450
R30 Attic Insul./Heat Pump	17.0	4,130	3,400	7,530
R11 Attic Insul./Storm Windows/ Heat Pump	17.0	4,000	3,400	7,400
R19 Attic Insul./Storm Windows/ Heat Pump	16.0	4,150	3,200	7,350
R30 Attic Insul./Storm Windows/ Heat Pump	15.5	4,330	3,100	7,430

[a]Most cost-effective combination.

Searching through Column (4) of Table 10-1, Parts A and B, we find that the lowest TLCC is for the combination of insulating to a level of R30 and adding storm windows.

Incremental SIR Approach:

As described above, this approach calls for a series of rounds of ranking projects, and increments to projects according to their incremental SIR's, each time adjusting SIR's for additional projects selected. Table 10-2 shows four rounds of selection, ending with the same optimal combination--attic insulation to a level of R30 and storm windows--as was determined using the aggregate TLCC approach.

In the first selection round, R11 attic insulation is chosen because its SIR is highest. The SIR of the heat pump is reduced accordingly. In the second round, caulking, with the highest SIR of remaining modifications, is selected, and the SIR's of the storm windows and heat pump are reduced. In round three, attic insulation is increased to R19, and the heat pump is dropped from consideration because the SIR falls below 1.0. In the final round, four, storm windows are selected, causing the SIR of caulking to fall below 1.0 and to be dropped from the tentative list of selected projects. At this point, only one additional decision remains--whether to increase attic insulation to R30. Since the SIR on the increment of R19-R30 exceeds 1.0, and since its selection is not affected by the storm windows and does not affect the preceding selections, it is also accepted in the fourth round.

10.1.2 Prerequisite and Complementary Projects

Project A is prerequisite to Project B if B cannot be accepted unless A is also accepted. This relationship can also be expressed by saying that acceptance of Project B is contingent upon the acceptance of Project A. The addition of wall insulation past a certain level, for example, may be physically impossible unless the size of the wall cavity is changed. Incorporating solar energy into a new bulding design may be contingent on selecting a particular building site.

The prerequisite project evaluated alone may not appear to be cost effective. Conversely, the project which is contingent upon the other may appear more cost effective than it actually is if the prerequisite is not taken into account. It is necessary to take them together and evaluate their combined cost effectiveness in order to make a decision about either.

Projects may complement one another without one being prerequisite to the other. Projects are complements if accepting one enhances the net cash flows of the others, such that in combination, their total net benefits are greater than the sum of their individual net benefits. This may result because costs are shared among the projects or because benefits are increased, or both. For example, a passive solar energy project might complement a noise reduction project if both make use of increased wall mass. A window replacement project for energy conservation might complement a rehabilitation project. Power generation and solid waste disposal can be complementary efforts. Evaluating such projects independently of synergistic effects is to understate their economic merit.

Table 10-2. Combining Interdependent Projects: Sequential SIR Selection Approach

		Incremental Investment Cost (1)	Present Value Incremental Energy Savings (2)	Incremental SIR (3)
<u>Round 1</u>				
Tentative Selection:	R11 Insulation	300	2,600	8.7
Remaining Projects:	Caulking	25	200	8.0
	Storm Windows	200	600	3.0
	R11-R19 Insulation	150	400	2.7
	R19-R30 Insulation	180	200	1.1
	Heat Pump	3,500	3,700	1.1
<u>Round 2</u>				
Tentative Selection:	R11 Insulation	300	2,600	8.7
	Caulking	25	200	8.0
Remaining Projects:	Storm Windows	200	400	2.0
	R11-R19 Insulation	150	400	2.7
	R19-R30 Insulation	180	200	1.1
	Heat Pump	3,500	3,600	1.0
<u>Round 3</u>				
Tentative Selection:	R11 Insulation	300	2,600	8.7
	R11-R19 Insulation[a]	150	400	2.7
	Caulking	25	200	8.0
Remaining Projects:	Storm Windows	200	400	2.0
	R19-R30 Insulation	180	200	1.1
	~~Heat Pump~~	~~3,500~~	~~3,400~~	~~1.0~~
<u>Round 4</u>				
Final Section:	R11 Insulation	300	2,600	8.7
	R11-R19 Insulation	150	400	2.7
	R19-R30 Insulation	130	200	1.1
	Storm Windows	200	600	3.0
	~~Caulking~~	~~25~~	~~-~~	~~1.0~~

[a]The breakdown of the insulation modification by size increments is preserved even after tentative selection to allow for the possibility that part, but not all, of this modification might be later eliminated because of interdependencies with a subsequent selection.

10.2 SELECTING PROJECTS FOR FUNDING

The Federal LCC Rule designates the SIR measure as the indicator of project priority. Projects with SIR's equal to or greater than one are to be ranked in descending order of their SIR's and selected for funding until the budget is exhausted. The SIR is used for allocating energy conservation budgets because, if used correctly, it can be expected to result in the greatest dollar savings from the funds expended.[1] The purpose of this section is first to give a brief overview of how the SIR is used for project ranking, and then to explain how to overcome several difficulties which may arise in using the SIR to allocate budgets.

10.2.1 Ranking by SIR

The SIR ranking and selection procedure is illustrated in Figure 10-1. The graph shows projects arrayed in order of their priority with the selection of projects made in accordance with a limited budget. Six candidate projects, independent of one another, are depicted in the first year as cost effective by having SIR's of one or greater. However, the budget in that year allows for only the first three to be done. In the second year, the budget allows for the remaining three projects to be accepted. (Note that projects not previously selected should be reevaluated if there is reason to think their SIR's may have changed significantly.) A new candidate Project (G) is omitted because the budget is insufficient to allow funding of all the available cost-effective projects in that budget cycle, and Project G has a lower SIR than the other candidate projects.

10.2.2 Submitting Interdependent Projects for Funding Approval

In the above illustration, it is assumed that all of the projects ranked for funding approval are <u>independent</u>, such that acceptance of one does not affect the cost effectiveness of another. One factor which must be taken into account in using SIR's for project selection and funding is project interdependence (see section 10.1). In submitting project proposals for review and approval by higher levels of management, it is important to make clear any interdependencies among projects.

In most cases, this can best be handled by grouping interdependent projects in sets, showing not only the economic performance measures for the individual projects within the set, but also for the set of projects taken together. It is important to compose project sets so that the sets are <u>not</u> interdependent with one another. The information on individual projects within a set should be preserved to allow selections from the set when budget limitations preclude funding all projects within a set (see section 10.2.3).

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[1]The SIR formulation adopted for the Federal Energy Management Program is designed to maximize the return to the capital budget.

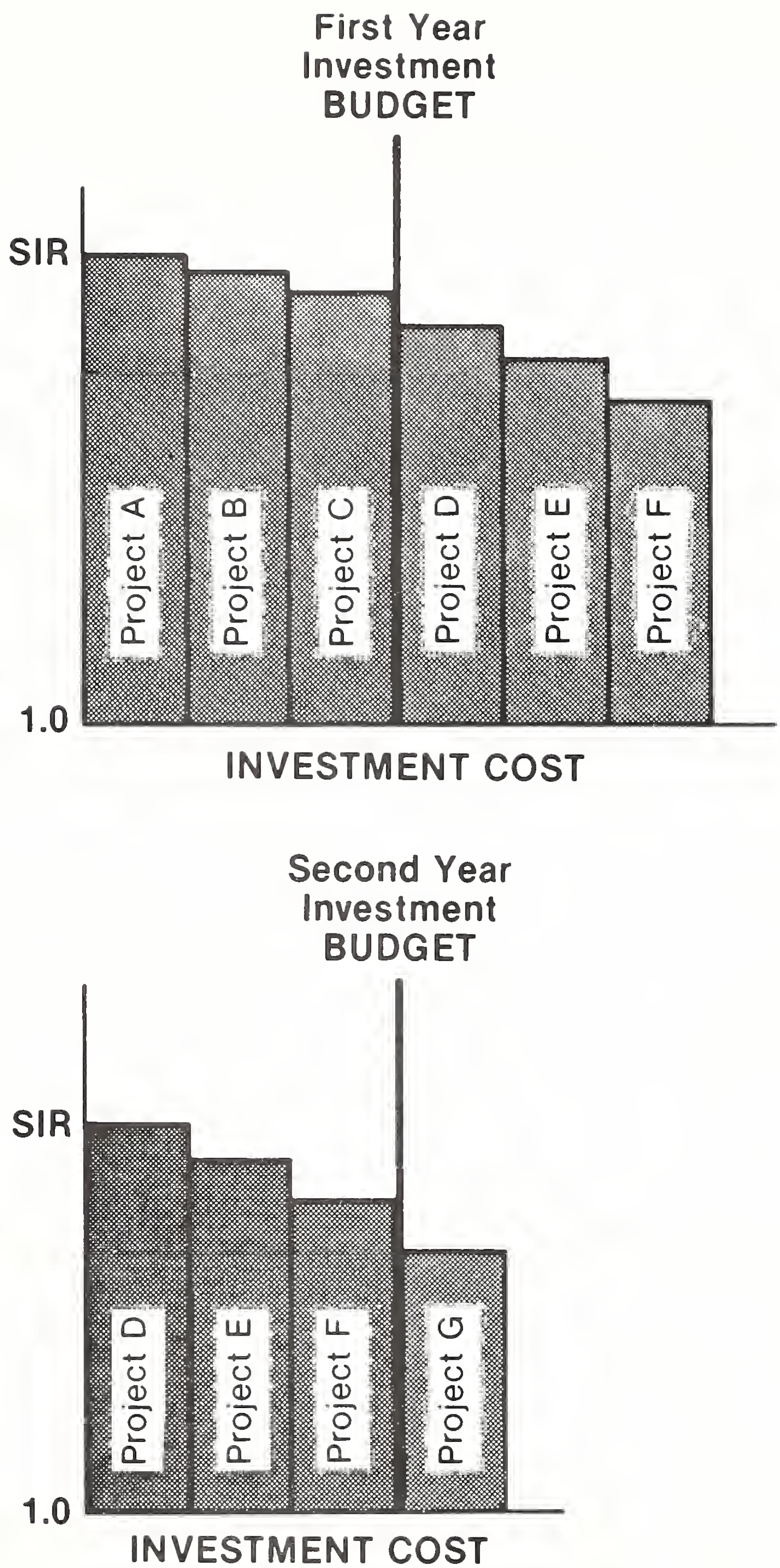

Figure 10-1. Allocating the Budget Among Alternative Projects Ranked by SIR

10.2.3 What to do When Project Costs Preclude Taking Projects in Order of Their SIR's

Selecting independent projects in descending order of their SIR's is conditional on a match between project costs and the budget which allows the budget to be exhausted by adhering to the SIR ranking. A close fit between project costs and budget is an underlying assumption of the illustration in Figure 10-1. But if project costs are "lumpy," such that the budget cannot be fully allocated by adhering to SIR rankings, it may be necessary to depart from the SIR rankings in order to select the group of projects which will maximize net savings from the total budget--the goal of the selection process. The purpose of this section is to illustrate this type of potential breakdown in the SIR selection process and to explain what to do when the problem arises.

Table 10-3 shows project investment costs, total savings, net savings (total savings net of project investment costs), SIR's (total savings/ first costs), and project rankings for seven independent projects (A, B, C...G). The project investment costs total almost $20 million. If the available budget were as much as $20 million, all of these projects would be accepted, because they all have positive net savings, and, hence, SIR's greater than 1.0.

But if a lesser budget were available--for example, only $10 million, it would be necessary to select from the seven candidates. Using the SIR ranking criterion to make the selection, we would choose Project E first (SIR = 12.5) and use $2.0 million of the budget. Next we would take Project F (SIR = 12.0) and use up another $3.0 million, for a total budget allocation of $5.0 million. Project G would be selected next (SIR = 9.0), for a total allocation of $6.0 million. Then we would look at the fourth-rated project, Project D (SIR = 8.0), and find that its cost, $10.0 million, when added to the costs of the projects already tentatively accepted, would exceed the budget. That would leave the following three options, the third not likely to be taken: (1) skip over Project D and continue selecting projects whose costs fit within the budget, (2) drop the preceding projects tentatively selected and accept only Project D, and (3) follow the SIR ranking guide as far as possible and leave unspent the remaining budget.[1]

Keeping in mind the objective--selecting the group of projects which maximizes net savings for the available budget, we would compare the net savings of these three options: Option 1, skipping over Project D, allows us to take all the other projects, for a total net savings of $83.1 million. Option 2, dropping the preceding projects and accepting only project D, results in net savings of $70.0 million. Option 3, taking Projects D, F, and G, and leaving the remaining budget unallocated, results in net savings of $33.5 million.

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[1]According to accepted practice in capital budget analysis, unspent funds are assumed to earn the required rate of return, such that additional net savings from the unallocated funds are zero.

Table 10-3. "Lumpiness" in Project Costs Can Necessitate Divergence from Budget Allocation by SIR

Projects	Investment Costs ($1 Million)	Total Savings ($1 Million)	Net Savings ($1 Million)	SIR	Ranking (No Budget Constraint)
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		

OPTIONS WITHIN BUDGET OF $10 MILLION:	(1) SELECT ALL PROJECTS EXCEPT D	(2) SELECT ONLY PROJECT D	(3) SELECT PROJECTS E, F, G ONLY
Expenditure (Million):	$ 9.8	$10.0	$ 6.0
Net Savings (Million):	$83.1	$70.0	$33.5

10.2.4 Allocating a Budget Among Projects of Variable Designs and Sizes

Section 2.3 recommends the use of the TLCC and NS methods for designing and sizing projects. The recommended guideline is to choose the design or size of a project which results in the lowest TLCC or the highest NS for the building while satisfying other performance requirements. It is explained in section 2.3 that this approach of designing/sizing individual projects without regard to the budget constraint is appropriate as a general guideline for the Federal Energy Management Program because of the Program's long-run goal to make all Federal buildings life-cycle cost effective with respect to their energy usage and the on-going nature of the effort.

There are, however, conditions under which this guideline will not maximize net savings. When funds are limited, upgrading the design or increasing the size of variable-design/size projects may mean choosing fewer total projects. The incremental return from upgrading certain projects may be greater or less than the average return on projects excluded or delayed as a consequence of that upgrade. In this case, the design/sizing problem and the project selection problem are inseparable, and a simultaneous solution is required in order to obtain maximum net savings from the available budget.

The purpose of this section is to clarify the conditions under which the design/sizing guideline given in section 2.3 is reliable, and the conditions under which alternative guidelines will perform better. This is done by examining how well alternative approaches to project design/sizing and selection perform under alternative budgetary conditions.

The budgetary conditions considered are the following:

(1) No budget constraint.

(2) A single, limited budget.

(3) A series of budgets, each limited in amount.

The approaches to project design/sizing and selection which are examined are the following:[1]

(1) Select all cost-effective projects and increments to projects which lower the building's life-cycle costs (i.e., those which offer positive net savings).

(2) Make project increments compete with projects in the budget allocation process, by selecting projects and project increments in descending order of their incremental SIR's.

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[1]Throughout this discussion, it is to be understood that interdependencies among projects must be taken into account, regardless of the budgetary condition or the approach taken to designing, sizing, and selecting projects.

(3) Design/size individual projects following the guideline of minimizing TLCC or maximizing NS for each project, and then, as a second step, select from among the pre-designed/sized projects in descending order of their SIR's.

(This third approach is that recommended in section 2.3.)

Table 10-4 summarizes in matrix form the combinations of budgetary conditions and approaches to designing, sizing, and selecting projects which are examined here, and indicates the example below which illustrates each combination.

The conditions under which the design/size guideline of section 2.3 is appropriate are given. The conditions under which this guideline is not appropriate are identified. A more complete set of guidelines for designing and sizing projects under alternative budgetary conditions conclude this section.

Table 10-5 presents information used in the examples. It is assumed that there are six independent projects (A, B, C, D, E, and F) under consideration for funding. The table gives their investment costs, total savings, and net savings. Note that Project B is available in two sizes: B(1) which costs \$5,000 and saves \$15,000 and B(2) which costs \$6,000 and saves \$17,000. B(1) and B(2) are mutually exclusive alternatives in that only one of the sizes can be selected. It is further assumed that the investment costs of Project B in either size has a component of fixed costs of \$1,000, which would be re-incurred if the smaller size of B were selected, put in place, then upgraded to the larger size at a later time; i.e., it will cost \$1,000 to upgrade B(1) to B(2) if the upgrade is done during the initial selection process, but \$2,000 if the upgrade is done after B(1) is already put in place.

<u>Example A: No Budget Constraint--Select All Cost-Effective Projects and Increments to Projects</u>

We look at Table 10-5 to see if any of the projects or increments to projects are not cost effective. We see that Project C is estimated to save less than it costs. Therefore we reject it even though funding is sufficient to accept it. We see that the larger size of Project B, B(2), costs \$1,000 more than the smaller size, B(1), but saves \$2,000 more. Therefore we choose to accept Project B in size B(2). We accept the remaining projects, A, D, E, and F because they are cost effective, and the funding is available.

<u>Example B: Single Budget--Make Project Increments Compete with Projects in the Selection Process, Choosing Projects and Project Increments in Descending Order of Their Incremental SIR's</u>

Table 10-6 is used to illustrate this approach. Assume that we receive a one-time budget of \$20,000, with no expectation of additional funding. The objective is to maximize the net savings from spending the one-time budget of \$20,000 on projects selected from Table 10-5. We will accept Project B in its smaller size only if the SIR on the smaller size gives it the necessary ranking relative to the other candidate projects. We will upgrade Project B to its larger size only if the SIR on the incremental investment is sufficiently high relative to the other candidate projects to give the upgrade the necessary priority.

Table 10-4. Alternative Budgetary Conditions and Approaches to Designing, Sizing, and Selecting Projects

Approaches to Designing/ Sizing/Selecting Projects	Budgetary Conditions: No Budget Constraint	Single Limited Budget	Series of Budgets, Each Limited
Select All Cost-Effective Projects and Increments Projects	Example A	N.A.	N.A.
Make Project Increments Compete with Projects for Limited Funds Using Incremental SIR's	N.A.	Example B	Example D
Design/Size Projects Without Regard to the Budget Constraint, and Select Projects on the Basis of Their SIR's	N.A.	Example C	Example E

N.A. = not applicable.

Table 10-5. Designing/Sizing Projects When the Budget is Limited: Sample Data

Project Alternatives	Investment Costs ($)	Total Savings ($)	Net Savings ($)
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

Table 10-6. Making Increments in Project Design/Size Compete for Limited Funds: Case Illustration

Projects	Investment Costs ($)	Total Savings ($)	Net Savings ($)	Incremental SIR[a]	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

For $20K:	Select	Aggregate Investment Costs ($)	Aggregate Net Savings ($)
	A	12K	48.0K
	D	3K	9.0K
	B(1)	5K	10.0K
		$20K	$67.0K

[a]These SIR's are all incremental. For B(1)→B(2), the SIR is based on the additional costs and savings of B(2) relative to B(1). For each of the other projects the SIR is based on having the project as compared with not having it, i.e., there is no difference between the "total SIR" and the incremental SIR.

The rankings of the projects and project increments based on incremental SIR's are shown in Table 10-6. (Note that for the projects other than B, SIR's will be the same whether based on total costs and savings or on increments. This is because these projects are each compared with the null alternative of having no project, such that total costs and savings are the increments.) Project A with an SIR of 5.00 is first chosen, for an expenditure of $12,000. Project D with an SIR of 4.00 is next selected, for a cumulative expenditure of $15,000. Project B in size B(1), with an SIR of 3.00, is next selected, for a cumulative expenditure of $20,000. Because the budget is now exhausted, Project B is not upgraded to size B(2), and the remaining projects, E and F, are not selected. Net savings from the expenditure of $20,000 total $67,000.

Example C: Single Budget--Design/Size Individual Projects Prior to Project Competition for Funding: Then Select Projects in Descending Order of Their SIR's

Table 10-7 is used to illustrate this approach. Again assume that we receive a one-time budget of $20,000, with no expectation of additional funding. Following this approach, we design and size the projects prior to funding competition.

Because the net savings are higher for Project B in size (2) than in size (1), we submit B(2) for funding consideration. The smaller version, B(1), is dropped from further consideration. Now Project B in size B(2) is ranked relative to the other cost-effective projects on the basis of their SIR's. Project A is again selected first, for an expenditure of $12,000. Project D is again selected second, for a cumulative expenditure of $15,000. Project F with an SIR of 2.9 is selected next, for a cumulative expenditure of $20,000. Project B is not selected because the SIR computed on the project in size B(2), 2.83, is too low to compete successfully for available funds. Net savings from the expenditure of $20,000 total $66,500, lower by $500 than net savings obtained by the approach demonstrated in Example B. For allocating a single budget, the preceding approach out-performed this approach.

Example D: Multiple Budgets--Make Project Increments Compete with Projects in the Selection Process for Each Budget Allocation, Choosing Projects and Project Increments in Descending Order of Their Incremental SIR's

Now assume that we receive the budget of $20,000 this year, and expect to receive a budget of $14,000 next year, as well as additional budgets in subsequent years. The approach demonstrated here is essentially the approach of Example B repeated for each budget to be allocated.

We saw in Example B that the initial budget allocation led to the selection of Project B in size B(1). By the next budget allocation, Project B has already been carried out in size B(1). Further assume that available projects in this second budget cycle are those remaining in Table 10-5 after the selection of Projects A, D, and B(1), i.e., E, F, and the upgrade of B(1) to B(2).

To upgrade Project B from size (1) to size (2) will require that the fixed costs of $1,000 be re-incurred, in addition to the variable costs of $1,000 to achieve the larger size. The total costs of the upgrade of $2,000 equals the

Table 10-7. Designing/Sizing Projects Prior to the Competition for Funding: Case Illustration

Projects	Investment Costs ($)	Total Savings ($)	Net Savings ($)	Incremental 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 $20K:	Select	Aggregate Investment Costs ($)	Aggregate Net Savings ($)
	A	12K	48.0K
	D	3K	9.0K
	F	5K	9.5K
		$20K	$66.5K

estimated savings, eliminating any net savings. Hence we reject the upgrade. We select the remaining Projects, E and F, for a total expenditure of $13,000 of the $14,000 budgeted.[1] Resulting savings are $26,500 and net savings are $13,500.

In summary, from the initial budget of $20,000, we obtained net savings of $67,000, and from the second budget of $14,000, we obtained net savings of $13,500. Available funding over the two years totaled $34,000, and net savings totaled $80,500.[2]

<u>Example E: Multiple Budgets: Design/Size Individual Projects Prior to Project Competition for Funding; Then Select Projects in Descending Order of Their SIR's</u>

As in the preceding example, assume that we receive the budget of $20,000 this year, and expect to receive a budget of $14,000 next year. The approach demonstrated here is essentially the approach of Example C repeated for each budget to be allocated.

We saw in Example C that the initial budget allocation led to the selection of Projects A, D, and F. Project B was submitted for funding consideration in size B(2), but was not a successful competitor for funding. Therefore, Projects E and B(2) remain for possible funding in the second budget cycle.

When the $14,000 in new funding is received, Project B(2) is first selected because it has the highest SIR. Project E is also selected because its SIR is greater than 1.0. The total expenditure is $14,000, the resulting total savings are $29,000, and the net savings are $15,000.

From the initial budget of $20,000, we obtained net savings of $66,500, and from the second budget of $14,000, we obtained net savings of $15,000. Available funding over the two years totaled $34,000, and net savings totaled $81,500.[3] Taken over the two budget cycles, this approach of designing and sizing projects prior to the competition for funding, out-performed the approach of making project increments compete with projects in the competition for funding.

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[1]The $1,000 of budgeted funds unallocated is, according to accepted practice, assumed to earn the minimum required rate of return, and, hence, to add nothing to net benefits.

[2]Note that these amounts are slightly overstated because the time delay between budget cycles has not been reflected in the second-round amounts. Applying a discount rate of 7 percent to the second-round amounts would yield aggregate present values of $33,020 in funding, and $79,555 in net savings.

[3]Again total net savings is slightly overstated because the time delay between budget cycles has not been reflected in the computation of net savings for the second-round projects. Adjusting the funding and net savings to present value using a 7 percent discount rate results in a total funding of $33,020 and total net savings of $80,450.

Implications of Examples A-E:

* Identifying the appropriate budgetary perspective is central to determining the appropriate guideline for designing, sizing, and selecting projects.

* When the problem is to allocate a single budget for maximum return, it is necessary that increments of projects of variable design/size compete with projects in the budget allocation process. (This is the approach and budget condition demonstrated by Example B.)

* When the problem is to accomplish a goal through the allocation of a series of on-going budgets, taking an overly short-run view of the budget can cause underdesigning and undersizing of projects and in the long run lead to a lower return on total investment. In this case, a practical guideline is to design/size each project to minimum TLCC (or maximum NS) prior to the competition for funding. (This is the approach and budget condition demonstrated by Example D, and the guideline recommended in section 2.3.)

* When additional funds are anticipated, but with significant delays, the quantitative analysis of potential tradeoffs is needed to make project selections which will maximize the return on investment. The potential tradeoffs are between funding projects at lower levels and doing them sooner, versus funding them at higher levels and delaying them.

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APPENDIX A

SPW AND UPW DISCOUNT FACTORS FOR FINDING PRESENT VALUES OF FUTURE AMOUNTS

CONTENTS:

[Note: These SPW and UPW discount factors are given for both 7 percent and 10 percent discount rates. The factors based on 7 percent are for use in evaluating nonfuel amounts associated with energy conservation and renewable energy projects. The factors based on 10 percent are for use in evaluating nonfuel amounts associated with most other Federal projects (unless specifically exempted from the 10 percent rates).]

Table A-1. Single Present Worth (SPW) Factors--Multipliers for Computing Present Value of Nonannually Recurring Amounts, Such as Repair and Replacement Costs and Resale or Scrap Value[a]

Elapsed Years Before Future Amount Occurs (n)	SPW Factor (d = .07)	SPW Factor (d = .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	0.42	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[b]	
26		0.08
27		0.08
28		0.07
29		0.06
30		0.06

[a]The formula for finding the present value (P) of a future amount (F) that occurs in N years, given d discount rate, is the following:

$$P = F \cdot \frac{1}{(1 + d)^N} = F \cdot SPW_N \text{ Factor} .$$

[b]The extended series is provided for use in evaluating most Federal projects which are not energy conservation or renewable energy projects and, hence, not subject to the study period limit of 25 years.

Table A-2. Uniform Present Worth (UPW) Factors--Multipliers for Computing Present Value of Annually Recurring Amounts, Such as Rountine Maintenance Costs[a]

Number of Years Over Which Amount Recurs (n)	UPW Factor (d = .07)	UPW Factor (d = .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[b]	
26		9.16
27		9.24
28		9.31
29		9.37
30		9.43

[a]The formula for finding the present value (P) of an annually recurring uniform amount (A) over N years at d discount rate is the following:

$$P = A \cdot \frac{(1 + d)^N - 1}{d(1 + d)^N} = A \cdot UPW_N \text{ Factor} .$$

[b]The extended series is provided for use in evaluating most Federal projects which are not energy conservation or renewable energy projects and, hence, not subject to the study period limit of 25 years.

APPENDIX B

UPW* DISCOUNT FACTORS FOR FINDING PRESENT VALUES OF FUTURE ENERGY COSTS OR SAVINGS

Note: **These are <u>not</u> up-to-date UPW* factors for actual use in project evaluation.** They are presented solely to illustrate the LCC methods presented in this Handbook. To receive up-to-date UPW* factors for use in project evaluation, request the latest edition of National Bureau of Standards Report NBSIR 85-3273, "Energy Prices and Discount Factors for Life-Cycle Cost Analysis," from the U.S. Department of Energy, Office of the Assistant Secretary for Conservation and Renewable Energy, Federal Energy Management Program, CE 10.1, Washington, D.C., 20585.

CONTENTS:

Note: The UPW* factors incorporate both discounting and the projected rates of change in energy prices reflected in the price indices of Appendix C. To use them, multiply the UPW* factor for the appropriate region, sector, fuel type, and study period by the product of the base-year price of energy times the base-year quantity of energy. The result is an estimate of the present value of energy costs over the study period.

The use of the UPW* factors requires that both the type and the annual quantity of energy be unchanging over the study period. (For an alternative calculation approach which allows the type and quantity of energy to change after the base year, see Appendix G.)

The UPW* factors are calculated from the price indices of Appendix C as follows:

$$UPW^* = \sum_{j=i}^{SP} I(\text{Base-Year} + j)/(1+d)^j$$

where j = Counter used to designate each year, with $j = 1$ for the first year after the base year;

SP = Study period in years;

$I(\text{Base-Year} + j)$ = Projected fuel price index given in Tables Ca-1 through Ca-11 for the year 1985 + j; and

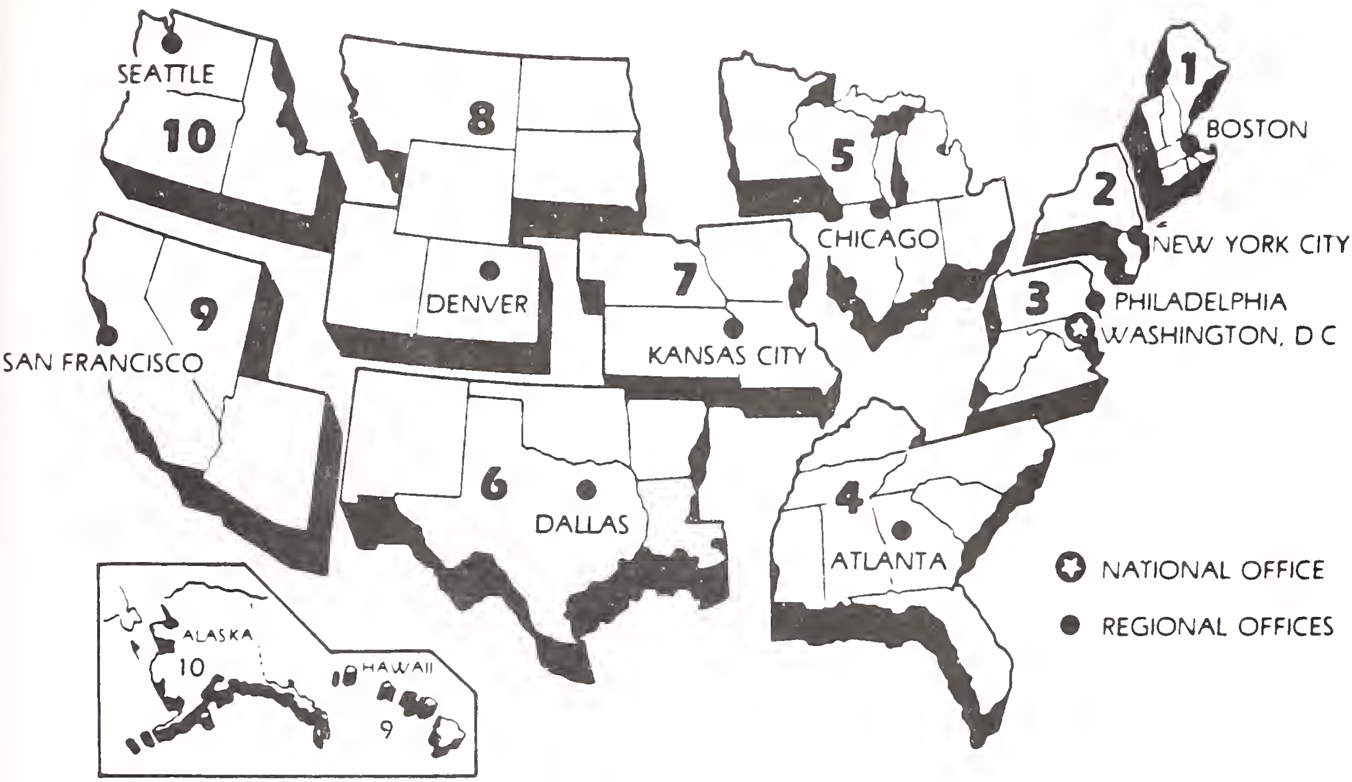
d = Discount rate, and

$(1 + d)^j$ = SPW factor for discount rate, d, and year, j.

Notation used in Tables B1-B11:

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

United States Federal Region Map



Region 1	- New England	- Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island
Region 2	- New York/ New Jersey	- New York, New Jersey, Puerto Rico, - Virgin Island;
Region 3	- Mid-Alantic	- Pennsylvania, Maryland, West Virginia, Virginia, District of Cloumbia, Delaware;
Region 4	- South Atlantic	- Kentucky, Tennessee, North Carolina, South Carolina, Mississippi, Alabama, Georgia, Florida;
Region 5	- Midwest	- Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio;
Region 6	- Southwest	- Texas, New Mexico, Oklahoma, Arkansas, Louisiana;
Region 7	- Central	- Kansas, Missouri, Iowa, Nebraska;
Region 8	- North Central	- Montana, North Dakota, South Dakota, Wyoming, Utah, Colorado;
Region 9	- West	- California, Nevada, Arizona, Hawaii, American Samoa, Guam;
Region 10	- Northwest	- Washington, Oregon, Idaho, Alaska.

Figure B-1. United States Federal Regional Map

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

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

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.94	0.92	0.92	0.93	0.94	0.91	0.93	0.93	0.94	0.94	0.91	0.93	0.93	0.95	0.91	1
2	1.85	1.77	1.77	1.84	1.85	1.77	1.81	1.84	1.84	1.86	1.77	1.81	1.87	1.84	1.77	2
3	2.74	2.60	2.60	2.73	2.74	2.60	2.66	2.74	2.68	2.76	2.59	2.66	2.79	2.69	2.58	3
4	3.56	3.39	3.39	3.61	3.56	3.39	3.47	3.63	3.48	3.58	3.39	3.48	3.72	3.49	3.36	4
5	4.32	4.16	4.16	4.47	4.32	4.16	4.26	4.52	4.25	4.34	4.16	4.28	4.65	4.26	4.10	5
6	5.02	4.90	4.91	5.32	5.02	4.93	5.08	5.40	4.98	5.06	4.93	5.06	5.58	4.99	4.82	6
7	5.68	5.64	5.64	6.16	5.68	5.68	5.78	6.28	5.67	5.72	5.68	5.82	6.50	5.68	5.52	7
8	6.31	6.36	6.36	6.98	6.31	6.41	6.50	7.15	6.33	6.35	6.42	6.56	7.41	6.34	6.21	8
9	6.89	7.05	7.06	7.78	6.89	7.13	7.20	8.00	6.95	6.94	7.14	7.28	8.31	6.96	6.88	9
10	7.43	7.74	7.74	8.55	7.43	7.84	7.87	8.82	7.54	7.49	7.85	7.97	9.18	7.56	7.52	10
11	7.95	8.40	8.40	9.31	7.95	8.53	8.53	9.63	8.10	8.01	8.55	8.65	10.03	8.12	8.14	11
12	8.43	9.04	9.04	10.04	8.43	9.19	9.17	10.41	8.63	8.50	9.22	9.30	10.87	8.65	8.74	12
13	8.89	9.66	9.66	10.75	8.89	9.84	9.79	11.18	9.13	8.97	9.88	9.94	11.69	9.15	9.31	13
14	9.33	10.26	10.26	11.44	9.33	10.47	10.40	11.92	9.61	9.41	10.53	10.56	12.50	9.63	9.85	14
15	9.74	10.84	10.84	12.11	9.74	11.08	10.99	12.64	10.05	9.84	11.16	11.17	13.29	10.08	10.38	15
16	10.13	11.40	11.40	12.75	10.13	11.67	11.56	13.34	10.48	10.23	11.77	11.75	14.05	10.50	10.88	16
17	10.50	11.95	11.94	13.38	10.50	12.24	12.11	14.02	10.88	10.61	12.36	12.31	14.80	10.90	11.36	17
18	10.84	12.47	12.46	13.98	10.84	12.79	12.65	14.67	11.25	10.96	12.93	12.85	15.53	11.28	11.82	18
19	11.17	12.97	12.96	14.57	11.17	13.31	13.16	15.31	11.60	11.30	13.49	13.38	16.23	11.63	12.26	19
20	11.47	13.45	13.44	15.13	11.48	13.82	13.66	15.92	11.94	11.62	14.02	13.88	16.92	11.96	12.67	20
21	11.76	13.92	13.91	15.68	11.76	14.32	14.15	16.52	12.25	11.91	14.55	14.38	17.59	12.28	13.08	21
22	12.02	14.38	14.36	16.21	12.03	14.80	14.62	17.10	12.54	12.19	15.06	14.85	18.24	12.57	13.46	22
23	12.27	14.82	14.80	16.72	12.28	15.27	15.08	17.66	12.82	12.44	15.55	15.32	18.88	12.85	13.83	23
24	12.50	15.25	15.23	17.22	12.51	15.73	15.52	18.20	13.08	12.68	16.04	15.77	19.50	13.11	14.19	24
25	12.72	15.66	15.64	17.70	12.72	16.17	15.96	18.73	13.33	12.90	16.51	16.20	20.10	13.36	14.54	25

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-2a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
DoE Region 2 (New York, New Jersey, Puerto Rico, Virgin Islands)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.92	0.92	0.92	0.94	0.92	0.91	0.93	0.93	0.95	0.92	0.91	0.93	0.93	0.95	0.91	1
2	1.81	1.78	1.78	1.82	1.80	1.77	1.81	1.82	1.84	1.80	1.77	1.81	1.83	1.85	1.77	2
3	2.66	2.60	2.60	2.67	2.66	2.59	2.66	2.66	2.68	2.67	2.59	2.66	2.70	2.71	2.58	3
4	3.45	3.39	3.39	3.50	3.45	3.39	3.48	3.49	3.49	3.47	3.39	3.49	3.56	3.52	3.36	4
5	4.17	4.16	4.16	4.31	4.17	4.17	4.27	4.30	4.25	4.19	4.16	4.29	4.41	4.29	4.10	5
6	4.84	4.90	4.90	5.10	4.84	4.93	5.04	5.09	4.96	4.85	4.93	5.07	5.25	5.03	4.82	6
7	5.45	5.64	5.63	5.87	5.45	5.69	5.79	5.87	5.64	5.47	5.68	5.84	6.07	5.72	5.53	7
8	6.02	6.35	6.35	6.62	6.02	6.43	6.52	6.63	6.29	6.03	6.42	6.58	6.87	6.38	6.21	8
9	6.55	7.05	7.04	7.34	6.55	7.15	7.22	7.37	6.89	6.56	7.15	7.30	7.66	7.01	6.88	9
10	7.04	7.72	7.72	8.05	7.04	7.87	7.91	8.09	7.47	7.05	7.86	8.00	8.43	7.60	7.53	10
11	7.51	8.38	8.38	8.74	7.51	8.56	8.57	8.80	8.01	7.52	8.55	8.67	9.17	8.16	8.15	11
12	7.96	9.02	9.01	9.40	7.96	9.23	9.22	9.48	8.53	7.96	9.23	9.33	9.91	8.69	8.75	12
13	8.38	9.64	9.63	10.05	8.38	9.89	9.85	10.15	9.02	8.38	9.89	9.98	10.63	9.19	9.32	13
14	8.77	10.23	10.22	10.67	8.77	10.52	10.46	10.79	9.48	8.78	10.54	10.60	11.33	9.67	9.87	14
15	9.15	10.81	10.80	11.28	9.15	11.14	11.06	11.43	9.92	9.16	11.17	11.21	12.02	10.12	10.39	15
16	9.51	11.37	11.36	11.87	9.50	11.73	11.64	12.04	10.33	9.52	11.78	11.79	12.69	10.54	10.90	16
17	9.84	11.91	11.90	12.44	9.84	12.31	12.20	12.63	10.71	9.85	12.37	12.35	13.35	10.94	11.38	17
18	10.16	12.43	12.41	12.99	10.15	12.86	12.73	13.20	11.08	10.17	12.94	12.90	13.98	11.32	11.84	18
19	10.45	12.93	12.91	13.52	10.45	13.39	13.26	13.75	11.42	10.47	13.50	13.43	14.60	11.67	12.27	19
20	10.73	13.41	13.39	14.04	10.73	13.91	13.76	14.29	11.75	10.76	14.03	13.93	15.20	12.00	12.69	20
21	10.99	13.88	13.85	14.53	10.99	14.41	14.25	14.81	12.05	11.02	14.56	14.43	15.79	12.32	13.10	21
22	11.23	14.33	14.30	15.01	11.23	14.90	14.73	15.31	12.34	11.27	15.07	14.91	16.36	12.61	13.48	22
23	11.46	14.77	14.74	15.48	11.46	15.37	15.19	15.80	12.61	11.50	15.56	15.37	16.92	12.89	13.86	23
24	11.67	15.20	15.16	15.93	11.67	15.83	15.64	16.28	12.86	11.71	16.05	15.82	17.46	13.15	14.22	24
25	11.87	15.61	15.57	16.37	11.86	16.27	16.08	16.74	13.10	11.91	16.52	16.26	17.99	13.40	14.56	25

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-3a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
DoE Region 3 (Pennsylvania, Maryland, West Virginia, Virginia, District of Columbia, Delaware)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.92	0.92	0.92	0.94	0.92	0.91	0.93	0.93	0.95	0.92	0.91	0.93	0.93	0.95	0.91	1
2	1.79	1.77	1.77	1.84	1.79	1.77	1.81	1.82	1.84	1.79	1.77	1.81	1.83	1.84	1.77	2
3	2.61	2.60	2.60	2.70	2.61	2.60	2.66	2.67	2.69	2.60	2.59	2.66	2.70	2.68	2.58	3
4	3.36	3.39	3.39	3.55	3.36	3.40	3.48	3.51	3.49	3.35	3.39	3.49	3.57	3.49	3.36	4
5	4.05	4.16	4.16	4.38	4.05	4.18	4.28	4.32	4.25	4.04	4.17	4.30	4.42	4.25	4.10	5
6	4.70	4.91	4.91	5.18	4.70	4.95	5.06	5.11	4.98	4.68	4.93	5.10	5.25	4.97	4.82	6
7	5.30	5.64	5.64	5.96	5.30	5.71	5.82	5.88	5.66	5.29	5.69	5.87	6.07	5.65	5.53	7
8	5.87	6.36	6.36	6.72	5.87	6.46	6.56	6.63	6.30	5.85	6.44	6.63	6.86	6.30	6.21	8
9	6.40	7.06	7.06	7.46	6.41	7.20	7.27	7.36	6.91	6.38	7.17	7.36	7.64	6.91	6.88	9
10	6.91	7.75	7.74	8.18	6.91	7.92	7.96	8.07	7.49	6.88	7.89	8.08	8.39	7.50	7.53	10
11	7.38	8.41	8.40	8.88	7.38	8.63	8.64	8.76	8.03	7.36	8.59	8.77	9.13	8.05	8.15	11
12	7.83	9.05	9.05	9.55	7.83	9.31	9.30	9.43	8.55	7.81	9.27	9.45	9.86	8.57	8.75	12
13	8.25	9.67	9.67	10.21	8.25	9.97	9.94	10.08	9.04	8.24	9.94	10.10	10.56	9.06	9.32	13
14	8.66	10.28	10.27	10.84	8.66	10.62	10.56	10.72	9.51	8.64	10.59	10.74	11.26	9.53	9.87	14
15	9.04	10.86	10.85	11.46	9.04	11.25	11.17	11.34	9.94	9.03	11.23	11.36	11.94	9.97	10.40	15
16	9.39	11.43	11.41	12.06	9.40	11.85	11.76	11.93	10.36	9.39	11.85	11.96	12.60	10.38	10.90	16
17	9.73	11.97	11.95	12.64	9.74	12.43	12.32	12.51	10.75	9.73	12.44	12.54	13.25	10.78	11.38	17
18	10.05	12.49	12.47	13.20	10.06	13.00	12.87	13.07	11.11	10.06	13.02	13.09	13.87	11.14	11.84	18
19	10.35	13.00	12.98	13.74	10.36	13.54	13.40	13.62	11.46	10.36	13.58	13.63	14.48	11.49	12.28	19
20	10.63	13.48	13.46	14.26	10.64	14.06	13.91	14.14	11.78	10.65	14.12	14.15	15.08	11.82	12.70	20
21	10.90	13.95	13.93	14.76	10.90	14.57	14.41	14.65	12.09	10.92	14.65	14.66	15.66	12.13	13.10	21
22	11.14	14.41	14.38	15.25	11.15	15.07	14.90	15.15	12.38	11.17	15.17	15.15	16.22	12.42	13.49	22
23	11.37	14.85	14.82	15.73	11.38	15.55	15.37	15.63	12.65	11.41	15.67	15.62	16.77	12.69	13.86	23
24	11.58	15.28	15.25	16.18	11.59	16.01	15.83	16.09	12.90	11.62	16.16	16.09	17.30	12.95	14.22	24
25	11.78	15.70	15.66	16.63	11.79	16.47	16.27	16.54	13.14	11.83	16.64	16.54	17.82	13.19	14.56	25

SAMPLE FACTORS

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-4a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
DoE Region 4 (Kentucky, Tennessee, North Carolina, South Carolina, Mississippi, Alabama, Georgia, Florida, Canal Zone)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.91	0.92	0.92	0.94	0.91	0.91	0.93	0.93	0.95	0.91	0.91	0.93	0.92	0.95	0.91	1
2	1.76	1.77	1.77	1.85	1.77	1.76	1.81	1.82	1.85	1.76	1.77	1.81	1.82	1.85	1.76	2
3	2.55	2.60	2.60	2.74	2.56	2.59	2.66	2.69	2.70	2.54	2.69	2.67	2.70	2.70	2.58	3
4	3.29	3.39	3.39	3.62	3.29	3.39	3.48	3.55	3.50	3.28	3.40	3.51	3.58	3.52	3.36	4
5	3.98	4.16	4.16	4.51	3.98	4.17	4.27	4.42	4.27	3.96	4.17	4.32	4.47	4.29	4.10	5
6	4.61	4.91	4.91	5.39	4.61	4.94	5.05	5.29	5.00	4.58	4.94	5.13	5.37	5.03	4.82	6
7	5.20	5.64	5.65	6.27	5.20	5.71	5.80	6.16	5.69	5.17	5.70	5.92	6.27	5.73	5.53	7
8	5.73	6.36	6.36	7.13	5.74	6.46	6.54	7.01	6.34	5.70	6.45	6.69	7.17	6.40	6.22	8
9	6.23	7.06	7.07	7.99	6.23	7.21	7.24	7.87	6.95	6.18	7.19	7.44	8.06	7.03	6.89	9
10	6.68	7.75	7.75	8.83	6.68	7.94	7.93	8.71	7.54	6.63	7.92	8.17	8.94	7.63	7.54	10
11	7.11	8.41	8.41	9.65	7.11	8.65	8.60	9.52	8.09	7.05	8.62	8.88	9.81	8.20	8.16	11
12	7.52	9.05	9.05	10.45	7.52	9.34	9.25	10.31	8.61	7.45	9.31	9.57	10.65	8.73	8.76	12
13	7.90	9.67	9.68	11.22	7.91	10.01	9.89	11.09	9.10	7.84	9.99	10.24	11.48	9.24	9.34	13
14	8.26	10.28	10.28	11.96	8.27	10.66	10.50	11.84	9.57	8.20	10.65	10.90	12.29	9.73	9.89	14
15	8.61	10.86	10.86	12.69	8.62	11.29	11.11	12.57	10.01	8.54	11.29	11.53	13.09	10.18	10.41	15
16	8.93	11.43	11.43	13.39	8.94	11.90	11.69	13.28	10.43	8.87	11.91	12.14	13.86	10.61	10.92	16
17	9.24	11.97	11.97	14.07	9.25	12.49	12.25	13.96	10.82	9.17	12.52	12.74	14.62	11.02	11.40	17
18	9.53	12.49	12.49	14.73	9.54	13.06	12.79	14.62	11.19	9.46	13.10	13.31	15.35	11.39	11.86	18
19	9.80	13.00	12.99	15.36	9.81	13.60	13.32	15.27	11.54	9.74	13.66	13.86	16.06	11.75	12.30	19
20	10.06	13.48	13.48	15.97	10.07	14.13	13.82	15.89	11.87	9.99	14.21	14.39	16.76	12.09	12.72	20
21	10.30	13.95	13.94	16.57	10.31	14.64	14.32	16.49	12.18	10.23	14.74	14.91	17.43	12.41	13.13	21
22	10.52	14.41	14.40	17.14	10.53	15.14	14.80	17.08	12.47	10.46	15.26	15.41	18.09	12.71	13.52	22
23	10.72	14.85	14.84	17.70	10.74	15.63	15.26	17.64	12.74	10.67	15.77	15.90	18.73	12.99	13.89	23
24	10.92	15.28	15.27	18.24	10.93	16.10	15.72	18.19	13.00	10.86	16.27	16.37	19.36	13.25	14.25	24
25	11.10	15.70	15.68	18.76	11.11	16.55	16.16	18.73	13.24	11.04	16.75	16.83	19.97	13.50	14.60	25

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-5a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
DoE Region 5 (Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio)

SAMPLE FACTORS

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.96	0.91	0.92	0.94	0.96	0.91	0.93	[illegible]	0.95	0.96	0.91	0.93	0.93	0.94	0.91	1
2	1.87	1.77	1.77	1.84	1.87	1.76	1.81	1.83	1.84	1.88	1.77	1.82	1.82	1.84	1.77	2
3	2.71	2.60	2.60	2.71	2.71	2.59	2.66	2.69	2.68	2.72	2.59	2.68	2.69	2.68	2.58	3
4	3.47	3.39	3.39	3.55	3.47	3.39	3.47	3.54	3.48	3.49	3.39	3.53	3.53	3.48	3.36	4
5	4.17	4.16	4.16	4.39	4.17	4.17	4.26	4.37	4.24	4.18	4.17	4.37	4.37	4.23	4.10	5
6	4.80	4.92	4.91	5.21	4.80	4.94	5.01	5.20	4.96	4.81	4.93	5.20	5.20	4.95	4.82	6
7	5.39	5.66	5.65	6.03	5.39	5.71	5.74	6.02	5.64	5.39	5.69	6.02	6.04	5.62	5.52	7
8	5.93	6.38	6.38	6.84	5.92	6.46	6.45	6.83	6.29	5.92	6.43	6.83	6.86	6.26	6.21	8
9	6.42	7.09	7.08	7.65	6.42	7.20	7.13	7.64	6.89	6.40	7.16	7.62	7.68	6.87	6.87	9
10	6.87	7.78	7.78	8.43	6.87	7.93	7.79	8.44	7.47	6.85	7.87	8.40	8.48	7.43	7.51	10
11	7.31	8.46	8.45	9.20	7.30	8.64	8.44	9.21	8.01	7.27	8.57	9.15	9.27	7.97	8.13	11
12	7.72	9.11	9.09	9.94	7.71	9.32	9.06	9.96	8.53	7.67	9.25	9.88	10.04	8.48	8.72	12
13	8.10	9.74	9.72	10.66	8.10	9.89	9.67	10.69	9.02	8.05	9.92	10.60	10.80	8.96	9.29	13
14	8.47	10.35	10.33	11.36	8.46	10.64	10.26	11.40	9.48	8.42	10.57	11.29	11.54	9.42	9.83	14
15	8.82	10.94	10.92	12.04	8.81	11.27	10.84	12.10	9.91	8.76	11.20	11.96	12.27	9.85	10.36	15
16	9.14	11.51	11.49	12.69	9.14	11.88	11.40	12.77	10.33	9.09	11.82	12.61	12.97	10.26	10.86	16
17	9.45	12.06	12.04	13.33	9.45	12.46	11.94	13.42	10.71	9.39	12.41	13.24	13.66	10.64	11.33	17
18	9.74	12.59	12.57	13.94	9.74	13.03	12.46	14.05	11.08	9.68	12.99	13.85	14.33	11.01	11.79	18
19	10.01	13.10	13.07	14.53	10.01	13.58	12.96	14.65	11.42	9.95	13.55	14.43	14.98	11.35	12.22	19
20	10.27	13.59	13.56	15.11	10.27	14.10	13.45	15.24	11.75	10.21	14.09	15.00	15.61	11.67	12.64	20
21	10.51	14.07	14.04	15.66	10.51	14.61	13.92	15.81	12.05	10.45	14.61	15.55	16.23	11.97	13.04	21
22	10.73	14.53	14.50	16.20	10.73	15.11	14.38	16.37	12.34	10.68	15.13	16.08	16.83	12.25	13.43	22
23	10.94	14.98	14.94	16.72	10.94	15.59	14.83	16.91	12.61	10.89	15.63	16.60	17.42	12.52	13.80	23
24	11.14	15.42	15.37	17.22	11.13	16.06	15.27	17.43	12.86	11.08	16.12	17.10	17.99	12.77	14.15	24
25	11.32	15.84	15.79	17.71	11.31	16.52	15.69	17.93	13.10	11.26	16.59	17.59	18.54	13.01	14.50	25

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-6a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
DoE Region 6 (Texas, New Mexico, Oklahoma, Arkansas, Louisiana)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.96	0.91	0.91	0.96	0.96	0.91	0.93	0.95	0.95	0.97	0.91	0.93	0.96	0.96	0.91	1
2	1.88	1.77	1.77	1.90	1.88	1.76	1.81	1.86	1.85	1.89	1.76	1.81	1.90	1.87	1.76	2
3	2.74	2.59	2.60	2.81	2.74	2.59	2.66	2.75	2.69	2.76	2.59	2.68	2.82	2.74	2.58	3
4	3.54	3.39	3.40	3.71	3.55	3.40	3.49	3.61	3.49	3.57	3.39	3.52	3.72	3.56	3.36	4
5	4.30	4.17	4.17	4.60	4.30	4.18	4.30	4.47	4.25	4.33	4.17	4.35	4.64	4.35	4.10	5
6	5.01	4.94	4.95	5.48	5.02	4.96	5.09	5.31	4.97	5.05	4.95	5.17	5.55	5.10	4.83	6
7	5.69	5.70	5.71	6.36	5.70	5.74	5.87	6.15	5.65	5.74	5.72	5.98	6.47	5.82	5.54	7
8	6.33	6.46	6.46	7.22	6.34	6.50	6.62	6.98	6.30	6.39	6.47	6.77	7.39	6.49	6.23	8
9	6.93	7.19	7.20	8.07	6.94	7.26	7.36	7.81	6.91	7.01	7.22	7.54	8.31	7.13	6.90	9
10	7.51	7.92	7.92	8.91	7.52	8.00	8.07	8.62	7.49	7.59	7.95	8.29	9.22	7.74	7.56	10
11	8.05	8.62	8.63	9.73	8.07	8.72	8.77	9.41	8.05	8.15	8.67	9.03	10.11	8.32	8.18	11
12	8.57	9.30	9.31	10.52	8.58	9.42	9.45	10.18	8.57	8.68	9.37	9.74	10.99	8.87	8.79	12
13	9.06	9.96	9.97	11.29	9.08	10.11	10.10	10.93	9.06	9.18	10.05	10.43	11.85	9.39	9.36	13
14	9.52	10.60	10.61	12.04	9.54	10.77	10.75	11.66	9.53	9.66	10.71	11.11	12.69	9.88	9.92	14
15	9.96	11.23	11.22	12.76	9.98	11.41	11.37	12.37	9.98	10.12	11.37	11.76	13.51	10.34	10.45	15
16	10.37	11.82	11.82	13.46	10.39	12.03	11.98	13.05	10.39	10.54	12.00	12.40	14.31	10.78	10.96	16
17	10.76	12.40	12.40	14.14	10.78	12.68	12.56	13.72	10.78	10.95	12.61	13.01	15.09	11.19	11.44	17
18	11.12	12.96	12.95	14.79	11.15	13.21	13.13	14.36	11.15	11.33	13.20	13.60	15.85	11.58	11.91	18
19	11.47	13.49	13.48	15.42	11.50	13.77	13.67	14.98	11.50	11.69	13.77	14.17	16.59	11.94	12.35	19
20	11.79	14.01	13.99	16.04	11.82	14.30	14.20	15.59	11.83	12.03	14.32	14.71	17.30	12.28	12.77	20
21	12.10	14.51	14.49	16.63	12.13	14.83	14.71	16.17	12.14	12.34	14.86	15.25	18.00	12.61	13.18	21
22	12.38	14.99	14.98	17.20	12.41	15.33	15.21	16.74	12.43	12.64	15.39	15.77	18.68	12.91	13.57	22
23	12.64	15.46	15.44	17.76	12.68	15.83	15.70	17.29	12.70	12.91	15.90	16.27	19.35	13.20	13.95	23
24	12.88	15.92	15.90	18.29	12.92	16.30	16.17	17.82	12.96	13.17	16.40	16.76	19.99	13.47	14.31	24
25	13.11	16.36	16.34	18.81	13.15	16.77	16.63	18.34	13.20	13.41	16.89	17.23	20.62	13.72	14.66	25

SAMPLE FACTORS

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-7a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
DoE Region 7 (Kansas, Missouri, Iowa, Nebraska)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.98	0.91	0.91	0.93	0.98	0.91	0.93	0.93	0.94	0.99	0.91	0.93	0.92	0.95	0.91	1
2	1.87	1.77	1.77	1.84	1.87	1.76	1.81	1.83	1.87	1.88	1.77	1.81	1.82	1.86	1.76	2
3	2.67	2.60	2.60	2.73	2.67	2.59	2.65	2.73	2.67	2.68	2.60	2.68	2.71	2.72	2.58	3
4	3.40	3.39	3.39	3.61	3.40	3.40	3.45	3.61	3.46	3.40	3.40	3.53	3.58	3.54	3.36	4
5	4.08	4.16	4.16	4.49	4.08	4.18	4.22	4.50	4.21	4.07	4.18	4.37	4.46	4.31	4.10	5
6	4.70	4.92	4.92	5.36	4.70	4.95	4.96	5.38	4.92	4.69	4.95	5.20	5.34	5.05	4.82	6
7	5.28	5.67	5.67	6.23	5.27	5.72	5.67	6.26	5.58	5.26	5.71	6.03	6.22	5.75	5.53	7
8	5.81	6.41	6.40	7.08	5.80	6.48	6.35	7.13	6.21	5.78	6.46	6.84	7.08	6.41	6.22	8
9	6.29	7.12	7.12	7.93	6.29	7.21	7.00	8.00	6.81	6.26	7.19	7.64	7.94	7.04	6.89	9
10	6.74	7.83	7.82	8.76	6.73	7.97	7.63	8.85	7.37	6.70	7.92	8.42	8.79	7.63	7.54	10
11	7.17	8.51	8.50	9.57	7.16	8.68	8.24	9.68	7.90	7.11	8.62	9.18	9.62	8.19	8.17	11
12	7.57	9.17	9.16	10.35	7.56	9.38	8.83	10.49	8.41	7.51	9.31	9.92	10.43	8.73	8.77	12
13	7.95	9.81	9.80	11.11	7.94	10.05	9.41	11.28	8.88	7.89	9.98	10.63	11.22	9.23	9.34	13
14	8.31	10.43	10.41	11.85	8.30	10.71	9.98	12.04	9.33	8.25	10.64	11.33	12.00	9.71	9.89	14
15	8.65	11.03	11.01	12.57	8.64	11.34	10.52	12.79	9.76	8.59	11.28	12.01	12.76	10.17	10.42	15
16	8.98	11.61	11.59	13.26	8.96	11.96	11.06	13.51	10.16	8.91	11.91	12.66	13.51	10.59	10.93	16
17	9.28	12.16	12.15	13.93	9.26	12.55	11.57	14.21	10.54	9.21	12.51	13.30	14.23	10.99	11.41	17
18	9.57	12.70	12.68	14.58	9.55	13.12	12.06	14.88	10.90	9.49	13.09	13.91	14.93	11.37	11.87	18
19	9.84	13.22	13.20	15.21	9.82	13.68	12.54	15.54	11.23	9.76	13.65	14.50	15.62	11.73	12.31	19
20	10.09	13.72	13.69	15.81	10.07	14.21	13.01	16.17	11.55	10.02	14.20	15.06	16.28	12.06	12.73	20
21	10.33	14.20	14.17	16.40	10.31	14.73	13.46	16.78	11.85	10.25	14.73	15.62	16.93	12.38	13.14	21
22	10.55	14.67	14.64	16.97	10.53	15.23	13.89	17.38	12.13	10.48	15.25	16.15	17.56	12.67	13.53	22
23	10.75	15.13	15.09	17.52	10.73	15.72	14.32	17.96	12.39	10.68	15.76	16.67	18.17	12.95	13.90	23
24	10.94	15.57	15.53	18.05	10.92	16.19	14.73	18.52	12.64	10.87	16.25	17.18	18.77	13.22	14.26	24
25	11.12	16.00	15.96	18.57	11.10	16.65	15.14	19.06	12.87	11.05	16.73	17.67	19.36	13.47	14.61	25

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-8a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
DoE Region 8 (Montana, North Dakota, South Dakota, Wyoming, Utah, Colorado)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.94	0.91	0.91	0.94	0.94	0.91	0.93	0.94	0.96	0.95	0.91	0.93	0.93	0.95	0.91	1
2	1.82	1.77	1.77	1.84	1.82	1.77	1.81	1.84	1.87	1.83	1.77	1.81	1.83	1.86	1.76	2
3	2.64	2.60	2.60	2.69	2.64	2.59	2.67	2.69	2.72	2.64	2.60	2.68	2.68	2.71	2.58	3
4	3.40	3.39	3.39	3.51	3.40	3.39	3.49	3.49	3.53	3.40	3.40	3.53	3.49	3.51	3.36	4
5	4.09	4.17	4.17	4.31	4.10	4.17	4.30	4.28	4.30	4.10	4.18	4.38	4.30	4.28	4.10	5
6	4.74	4.93	4.93	5.10	4.74	4.94	5.09	5.06	5.02	4.74	4.95	5.23	5.10	5.00	4.82	6
7	5.34	5.68	5.68	5.89	5.34	5.71	5.86	5.85	5.71	5.33	5.71	6.06	5.89	5.69	5.53	7
8	5.89	6.42	6.41	6.65	5.88	6.46	6.62	6.58	6.36	5.87	6.46	6.88	6.68	6.35	6.22	8
9	6.39	7.14	7.13	7.41	6.39	7.20	7.35	7.32	6.97	6.37	7.20	7.69	7.46	6.96	6.89	9
10	6.87	7.84	7.84	8.15	6.86	7.93	8.06	8.05	7.55	6.83	7.93	8.49	8.24	7.54	7.54	10
11	7.31	8.53	8.52	8.87	7.31	8.64	8.75	8.75	8.09	7.27	8.64	9.26	8.99	8.10	8.16	11
12	7.74	9.19	9.18	9.58	7.73	9.33	9.42	9.44	8.61	7.69	9.33	10.02	9.73	8.61	8.76	12
13	8.14	9.83	9.83	10.26	8.13	9.99	10.08	10.11	9.10	8.09	10.01	10.75	10.46	9.11	9.33	13
14	8.52	10.46	10.45	10.92	8.51	10.64	10.72	10.76	9.56	8.47	10.67	11.46	11.17	9.58	9.88	14
15	8.88	11.06	11.05	11.56	8.87	11.27	11.34	11.40	10.00	8.83	11.31	12.15	11.87	10.02	10.41	15
16	9.22	11.64	11.63	12.18	9.21	11.88	11.94	12.01	10.41	9.17	11.94	12.82	12.55	10.44	10.91	16
17	9.54	12.21	12.19	12.77	9.53	12.47	12.53	12.60	10.80	9.49	12.54	13.46	13.21	10.83	11.39	17
18	9.84	12.75	12.73	13.35	9.83	13.03	13.09	13.18	11.17	9.79	13.13	14.09	13.85	11.20	11.85	18
19	10.12	13.27	13.25	13.91	10.11	13.58	13.63	13.73	11.51	10.07	13.70	14.68	14.48	11.55	12.29	19
20	10.39	13.77	13.74	14.45	10.38	14.10	14.15	14.27	11.84	10.34	14.24	15.26	15.08	11.87	12.72	20
21	10.64	14.26	14.23	14.98	10.63	14.62	14.66	14.80	12.14	10.59	14.78	15.83	15.68	12.18	13.12	21
22	10.87	14.73	14.70	15.48	10.86	15.11	15.16	15.30	12.43	10.83	15.30	16.37	16.25	12.47	13.51	22
23	11.09	15.19	15.15	15.98	11.08	15.59	15.64	15.79	12.70	11.05	15.81	16.91	16.81	12.75	13.88	23
24	11.29	15.63	15.59	16.45	11.28	16.06	16.11	16.27	12.96	11.25	16.30	17.42	17.36	13.00	14.24	24
25	11.48	16.06	16.02	16.91	11.46	16.52	16.57	16.74	13.20	11.44	16.79	17.92	17.90	13.24	14.59	25

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-9a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
DoE Region 9 (California, Nevada, Arizona, Hawaii, Trust Territory of the Pacific Islands, American Samoa, Guam)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.99	0.91	0.91	0.91	0.99	0.91	0.93	0.89	1.04	0.99	0.91	0.94	0.90	0.95	0.91	1
2	1.92	1.77	1.77	1.79	1.92	1.76	1.81	1.74	2.01	1.93	1.76	1.82	1.77	1.85	1.76	2
3	2.77	2.60	2.60	2.64	2.77	2.59	2.65	2.54	2.93	2.79	2.59	2.68	2.59	2.69	2.58	3
4	3.57	3.39	3.39	3.52	3.57	3.40	3.47	3.36	3.81	3.58	3.39	3.51	3.44	3.49	3.36	4
5	4.32	4.16	4.16	4.40	4.32	4.18	4.26	4.17	4.65	4.34	4.17	4.32	4.28	4.25	4.10	5
6	5.02	4.92	4.92	5.27	5.02	4.96	5.02	4.96	5.45	5.04	4.95	5.12	5.10	4.96	4.82	6
7	5.68	5.66	5.66	6.13	5.69	5.73	5.77	5.72	6.21	5.71	5.71	5.89	5.92	5.65	5.53	7
8	6.32	6.39	6.39	6.97	6.32	6.50	6.49	6.47	6.93	6.35	6.47	6.65	6.72	6.29	6.22	8
9	6.92	7.11	7.11	7.81	6.92	7.25	7.18	7.19	7.61	6.96	7.22	7.38	7.51	6.90	6.90	9
10	7.49	7.80	7.80	8.62	7.49	8.00	7.85	7.88	8.26	7.54	7.95	8.09	8.27	7.48	7.55	10
11	8.03	8.48	8.48	9.41	8.04	8.72	8.51	8.56	8.88	8.09	8.67	8.78	9.03	8.03	8.18	11
12	8.55	9.13	9.13	10.18	8.55	9.42	9.16	9.22	9.47	8.61	9.37	9.45	9.76	8.55	8.78	12
13	9.03	9.77	9.77	10.93	9.04	10.10	9.77	9.86	10.03	9.10	10.05	10.11	10.49	9.04	9.36	13
14	9.49	10.38	10.38	11.65	9.50	10.77	10.37	10.49	10.55	9.57	10.72	10.74	11.19	9.50	9.91	14
15	9.93	10.98	10.97	12.35	9.93	11.41	10.96	11.10	11.05	10.02	11.37	11.36	11.89	9.94	10.44	15
16	10.34	11.56	11.55	13.03	10.34	12.03	11.53	11.68	11.52	10.44	12.00	11.96	12.56	10.36	10.95	16
17	10.72	12.11	12.10	13.69	10.73	12.63	12.08	12.25	11.96	10.84	12.61	12.53	13.22	10.75	11.44	17
18	11.09	12.64	12.63	14.32	11.10	13.21	12.61	12.81	12.37	11.22	13.21	13.09	13.86	11.12	11.90	18
19	11.43	13.16	13.14	14.94	11.44	13.76	13.12	13.34	12.76	11.57	13.78	13.62	14.48	11.46	12.34	19
20	11.75	13.65	13.63	15.53	11.76	14.30	13.62	13.86	13.13	11.91	14.33	14.14	15.09	11.79	12.77	20
21	12.05	14.13	14.11	16.10	12.07	14.83	14.10	14.36	13.48	12.22	14.87	14.64	15.68	12.10	13.18	21
22	12.33	14.60	14.58	16.66	12.35	15.33	14.57	14.84	13.81	12.51	15.40	15.13	16.25	12.39	13.57	22
23	12.59	15.05	15.03	17.20	12.61	15.83	15.03	15.32	14.11	12.78	15.91	15.61	16.81	12.66	13.94	23
24	12.84	15.49	15.46	17.72	12.85	16.30	15.47	15.77	14.40	13.03	16.41	16.07	17.35	12.91	14.31	24
25	13.06	15.92	15.88	18.23	13.08	16.77	15.90	16.22	14.67	13.27	16.90	16.52	17.88	13.15	14.65	25

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-10a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
DoE Region 10 (Washington, Oregon, Idaho, Alaska)

SAMPLE FACTORS

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.89	0.92	0.92	0.93	0.89	0.91	0.93	0.93	0.94	0.88	0.91	0.93	0.93	0.95	0.91	1
2	1.72	1.77	1.78	1.80	1.72	1.77	1.81	1.80	1.82	1.69	1.77	1.81	1.80	1.84	1.76	2
3	2.50	2.60	2.60	2.61	2.50	2.59	2.65	2.62	2.65	2.45	2.59	2.66	2.62	2.68	2.58	3
4	3.23	3.39	3.40	3.41	3.23	3.40	3.46	3.43	3.43	3.17	3.39	3.48	3.45	3.48	3.36	4
5	3.92	4.16	4.16	4.19	3.92	4.17	4.24	4.23	4.17	3.86	4.17	4.27	4.26	4.24	4.10	5
6	4.58	4.91	4.91	4.94	4.58	4.95	4.99	5.01	4.88	4.52	4.94	5.03	5.06	4.95	4.82	6
7	5.22	5.64	5.65	5.68	5.22	5.71	5.72	5.76	5.54	5.16	5.70	5.78	5.85	5.63	5.53	7
8	5.80	6.36	6.37	6.39	5.80	6.46	6.42	6.50	6.17	5.73	6.45	6.50	6.61	6.28	6.21	8
9	6.35	7.07	7.07	7.09	6.35	7.21	7.10	7.12	6.76	6.29	7.19	7.19	7.37	6.89	6.88	9
10	6.88	7.75	7.75	7.77	6.88	7.94	7.75	7.93	7.33	6.83	7.91	7.87	8.11	7.47	7.53	10
11	7.39	8.41	8.42	8.43	7.39	8.64	8.38	8.61	7.86	7.34	8.62	8.52	8.84	8.01	8.16	11
12	7.87	9.06	9.06	9.06	7.87	9.33	9.06	9.28	8.37	7.83	9.31	9.15	9.55	8.53	8.75	12
13	8.32	9.68	9.68	9.68	8.32	10.00	9.60	9.93	8.84	8.29	9.98	9.77	10.24	9.02	9.33	13
14	8.75	10.28	10.29	10.28	8.75	10.65	10.18	10.56	9.30	8.73	10.64	10.37	10.92	9.49	9.88	14
15	9.15	10.87	10.87	10.87	9.15	11.28	10.75	11.17	9.72	9.15	11.28	10.95	11.59	9.92	10.40	15
16	9.53	11.43	11.43	11.43	9.54	11.89	11.31	11.77	10.13	9.54	11.90	11.52	12.24	10.34	10.91	16
17	9.89	11.98	11.97	11.98	9.90	12.47	11.84	12.34	10.51	9.91	12.51	12.06	12.87	10.73	11.39	17
18	10.23	12.50	12.50	12.50	10.24	13.04	12.35	12.90	10.87	10.26	13.09	12.59	13.49	11.09	11.85	18
19	10.55	13.01	13.00	13.01	10.56	13.59	12.85	13.44	11.20	10.60	13.65	13.09	14.09	11.44	12.29	19
20	10.85	13.49	13.48	13.51	10.86	14.11	13.33	13.96	11.52	10.91	14.20	13.58	14.67	11.77	12.71	20
21	11.13	13.97	13.95	13.98	11.14	14.62	13.80	14.47	11.82	11.20	14.73	14.06	15.24	12.07	13.12	21
22	11.39	14.42	14.41	14.45	11.40	15.12	14.25	14.96	12.10	11.47	15.25	14.52	15.79	12.36	13.50	22
23	11.64	14.87	14.85	14.89	11.64	15.61	14.69	15.44	12.37	11.72	15.76	14.97	16.33	12.63	13.88	23
24	11.86	15.30	15.28	15.33	11.87	16.07	15.12	15.90	12.61	11.96	16.25	15.40	16.85	12.89	14.24	24
25	12.07	15.71	15.69	15.75	12.08	16.53	15.54	16.35	12.85	12.18	16.73	15.82	17.36	13.13	14.58	25

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-11a. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 7 PERCENT
United States Average

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.94	0.92	0.91	0.93	0.94	0.91	0.93	0.92	0.95	0.94	0.91	0.93	0.94	0.96	0.91	1
2	1.83	1.78	1.77	1.83	1.83	1.76	1.81	1.82	1.84	1.83	1.76	1.81	1.84	1.87	1.76	2
3	2.65	2.60	2.60	2.70	2.67	2.59	2.65	2.68	2.69	2.66	2.59	2.67	2.72	2.74	2.58	3
4	3.42	3.40	3.39	3.56	3.43	3.39	3.47	3.53	3.49	3.43	3.39	3.50	3.59	3.57	3.36	4
5	4.12	4.16	4.16	4.40	4.14	4.16	4.26	4.36	4.25	4.13	4.17	4.31	4.46	4.36	4.10	5
6	4.78	4.91	4.91	5.23	4.81	4.93	5.03	5.19	4.97	4.79	4.94	5.11	5.33	5.12	4.82	6
7	5.40	5.65	5.65	6.05	5.42	5.69	5.78	6.00	5.65	5.40	5.70	5.89	6.19	5.84	5.52	7
8	5.97	6.37	6.38	6.86	6.00	6.43	6.51	6.81	6.29	5.97	6.44	6.66	7.05	6.52	6.21	8
9	6.50	7.07	7.09	7.65	6.55	7.17	7.22	7.60	6.90	6.50	7.18	7.40	7.90	7.18	6.88	9
10	7.00	7.75	7.78	8.43	7.03	7.89	7.98	8.37	7.48	6.99	7.90	8.13	8.74	7.79	7.53	10
11	7.47	8.42	8.46	9.18	7.51	8.59	8.67	9.12	8.02	7.46	8.61	8.84	9.56	8.38	8.15	11
12	7.91	9.06	9.11	9.91	7.96	9.27	9.21	9.85	8.54	7.90	9.29	9.52	10.36	8.93	8.75	12
13	8.33	9.68	9.74	10.62	8.38	9.93	9.84	10.57	9.03	8.33	9.97	10.19	11.15	9.46	9.32	13
14	8.73	10.29	10.35	11.31	8.78	10.67	10.46	11.26	9.49	8.73	10.62	10.84	11.92	9.96	9.87	14
15	9.11	10.87	10.94	11.98	9.17	11.19	11.06	11.94	9.93	9.11	11.26	11.46	12.68	10.43	10.39	15
16	9.47	11.44	11.51	12.62	9.52	11.79	11.64	12.59	10.34	9.47	11.88	12.07	13.41	10.87	10.90	16
17	9.80	11.98	12.06	13.25	9.86	12.37	12.20	13.22	10.73	9.81	12.48	12.66	14.13	11.28	11.38	17
18	10.12	12.50	12.59	13.85	10.18	12.93	12.74	13.83	11.09	10.13	13.07	13.23	14.82	11.68	11.84	18
19	10.42	13.01	13.10	14.44	10.48	13.47	13.26	14.42	11.44	10.43	13.63	13.77	15.50	12.05	12.28	19
20	10.70	13.50	13.59	15.00	10.77	13.99	13.76	15.00	11.76	10.72	14.17	14.30	16.16	12.39	12.70	20
21	10.96	13.97	14.07	15.55	11.03	14.50	14.25	15.55	12.07	10.98	14.71	14.81	16.80	12.72	13.10	21
22	11.20	14.42	14.53	16.08	11.28	14.99	14.73	16.09	12.35	11.23	15.22	15.31	17.43	13.03	13.49	22
23	11.43	14.87	14.98	16.59	11.51	15.47	15.19	16.62	12.62	11.46	15.73	15.79	18.04	13.32	13.86	23
24	11.64	15.30	15.41	17.09	11.72	15.93	15.65	17.13	12.88	11.68	16.22	16.26	18.63	13.59	14.22	24
25	11.84	15.72	15.83	17.57	11.92	16.38	16.08	17.62	13.12	11.88	16.70	16.72	19.21	13.85	14.57	25

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-1b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 1 (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.92	0.89	0.89	0.91	0.92	0.89	0.91	0.90	0.92	0.92	0.89	0.91	0.91	0.92	0.89	1
2	1.78	1.70	1.70	1.77	1.78	1.70	1.74	1.77	1.76	1.79	1.70	1.74	1.79	1.77	1.69	2
3	2.60	2.46	2.46	2.58	2.60	2.46	2.52	2.59	2.54	2.61	2.46	2.52	2.64	2.55	2.44	3
4	3.33	3.17	3.17	3.37	3.33	3.17	3.25	3.39	3.26	3.35	3.17	3.25	3.47	3.27	3.14	4
5	3.99	3.84	3.84	4.12	3.99	3.84	3.93	4.17	3.93	4.01	3.84	3.95	4.29	3.94	3.79	5
6	4.59	4.47	4.47	4.84	4.59	4.49	4.59	4.92	4.54	4.62	4.49	4.61	5.07	4.55	4.40	6
7	5.13	5.08	5.08	5.53	5.13	5.11	5.20	5.64	5.11	5.16	5.11	5.24	5.83	5.13	4.98	7
8	5.63	5.65	5.65	6.19	5.63	5.70	5.78	6.33	5.64	5.67	5.70	5.83	6.56	5.65	5.53	8
9	6.09	6.20	6.20	6.81	6.09	6.26	6.32	6.99	6.12	6.13	6.27	6.39	7.26	6.14	6.05	9
10	6.50	6.71	6.72	7.40	6.50	6.80	6.83	7.62	6.57	6.54	6.81	6.92	7.92	6.59	6.54	10
11	6.88	7.20	7.20	7.96	6.88	7.30	7.32	8.22	6.99	6.93	7.32	7.41	8.55	7.00	6.99	11
12	7.22	7.66	7.66	8.48	7.22	7.78	7.78	8.78	7.37	7.28	7.80	7.89	9.15	7.38	7.42	12
13	7.55	8.09	8.09	8.98	7.55	8.23	8.21	9.31	7.72	7.61	8.26	8.33	9.73	7.73	7.82	13
14	7.84	8.50	8.50	9.45	7.84	8.66	8.63	9.82	8.04	7.91	8.70	8.75	10.27	8.06	8.19	14
15	8.11	8.89	8.89	9.89	8.12	9.06	9.02	10.29	8.32	8.19	9.12	9.15	10.79	8.35	8.54	15
16	8.36	9.25	9.25	10.30	8.37	9.44	9.38	10.74	8.61	8.44	9.51	9.53	11.29	8.63	8.86	16
17	8.59	9.59	9.58	10.69	8.59	9.80	9.73	11.17	8.86	8.68	9.88	9.88	11.75	8.88	9.16	17
18	8.80	9.90	9.90	11.06	8.80	10.13	10.05	11.56	9.08	8.89	10.23	10.21	12.19	9.10	9.44	18
19	9.00	10.20	10.19	11.41	9.00	10.44	10.36	11.94	9.29	9.09	10.56	10.52	12.61	9.31	9.70	19
20	9.17	10.48	10.47	11.73	9.17	10.74	10.64	12.29	9.48	9.27	10.86	10.81	13.01	9.50	9.94	20
21	9.33	10.74	10.73	12.04	9.33	11.01	10.92	12.63	9.66	9.44	11.16	11.08	13.38	9.68	10.16	21
22	9.48	10.99	10.98	12.33	9.48	11.28	11.17	12.94	9.82	9.59	11.43	11.34	13.74	9.84	10.37	22
23	9.61	11.22	11.21	12.60	9.61	11.52	11.41	13.24	9.97	9.73	11.70	11.59	14.07	9.99	10.57	23
24	9.73	11.44	11.43	12.85	9.73	11.76	11.64	13.52	10.10	9.85	11.95	11.82	14.39	10.12	10.75	24
25	9.83	11.65	11.64	13.09	9.84	11.98	11.86	13.78	10.22	9.96	12.18	12.04	14.69	10.25	10.93	25

*** Extended Series ***

26	9.93	11.85	11.83	13.32	9.93	12.19	12.07	14.03	10.34	10.06	12.41	12.25	14.98	10.36	11.09	26
27	10.02	12.03	12.02	13.54	10.02	12.39	12.26	14.27	10.44	10.15	12.62	12.44	15.25	10.46	11.24	27
28	10.10	12.21	12.19	13.74	10.10	12.57	12.45	14.49	10.54	10.24	12.82	12.63	15.51	10.56	11.38	28
29	10.17	12.37	12.35	13.93	10.17	12.75	12.62	14.70	10.62	10.31	13.01	12.80	15.75	10.65	11.51	29
30	10.23	12.53	12.51	14.11	10.24	12.92	12.79	14.90	10.70	10.38	13.19	12.97	15.98	10.73	11.63	30

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-2b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 2 (New York, New Jersey, Puerto Rico, Virgin Islands)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.89	0.89	0.89	0.91	0.89	0.89	0.91	0.91	0.92	0.89	0.89	0.91	0.91	0.92	0.89	1
2	1.73	1.70	1.70	1.75	1.73	1.70	1.74	1.74	1.77	1.73	1.70	1.74	1.76	1.77	1.69	2
3	2.52	2.46	2.46	2.53	2.52	2.46	2.52	2.52	2.54	2.53	2.46	2.52	2.56	2.56	2.45	3
4	3.23	3.17	3.17	3.28	3.23	3.17	3.25	3.26	3.26	3.24	3.17	3.26	3.33	3.29	3.14	4
5	3.85	3.84	3.84	3.98	3.86	3.85	3.94	3.97	3.92	3.87	3.84	3.96	4.07	3.97	3.79	5
6	4.42	4.47	4.47	4.65	4.42	4.49	4.60	4.64	4.53	4.43	4.49	4.62	4.78	4.59	4.40	6
7	4.92	5.07	5.07	5.28	4.92	5.12	5.21	5.28	5.09	4.94	5.11	5.25	5.45	5.16	4.98	7
8	5.38	5.65	5.65	5.88	5.38	5.71	5.80	5.89	5.61	5.39	5.70	5.85	6.10	5.69	5.53	8
9	5.79	6.19	6.19	6.45	5.79	6.28	6.35	6.47	6.08	5.80	6.27	6.41	6.71	6.18	6.05	9
10	6.17	6.70	6.70	6.98	6.17	6.82	6.86	7.01	6.52	6.17	6.81	6.94	7.29	6.63	6.54	10
11	6.51	7.19	7.18	7.49	6.51	7.33	7.35	7.53	6.92	6.52	7.32	7.44	7.84	7.04	7.00	11
12	6.83	7.65	7.64	7.97	6.83	7.81	7.82	8.02	7.29	6.84	7.81	7.91	8.37	7.42	7.43	12
13	7.13	8.08	8.07	8.42	7.13	8.27	8.26	8.49	7.63	7.13	8.27	8.36	8.87	7.77	7.83	13
14	7.40	8.48	8.48	8.84	7.40	8.70	8.68	8.93	7.94	7.40	8.71	8.78	9.35	8.09	8.20	14
15	7.64	8.87	8.86	9.24	7.64	9.11	9.07	9.35	8.23	7.65	9.12	9.18	9.81	8.39	8.55	15
16	7.87	9.23	9.22	9.62	7.87	9.49	9.44	9.74	8.49	7.88	9.52	9.56	10.24	8.66	8.87	16
17	8.08	9.56	9.55	9.98	8.08	9.85	9.79	10.11	8.71	8.09	9.89	9.91	10.65	8.91	9.17	17
18	8.27	9.88	9.86	10.31	8.27	10.18	10.12	10.46	8.96	8.29	10.23	10.24	11.03	9.14	9.45	18
19	8.45	10.17	10.16	10.63	8.45	10.50	10.43	10.78	9.16	8.46	10.56	10.55	11.40	9.35	9.71	19
20	8.61	10.45	10.43	10.92	8.61	10.80	10.72	11.09	9.35	8.63	10.87	10.85	11.75	9.54	9.95	20
21	8.76	10.71	10.69	11.20	8.75	11.08	10.99	11.38	9.52	8.78	11.16	11.12	12.07	9.72	10.18	21
22	8.89	10.96	10.94	11.46	8.89	11.34	11.25	11.66	9.67	8.91	11.44	11.38	12.38	9.88	10.39	22
23	9.01	11.19	11.17	11.71	9.01	11.59	11.49	11.92	9.82	9.03	11.71	11.63	12.68	10.02	10.58	23
24	9.11	11.41	11.39	11.94	9.11	11.83	11.73	12.16	9.95	9.14	11.95	11.86	12.96	10.16	10.77	24
25	9.21	11.62	11.59	12.16	9.21	12.05	11.95	12.39	10.07	9.24	12.19	12.08	13.22	10.28	10.94	25
								*** Extended Series ***								
26	9.30	11.81	11.79	12.37	9.30	12.26	12.15	12.61	10.18	9.33	12.42	12.29	13.47	10.40	11.10	26
27	9.38	12.00	11.97	12.56	9.38	12.46	12.35	12.82	10.28	9.42	12.63	12.49	13.71	10.50	11.25	27
28	9.45	12.17	12.14	12.75	9.45	12.65	12.54	13.01	10.37	9.49	12.83	12.67	13.94	10.59	11.40	28
29	9.52	12.34	12.31	12.92	9.52	12.83	12.71	13.19	10.45	9.56	13.02	12.85	14.15	10.68	11.53	29
30	9.58	12.49	12.46	13.08	9.58	12.99	12.88	13.37	10.53	9.62	13.20	13.01	14.35	10.76	11.65	30

SAMPLE FACTORS

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-3b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 3 (Pennsylvania, Maryland, West Virginia, Virginia, District of Columbia, Delaware)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.90	0.89	0.89	0.91	0.90	0.89	0.91	0.91	0.92	0.89	0.89	0.91	0.91	0.92	0.89	1
2	1.72	1.70	1.70	1.76	1.72	1.70	1.74	1.75	1.77	1.72	1.70	1.74	1.76	1.76	1.69	2
3	2.47	2.46	2.46	2.56	2.47	2.46	2.52	2.53	2.55	2.47	2.46	2.52	2.56	2.54	2.45	3
4	3.14	3.17	3.17	3.32	3.14	3.18	3.25	3.28	3.27	3.14	3.17	3.27	3.33	3.26	3.14	4
5	3.75	3.84	3.84	4.04	3.75	3.85	3.95	3.99	3.93	3.74	3.85	3.97	4.08	3.92	3.79	5
6	4.29	4.47	4.47	4.72	4.29	4.51	4.61	4.66	4.54	4.28	4.50	4.64	4.78	4.54	4.40	6
7	4.79	5.08	5.08	5.36	4.79	5.13	5.24	5.29	5.10	4.79	5.12	5.28	5.45	5.10	4.98	7
8	5.25	5.66	5.65	5.97	5.25	5.74	5.83	5.89	5.62	5.23	5.72	5.89	6.09	5.62	5.53	8
9	5.66	6.20	6.20	6.55	5.66	6.31	6.38	6.46	6.09	5.65	6.29	6.46	6.70	6.10	6.05	9
10	6.04	6.72	6.72	7.09	6.04	6.86	6.91	7.00	6.53	6.03	6.83	7.00	7.27	6.54	6.54	10
11	6.39	7.21	7.21	7.61	6.39	7.38	7.41	7.51	6.94	6.37	7.35	7.31	7.81	6.94	7.00	11
12	6.72	7.67	7.67	8.09	6.72	7.87	7.88	7.99	7.31	6.70	7.84	8.00	8.33	7.32	7.43	12
13	7.01	8.11	8.10	8.55	7.01	8.34	8.33	8.45	7.65	7.00	8.31	8.46	8.83	7.66	7.83	13
14	7.29	8.52	8.51	8.98	7.29	8.77	8.75	8.88	7.96	7.27	8.75	8.89	9.30	7.98	8.20	14
15	7.54	8.90	8.89	9.39	7.54	9.19	9.15	9.28	8.25	7.59	9.17	9.30	9.75	8.27	8.55	15
16	7.77	9.26	9.25	9.77	7.77	9.58	9.53	9.67	8.52	7.76	9.57	9.68	10.17	8.54	8.87	16
17	7.98	9.60	9.59	10.14	7.98	9.94	9.88	10.03	8.76	7.97	9.94	10.05	10.58	8.78	9.17	17
18	8.17	9.92	9.91	10.47	8.17	10.28	10.22	10.37	8.98	8.17	10.29	10.38	10.96	9.01	9.45	18
19	8.35	10.22	10.21	10.79	8.35	10.60	10.53	10.69	9.19	8.35	10.62	10.70	11.32	9.21	9.71	19
20	8.51	10.50	10.48	11.09	8.52	10.91	10.83	10.99	9.38	8.52	10.94	11.00	11.66	9.40	9.95	20
21	8.66	10.76	10.75	11.38	8.66	11.19	11.10	11.28	9.55	8.67	11.23	11.28	11.98	9.57	10.18	21
22	8.79	11.01	10.99	11.64	8.80	11.46	11.37	11.55	9.70	8.81	11.51	11.55	12.29	9.73	10.39	22
23	8.91	11.25	11.23	11.89	8.92	11.71	11.62	11.80	9.85	8.93	11.78	11.80	12.58	9.87	10.59	23
24	9.02	11.47	11.45	12.13	9.03	11.95	11.85	12.04	9.98	9.04	12.03	12.04	12.86	10.01	10.77	24
25	9.12	11.68	11.65	12.35	9.13	12.18	12.08	12.27	10.10	9.14	12.27	12.27	13.12	10.13	10.94	25
							*** Extended Series ***									
26	9.21	11.87	11.85	12.56	9.22	12.40	12.29	12.48	10.21	9.24	12.49	12.48	13.36	10.24	11.11	26
27	9.29	12.06	12.03	12.76	9.30	12.60	12.49	12.68	10.31	9.32	12.71	12.68	13.60	10.34	11.26	27
28	9.37	12.24	12.21	12.95	9.37	12.79	12.68	12.87	10.40	9.40	12.91	12.87	13.82	10.43	11.40	28
29	9.43	12.40	12.37	13.12	9.44	12.97	12.86	13.05	10.49	9.46	13.11	13.05	14.03	10.52	11.53	29
30	9.49	12.56	12.53	13.29	9.50	13.14	13.03	13.22	10.56	9.53	13.29	13.22	14.23	10.60	11.65	30

SAMPLE FACTORS

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-4b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 4 (Kentucky, Tennessee, North Carolina, South Carolina, Mississippi, Alabama, Georgia, Florida, Canal Zone)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.89	0.89	0.89	0.91	0.89	0.89	0.91	0.90	0.92	0.89	0.89	0.91	0.90	0.92	0.89	1
2	1.69	1.70	1.70	1.77	1.69	1.69	1.74	1.74	1.77	1.69	1.70	1.74	1.74	1.78	1.69	2
3	2.42	2.46	2.46	2.59	2.42	2.45	2.52	2.55	2.56	2.41	2.46	2.53	2.56	2.56	2.44	3
4	3.08	3.17	3.17	3.38	3.08	3.17	3.25	3.32	3.28	3.07	3.17	3.28	3.35	3.29	3.14	4
5	3.68	3.84	3.84	4.16	3.68	3.85	3.95	4.08	3.95	3.66	3.85	3.99	4.12	3.97	3.79	5
6	4.21	4.47	4.48	4.90	4.21	4.50	4.60	4.81	4.56	4.19	4.50	4.67	4.88	4.59	4.40	6
7	4.70	5.08	5.08	5.62	4.70	5.14	5.22	5.53	5.13	4.67	5.13	5.32	5.62	5.17	4.98	7
8	5.13	5.66	5.66	6.32	5.13	5.74	5.81	6.21	5.65	5.10	5.73	5.94	6.34	5.70	5.53	8
9	5.51	6.20	6.21	6.99	5.51	6.32	6.36	6.88	6.13	5.48	6.31	6.52	7.04	6.19	6.06	9
10	5.86	6.72	6.72	7.63	5.86	6.87	6.88	7.61	6.57	5.81	6.86	7.08	7.71	6.65	6.55	10
11	6.17	7.21	7.21	8.23	6.18	7.40	7.38	8.12	6.98	6.13	7.38	7.60	8.35	7.07	7.01	11
12	6.46	7.67	7.67	8.80	6.47	7.89	7.85	8.69	7.35	6.41	7.88	8.10	8.95	7.45	7.44	12
13	6.73	8.11	8.11	9.34	6.74	8.36	8.29	9.22	7.70	6.68	8.35	8.57	9.53	7.81	7.84	13
14	6.98	8.52	8.52	9.85	6.99	8.80	8.71	9.73	8.02	6.93	8.79	9.01	10.08	8.14	8.21	14
15	7.21	8.90	8.90	10.33	7.21	9.22	9.11	10.22	8.31	7.15	9.22	9.43	10.61	8.44	8.56	15
16	7.42	9.26	9.26	10.78	7.42	9.61	9.48	10.67	8.58	7.36	9.62	9.82	11.11	8.71	8.89	16
17	7.61	9.60	9.60	11.20	7.62	9.98	9.83	11.10	8.82	7.55	9.99	10.19	11.58	8.97	9.19	17
18	7.78	9.92	9.92	11.60	7.79	10.32	10.16	11.50	9.05	7.73	10.35	10.54	12.02	9.20	9.47	18
19	7.94	10.22	10.22	11.97	7.95	10.65	10.47	11.88	9.25	7.89	10.68	10.87	12.44	9.41	9.73	19
20	8.09	10.50	10.50	12.33	8.10	10.95	10.76	12.24	9.44	8.04	11.00	11.17	12.84	9.60	9.97	20
21	8.23	10.76	10.76	12.66	8.23	11.24	11.04	12.58	9.61	8.17	11.30	11.46	13.22	9.78	10.20	21
22	8.35	11.01	11.01	12.97	8.36	11.51	11.30	12.90	9.77	8.30	11.58	11.74	13.58	9.94	10.41	22
23	8.46	11.25	11.24	13.27	8.46	11.77	11.55	13.20	9.92	8.41	11.85	11.99	13.92	10.09	10.61	23
24	8.55	11.47	11.46	13.54	8.56	12.01	11.78	13.48	10.05	8.51	12.10	12.24	14.24	10.23	10.79	24
25	8.64	11.68	11.67	13.81	8.65	12.24	12.00	13.75	10.17	8.60	12.34	12.47	14.55	10.35	10.97	25
							*** Extended Series ***									
26	8.73	11.87	11.86	14.05	8.74	12.45	12.21	14.00	10.28	8.68	12.57	12.69	14.84	10.47	11.13	26
27	8.80	12.06	12.05	14.29	8.81	12.66	12.41	14.24	10.38	8.76	12.79	12.89	15.11	10.57	11.28	27
28	8.87	12.24	12.22	14.50	8.88	12.85	12.60	14.46	10.48	8.82	12.99	13.09	15.37	10.67	11.42	28
29	8.93	12.40	12.39	14.71	8.94	13.03	12.77	14.68	10.56	8.89	13.19	13.27	15.62	10.76	11.56	29
30	8.98	12.56	12.54	14.90	8.99	13.21	12.94	14.88	10.64	8.94	13.37	13.45	15.85	10.84	11.68	30

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-5b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 5 (Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.93	0.89	0.89	0.92	0.93	0.89	0.91	0.91	0.92	0.94	0.89	0.91	0.91	0.92	0.89	1
2	1.79	1.70	1.70	1.76	1.79	1.69	1.74	1.76	1.77	1.81	1.70	1.74	1.75	1.76	1.70	2
3	2.56	2.46	2.46	2.56	2.56	2.45	2.52	2.55	2.54	2.58	2.46	2.54	2.54	2.54	2.45	3
4	3.25	3.17	3.17	3.32	3.25	3.17	3.24	3.31	3.26	3.26	3.17	3.30	3.30	3.25	3.14	4
5	3.85	3.84	3.84	4.05	3.85	3.85	3.92	4.03	3.92	3.87	3.85	4.03	4.03	3.91	3.79	5
6	4.39	4.48	4.48	4.75	4.39	4.50	4.57	4.73	4.53	4.40	4.49	4.74	4.74	4.52	4.40	6
7	4.88	5.09	5.09	5.42	4.88	5.13	5.17	5.41	5.09	4.68	5.12	5.41	5.42	5.07	4.98	7
8	5.31	5.67	5.67	6.07	5.31	5.74	5.74	6.06	5.61	5.30	5.71	6.06	6.08	5.59	5.52	8
9	5.69	6.23	6.22	6.70	5.69	6.32	6.27	6.69	6.08	5.68	6.28	6.67	6.72	6.06	6.04	9
10	6.04	6.75	6.74	7.30	6.03	6.87	6.77	7.30	6.52	6.02	6.82	7.26	7.33	6.49	6.53	10
11	6.36	7.25	7.24	7.86	6.35	7.39	7.25	7.87	6.92	6.33	7.34	7.82	7.91	6.89	6.98	11
12	6.65	7.71	7.70	8.39	6.65	7.88	7.69	8.40	7.29	6.62	7.83	8.35	8.47	7.25	7.41	12
13	6.92	8.15	8.14	8.89	6.92	8.35	8.12	8.92	7.63	6.88	8.29	8.84	8.99	7.59	7.81	13
14	7.17	8.57	8.56	9.37	7.16	8.79	8.52	9.40	7.94	7.13	8.73	9.32	9.50	7.90	8.18	14
15	7.40	8.96	8.95	9.82	7.39	9.20	8.90	9.86	8.23	7.36	9.15	9.76	9.98	8.18	8.52	15
16	7.61	9.33	9.31	10.24	7.60	9.59	9.26	10.29	8.49	7.57	9.55	10.18	10.43	8.44	8.84	16
17	7.80	9.67	9.65	10.64	7.80	9.96	9.60	10.69	8.74	7.76	9.92	10.57	10.86	8.68	9.14	17
18	7.98	9.99	9.97	11.01	7.97	10.30	9.92	11.07	8.96	7.93	10.27	10.94	11.27	8.90	9.42	18
19	8.14	10.29	10.27	11.36	8.13	10.63	10.21	11.43	9.16	8.10	10.60	11.28	11.65	9.10	9.67	19
20	8.29	10.58	10.56	11.69	8.28	10.93	10.49	11.77	9.35	8.24	10.91	11.61	12.02	9.29	9.91	20
21	8.42	10.84	10.82	12.00	8.42	11.22	10.76	12.09	9.52	8.38	11.20	11.92	12.36	9.46	10.14	21
22	8.54	11.10	11.07	12.29	8.54	11.49	11.01	12.39	9.67	8.50	11.48	12.21	12.69	9.61	10.35	22
23	8.65	11.33	11.31	12.57	8.65	11.74	11.25	12.68	9.82	8.61	11.75	12.48	13.00	9.75	10.54	23
24	8.75	11.56	11.53	12.83	8.75	11.98	11.47	12.95	9.95	8.71	12.00	12.74	13.29	9.88	10.73	24
25	8.84	11.77	11.74	13.07	8.84	12.21	11.68	13.20	10.07	8.80	12.24	12.98	13.57	10.00	10.90	25
*** Extended Series ***																
26	8.92	11.97	11.94	13.30	8.92	12.43	11.89	13.44	10.18	8.89	12.46	13.22	13.83	10.11	11.06	26
27	9.00	12.16	12.12	13.52	8.99	12.63	12.08	13.67	10.28	8.96	12.68	13.43	14.08	10.21	11.21	27
28	9.06	12.34	12.30	13.72	9.06	12.82	12.26	13.88	10.37	9.03	12.88	13.64	14.32	10.30	11.35	28
29	9.13	12.50	12.47	13.92	9.12	13.01	12.43	14.08	10.45	9.09	13.07	13.84	14.55	10.38	11.48	29
30	9.18	12.66	12.62	14.10	9.18	13.18	12.59	14.27	10.53	9.15	13.26	14.02	14.76	10.46	11.60	30

SAMPLE FACTORS

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-6b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 6 (Texas, New Mexico, Oklahoma, Arkansas, Louisiana)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.94	0.89	0.89	0.93	0.94	0.89	0.91	0.92	0.93	0.94	0.89	0.91	0.93	0.93	0.89	1
2	1.80	1.70	1.70	1.82	1.80	1.69	1.74	1.79	1.77	1.81	1.69	1.74	1.82	1.79	1.69	2
3	2.60	2.46	2.46	2.66	2.60	2.46	2.52	2.60	2.55	2.61	2.46	2.54	2.67	2.59	2.44	3
4	3.32	3.17	3.18	3.47	3.32	3.18	3.27	3.38	3.26	3.34	3.17	3.29	3.48	3.33	3.14	4
5	3.97	3.85	3.85	4.24	3.98	3.86	3.97	4.12	3.93	4.00	3.85	4.02	4.27	4.02	3.79	5
6	4.58	4.50	4.51	4.99	4.58	4.52	4.64	4.84	4.54	4.62	4.51	4.71	5.05	4.65	4.40	6
7	5.13	5.13	5.14	5.71	5.14	5.16	5.28	5.53	5.10	5.18	5.14	5.37	5.81	5.24	4.99	7
8	5.65	5.73	5.74	6.40	5.66	5.77	5.88	6.20	5.62	5.70	5.75	6.01	6.54	5.79	5.54	8
9	6.12	6.31	6.31	7.07	6.13	6.36	6.46	6.84	6.09	6.18	6.33	6.61	7.26	6.29	6.07	9
10	6.55	6.86	6.86	7.70	6.57	6.92	7.00	7.45	6.54	6.63	6.88	7.18	7.95	6.75	6.56	10
11	6.96	7.38	7.38	8.31	6.97	7.46	7.51	8.04	6.94	7.04	7.41	7.72	8.61	7.17	7.03	11
12	7.33	7.87	7.87	8.87	7.34	7.96	8.00	8.59	7.32	7.42	7.91	8.23	9.24	7.57	7.46	12
13	7.67	8.33	8.33	9.41	7.68	8.44	8.46	9.11	7.67	7.77	8.39	8.72	9.84	7.93	7.86	13
14	7.98	8.76	8.76	9.92	8.00	8.89	8.89	9.61	7.98	8.10	8.84	9.18	10.41	8.26	8.24	14
15	8.27	9.17	9.17	10.40	8.29	9.31	9.31	10.08	8.28	8.39	9.27	9.61	10.95	8.57	8.59	15
16	8.54	9.56	9.56	10.85	8.55	9.71	9.70	10.52	8.54	8.67	9.68	10.01	11.47	8.85	8.92	16
17	8.78	9.92	9.92	11.27	8.80	10.08	10.06	10.93	8.79	8.92	10.06	10.40	11.95	9.11	9.22	17
18	9.00	10.26	10.25	11.67	9.02	10.44	10.40	11.32	9.01	9.15	10.42	10.75	12.41	9.34	9.50	18
19	9.20	10.57	10.57	12.04	9.23	10.76	10.73	11.69	9.22	9.37	10.76	11.09	12.85	9.56	9.76	19
20	9.39	10.87	10.86	12.39	9.41	11.07	11.03	12.04	9.41	9.56	11.08	11.41	13.26	9.75	10.01	20
21	9.56	11.15	11.14	12.72	9.58	11.37	11.32	12.36	9.58	9.74	11.38	11.71	13.65	9.93	10.24	21
22	9.71	11.41	11.40	13.04	9.74	11.64	11.59	12.67	9.74	9.90	11.66	11.99	14.02	10.10	10.45	22
23	9.85	11.66	11.65	13.33	9.88	11.90	11.85	12.96	9.88	10.04	11.94	12.25	14.38	10.25	10.65	23
24	9.98	11.90	11.88	13.61	10.01	12.15	12.09	13.24	10.02	10.18	12.19	12.51	14.71	10.39	10.84	24
25	10.09	12.12	12.10	13.87	10.12	12.38	12.32	13.50	10.14	10.30	12.44	12.74	15.02	10.52	11.01	25
								*** Extended Series ***								
26	10.20	12.33	12.31	14.11	10.22	12.60	12.54	13.74	10.25	10.41	12.67	12.97	15.32	10.63	11.17	26
27	10.29	12.52	12.51	14.34	10.32	12.81	12.74	13.97	10.35	10.50	12.89	13.18	15.61	10.74	11.33	27
28	10.37	12.71	12.69	14.56	10.40	13.01	12.94	14.19	10.44	10.59	13.10	13.38	15.88	10.84	11.47	28
29	10.45	12.89	12.87	14.77	10.48	13.19	13.12	14.40	10.53	10.68	13.29	13.57	16.13	10.93	11.60	29
30	10.52	13.05	13.03	14.96	10.55	13.37	13.30	14.59	10.61	10.75	13.48	13.75	16.37	11.01	11.73	30

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-7b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 7 (Kansas, Missouri, Iowa, Nebraska)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.95	0.89	0.89	0.91	0.95	0.89	0.91	0.90	0.92	0.96	0.89	0.91	0.90	0.93	0.89	1
2	1.79	1.70	1.70	1.76	1.80	1.69	1.74	1.76	1.76	1.80	1.70	1.74	1.75	1.79	1.69	2
3	2.53	2.46	2.46	2.59	2.54	2.45	2.51	2.58	2.53	2.54	2.46	2.54	2.57	2.58	2.44	3
4	3.19	3.17	3.17	3.37	3.19	3.17	3.23	3.37	3.24	3.19	3.18	3.30	3.35	3.31	3.14	4
5	3.77	3.84	3.84	4.14	3.77	3.85	3.90	4.14	3.89	3.77	3.85	4.03	4.11	3.98	3.79	5
6	4.30	4.49	4.49	4.87	4.30	4.51	4.52	4.89	4.49	4.29	4.51	4.74	4.86	4.61	4.40	6
7	4.78	5.10	5.10	5.59	4.78	5.15	5.11	5.62	5.04	4.76	5.13	5.42	5.58	5.18	4.98	7
8	5.20	5.69	5.69	6.28	5.20	5.76	5.65	6.32	5.54	5.18	5.73	6.07	6.27	5.71	5.54	8
9	5.58	6.25	6.25	6.94	5.58	6.34	6.16	6.99	6.01	5.55	6.31	6.69	6.94	6.20	6.06	9
10	5.92	6.78	6.78	7.57	5.92	6.90	6.64	7.64	6.44	5.89	6.86	7.28	7.58	6.65	6.55	10
11	6.24	7.29	7.28	8.16	6.23	7.42	7.09	8.25	6.83	6.19	7.38	7.84	8.20	7.07	7.01	11
12	6.53	7.76	7.75	8.73	6.52	7.92	7.51	8.83	7.19	6.48	7.87	8.37	8.78	7.45	7.44	12
13	6.79	8.21	8.20	9.26	6.78	8.39	7.92	9.38	7.52	6.74	8.34	8.87	9.33	7.80	7.84	13
14	7.04	8.63	8.62	9.76	7.03	8.84	8.30	9.90	7.83	6.99	8.79	9.35	9.86	8.13	8.22	14
15	7.26	9.03	9.02	10.23	7.25	9.26	8.66	10.39	8.11	7.21	9.21	9.79	10.37	8.43	8.57	15
16	7.47	9.40	9.39	10.68	7.46	9.66	9.00	10.86	8.37	7.42	9.61	10.21	10.84	8.70	8.89	16
17	7.66	9.75	9.73	11.10	7.65	10.03	9.33	11.29	8.60	7.60	9.99	10.61	11.29	8.95	9.19	17
18	7.83	10.07	10.06	11.49	7.82	10.37	9.63	11.70	8.82	7.78	10.34	10.98	11.72	9.18	9.47	18
19	7.99	10.38	10.36	11.86	7.98	10.70	9.91	12.09	9.02	7.94	10.68	11.33	12.13	9.39	9.74	19
20	8.14	10.67	10.65	12.21	8.13	11.01	10.18	12.45	9.20	8.08	10.99	11.65	12.51	9.59	9.98	20
21	8.27	10.94	10.92	12.54	8.26	11.30	10.43	12.80	9.37	8.22	11.29	11.96	12.87	9.76	10.20	21
22	8.39	11.19	11.17	12.85	8.38	11.57	10.67	13.12	9.52	8.34	11.57	12.26	13.21	9.92	10.42	22
23	8.50	11.43	11.41	13.14	8.49	11.83	10.89	13.43	9.66	8.45	11.84	12.53	13.54	10.07	10.62	23
24	8.60	11.66	11.64	13.41	8.58	12.07	11.10	13.72	9.79	8.55	12.09	12.79	13.85	10.21	10.80	24
25	8.69	11.88	11.85	13.67	8.67	12.30	11.31	13.99	9.91	8.63	12.33	13.04	14.14	10.33	10.97	25

*** Extended Series ***

26	8.77	12.08	12.05	13.91	8.75	12.52	11.50	14.25	10.01	8.72	12.56	13.27	14.42	10.45	11.14	26
27	8.84	12.27	12.24	14.14	8.83	12.73	11.68	14.49	10.11	8.79	12.78	13.49	14.68	10.55	11.29	27
28	8.91	12.45	12.42	14.36	8.89	12.92	11.85	14.72	10.20	8.86	12.98	13.70	14.93	10.65	11.43	28
29	8.97	12.62	12.59	14.56	8.95	13.10	12.01	14.94	10.28	8.92	13.18	13.90	15.16	10.73	11.56	29
30	9.02	12.78	12.75	14.75	9.00	13.28	12.17	15.14	10.36	8.97	13.36	14.08	15.39	10.81	11.69	30

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-8b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 8 (Montana, North Dakota, South Dakota, Wyoming, Utah, Colorado)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.92	0.89	0.89	0.91	0.92	0.89	0.91	0.92	0.93	0.92	0.89	0.91	0.91	0.93	0.89	1
2	1.75	1.70	1.70	1.76	1.75	1.69	1.74	1.76	1.79	1.75	1.70	1.74	1.75	1.78	1.69	2
3	2.50	2.46	2.46	2.55	2.50	2.46	2.53	2.55	2.58	2.51	2.46	2.54	2.54	2.57	2.44	3
4	3.18	3.17	3.17	3.28	3.18	3.17	3.27	3.26	3.30	3.18	3.18	3.30	3.26	3.29	3.14	4
5	3.79	3.85	3.85	3.98	3.79	3.85	3.97	3.96	3.97	3.79	3.86	4.04	3.97	3.95	3.79	5
6	4.33	4.49	4.49	4.65	4.33	4.51	4.64	4.61	4.59	4.33	4.51	4.76	4.64	4.57	4.40	6
7	4.83	5.11	5.11	5.30	4.82	5.13	5.28	5.25	5.15	4.82	5.14	5.44	5.30	5.13	4.98	7
8	5.27	5.70	5.70	5.91	5.26	5.74	5.88	5.85	5.67	5.25	5.74	6.10	5.93	5.66	5.53	8
9	5.66	6.26	6.26	6.50	5.66	6.32	6.45	6.43	6.15	5.64	6.32	6.73	6.54	6.14	6.06	9
10	6.02	6.80	6.80	7.06	6.02	6.87	6.99	6.98	6.59	5.99	6.87	7.34	7.13	6.58	6.55	10
11	6.35	7.30	7.30	7.60	6.35	7.39	7.50	7.50	6.99	6.32	7.39	7.91	7.69	6.99	7.01	11
12	6.65	7.78	7.77	8.10	6.65	7.88	7.98	7.99	7.36	6.62	7.89	8.45	8.22	7.36	7.44	12
13	6.93	8.23	8.22	8.57	6.93	8.35	8.44	8.46	7.70	6.90	8.36	8.96	8.73	7.70	7.84	13
14	7.19	8.65	8.64	9.02	7.19	8.79	8.87	8.90	8.01	7.15	8.81	9.44	9.21	8.02	8.21	14
15	7.43	9.05	9.04	9.45	7.42	9.21	9.29	9.32	8.30	7.39	9.24	9.90	9.67	8.31	8.56	15
16	7.65	9.43	9.42	9.84	7.64	9.60	9.67	9.71	8.57	7.61	9.64	10.33	10.11	8.58	8.88	16
17	7.85	9.78	9.76	10.22	7.84	9.96	10.04	10.09	8.81	7.81	10.02	10.73	10.52	8.83	9.18	17
18	8.03	10.11	10.09	10.57	8.02	10.31	10.38	10.43	9.04	7.99	10.37	11.11	10.91	9.05	9.46	18
19	8.20	10.41	10.40	10.90	8.19	10.63	10.70	10.76	9.24	8.16	10.71	11.47	11.28	9.26	9.72	19
20	8.35	10.70	10.69	11.21	8.35	10.93	11.00	11.07	9.43	8.32	11.02	11.80	11.63	9.45	9.97	20
21	8.49	10.97	10.96	11.50	8.48	11.22	11.28	11.37	9.60	8.46	11.32	12.11	11.96	9.62	10.19	21
22	8.62	11.23	11.21	11.78	8.61	11.49	11.56	11.64	9.75	8.58	11.60	12.41	12.27	9.78	10.40	22
23	8.73	11.47	11.45	12.04	8.72	11.74	11.81	11.90	9.90	8.70	11.87	12.69	12.57	9.92	10.60	23
24	8.84	11.70	11.68	12.29	8.83	11.99	12.05	12.15	10.03	8.80	12.13	12.96	12.85	10.05	10.79	24
25	8.93	11.92	11.89	12.52	8.92	12.21	12.28	12.38	10.15	8.90	12.37	13.21	13.12	10.18	10.96	25

*** Extended Series ***

26	9.01	12.12	12.10	12.73	9.01	12.43	12.50	12.60	10.26	8.98	12.60	13.45	13.37	10.29	11.12	26
27	9.09	12.31	12.29	12.94	9.08	12.63	12.70	12.81	10.36	9.06	12.82	13.67	13.61	10.39	11.27	27
28	9.16	12.50	12.47	13.13	9.15	12.83	12.90	13.00	10.45	9.13	13.02	13.88	13.84	10.48	11.42	28
29	9.22	12.67	12.64	13.31	9.22	13.01	13.08	13.19	10.54	9.20	13.22	14.08	14.06	10.57	11.55	29
30	9.28	12.83	12.79	13.49	9.27	13.18	13.26	13.36	10.61	9.26	13.41	14.27	14.26	10.64	11.67	30

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-9b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 9 (California, Nevada, Arizona, Hawaii, Trust Territory of the Pacific Islands, American Samoa, Guam)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.96	0.89	0.89	0.88	0.96	0.88	0.91	0.86	1.01	0.97	0.89	0.91	0.88	0.92	0.89	1
2	1.84	1.70	1.70	1.72	1.84	1.69	1.74	1.67	1.93	1.85	1.69	1.75	1.70	1.77	1.69	2
3	2.63	2.46	2.46	2.50	2.63	2.45	2.51	2.40	2.78	2.64	2.45	2.54	2.45	2.55	2.44	3
4	3.34	3.17	3.17	3.29	3.34	3.17	3.24	3.14	3.57	3.35	3.17	3.28	3.21	3.26	3.14	4
5	3.99	3.84	3.84	4.06	3.99	3.86	3.93	3.85	4.29	4.01	3.85	3.99	3.94	3.92	3.79	5
6	4.59	4.48	4.48	4.79	4.59	4.52	4.58	4.51	4.97	4.61	4.51	4.66	4.64	4.53	4.40	6
7	5.13	5.10	5.10	5.50	5.14	5.15	5.19	5.14	5.60	5.16	5.14	5.30	5.31	5.09	4.98	7
8	5.64	5.68	5.68	6.18	5.64	5.77	5.77	5.74	6.17	5.67	5.75	5.90	5.96	5.61	5.54	8
9	6.11	6.24	6.24	6.82	6.11	6.36	6.31	6.30	6.71	6.15	6.33	6.48	6.57	6.09	6.06	9
10	6.54	6.77	6.77	7.44	6.55	6.92	6.82	6.83	7.20	6.58	6.89	7.02	7.15	6.53	6.56	10
11	6.94	7.27	7.26	8.03	6.95	7.46	7.30	7.33	7.66	6.99	7.41	7.53	7.71	6.93	7.02	11
12	7.31	7.73	7.73	8.58	7.32	7.96	7.76	7.80	8.08	7.36	7.92	8.01	8.24	7.30	7.46	12
13	7.65	8.18	8.18	9.10	7.66	8.43	8.19	8.25	8.47	7.71	8.39	8.47	8.74	7.65	7.86	13
14	7.96	8.60	8.59	9.59	7.97	8.88	8.60	8.68	8.82	8.03	8.85	8.90	9.22	7.96	8.23	14
15	8.25	8.99	8.99	10.05	8.26	9.31	8.99	9.08	9.15	8.33	9.26	9.30	9.68	8.25	8.59	15
16	8.51	9.36	9.35	10.49	8.52	9.71	9.36	9.46	9.45	8.60	9.68	9.69	10.11	8.52	8.91	16
17	8.76	9.71	9.70	10.90	8.76	10.08	9.70	9.81	9.73	8.84	10.07	10.05	10.52	8.76	9.21	17
18	8.98	10.03	10.02	11.29	8.98	10.43	10.02	10.15	9.98	9.07	10.42	10.39	10.91	8.99	9.50	18
19	9.18	10.33	10.32	11.65	9.19	10.76	10.33	10.46	10.21	9.28	10.76	10.70	11.28	9.19	9.76	19
20	9.37	10.62	10.61	11.99	9.37	11.07	10.61	10.76	10.43	9.47	11.08	11.00	11.63	9.38	10.00	20
21	9.53	10.89	10.88	12.31	9.54	11.37	10.88	11.04	10.62	9.65	11.38	11.28	11.96	9.55	10.23	21
22	9.69	11.14	11.13	12.62	9.70	11.64	11.14	11.30	10.80	9.81	11.67	11.55	12.27	9.71	10.44	22
23	9.82	11.38	11.37	12.90	9.83	11.90	11.38	11.55	10.96	9.95	11.94	11.80	12.57	9.85	10.64	23
24	9.95	11.61	11.59	13.17	9.96	12.15	11.61	11.79	11.11	10.08	12.20	12.04	12.85	9.98	10.83	24
25	10.06	11.82	11.80	13.42	10.07	12.38	11.83	12.01	11.25	10.20	12.45	12.26	13.11	10.10	11.00	25
	*** Extended Series ***															
26	10.17	12.02	12.00	13.66	10.18	12.60	12.03	12.22	11.37	10.31	12.68	12.47	13.37	10.21	11.17	26
27	10.26	12.21	12.19	13.89	10.27	12.81	12.23	12.42	11.48	10.40	12.90	12.67	13.60	10.32	11.32	27
28	10.34	12.39	12.37	14.10	10.35	13.01	12.41	12.61	11.59	10.49	13.11	12.86	13.83	10.41	11.46	28
29	10.42	12.56	12.53	14.30	10.43	13.19	12.58	12.79	11.69	10.57	13.30	13.04	14.04	10.49	11.60	29
30	10.49	12.72	12.69	14.49	10.50	13.37	12.75	12.95	11.77	10.64	13.49	13.21	14.25	10.57	11.72	30

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-10b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
DoE Region 10 (Washington, Oregon, Idaho, Alaska)

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.87	0.89	0.89	0.90	0.87	0.89	0.91	0.90	0.91	0.85	0.89	0.91	0.91	0.92	0.89	1
2	1.65	1.70	1.70	1.72	1.65	1.69	1.74	1.73	1.75	1.62	1.70	1.74	1.73	1.77	1.69	2
3	2.37	2.46	2.46	2.47	2.37	2.46	2.51	2.48	2.51	2.33	2.46	2.52	2.49	2.54	2.44	3
4	3.02	3.17	3.18	3.18	3.02	3.17	3.24	3.21	3.21	2.97	3.17	3.25	3.22	3.26	3.14	4
5	3.62	3.84	3.84	3.87	3.62	3.85	3.92	3.91	3.86	3.56	3.85	3.94	3.93	3.91	3.78	5
6	4.19	4.48	4.48	4.51	4.19	4.51	4.55	4.56	4.45	4.13	4.50	4.59	4.61	4.52	4.40	6
7	4.71	5.08	5.09	5.11	4.71	5.14	5.15	5.19	5.00	4.65	5.13	5.20	5.26	5.08	4.98	7
8	5.17	5.66	5.66	5.69	5.17	5.74	5.71	5.78	5.50	5.11	5.73	5.78	5.87	5.60	5.53	8
9	5.60	6.21	6.21	6.23	5.60	6.32	6.24	6.34	5.97	5.55	6.30	6.32	6.46	6.07	6.05	9
10	6.01	6.72	6.73	6.74	6.01	6.87	6.73	6.88	6.40	5.96	6.85	6.83	7.02	6.51	6.55	10
11	6.38	7.21	7.22	7.23	6.38	7.39	7.20	7.38	6.79	6.33	7.37	7.31	7.56	6.92	7.00	11
12	6.72	7.68	7.68	7.69	6.72	7.89	7.64	7.86	7.15	6.68	7.87	7.77	8.07	7.29	7.43	12
13	7.04	8.11	8.11	8.12	7.04	8.35	8.06	8.31	7.48	7.01	8.34	8.20	8.55	7.63	7.83	13
14	7.33	8.52	8.52	8.53	7.33	8.80	8.46	8.74	7.79	7.31	8.79	8.61	9.02	7.95	8.21	14
15	7.60	8.91	8.91	8.91	7.60	9.21	8.84	9.15	8.07	7.58	9.21	8.99	9.46	8.24	8.56	15
16	7.84	9.27	9.27	9.27	7.84	9.60	9.19	9.53	8.33	7.83	9.61	9.35	9.88	8.50	8.88	16
17	8.07	9.61	9.61	9.62	8.07	9.97	9.52	9.89	8.57	8.07	9.99	9.69	10.27	8.74	9.18	17
18	8.27	9.93	9.93	9.94	8.28	10.31	9.84	10.23	8.79	8.29	10.34	10.01	10.64	8.97	9.46	18
19	8.46	10.23	10.22	10.24	8.46	10.64	10.13	10.54	8.99	8.47	10.67	10.31	11.00	9.17	9.72	19
20	8.64	10.51	10.50	10.52	8.64	10.94	10.41	10.84	9.17	8.65	10.99	10.59	11.33	9.36	9.96	20
21	8.79	10.77	10.77	10.79	8.80	11.23	10.67	11.13	9.34	8.82	11.29	10.86	11.65	9.53	10.19	21
22	8.93	11.02	11.01	11.04	8.94	11.50	10.92	11.40	9.49	8.97	11.57	11.11	11.95	9.69	10.40	22
23	9.06	11.25	11.25	11.28	9.07	11.75	11.15	11.65	9.63	9.10	11.84	11.35	12.24	9.83	10.60	23
24	9.18	11.48	11.47	11.50	9.18	11.99	11.37	11.89	9.76	9.22	12.09	11.57	12.51	9.96	10.78	24
25	9.29	11.69	11.67	11.71	9.29	12.22	11.58	12.11	9.88	9.33	12.33	11.78	12.76	10.08	10.96	25
								*** Extended Series ***								
26	9.38	11.88	11.87	11.91	9.38	12.44	11.78	12.32	9.98	9.43	12.56	11.98	13.01	10.19	11.12	26
27	9.47	12.07	12.06	12.09	9.47	12.64	11.97	12.52	10.08	9.52	12.78	12.17	13.24	10.29	11.27	27
28	9.55	12.25	12.23	12.27	9.55	12.83	12.15	12.71	10.17	9.60	12.98	12.35	13.45	10.39	11.41	28
29	9.62	12.41	12.39	12.44	9.62	13.02	12.31	12.89	10.26	9.68	13.18	12.52	13.66	10.47	11.54	29
30	9.68	12.57	12.55	12.59	9.69	13.19	12.47	13.06	10.33	9.75	13.36	12.68	13.86	10.55	11.67	30

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE B-11b. UPW* DISCOUNT FACTORS ADJUSTED FOR AVERAGE FUEL PRICE ESCALATION
BY END-USE SECTOR AND MAJOR FUEL
DISCOUNT RATE = 10 PERCENT
United States Average

	RESIDENTIAL				COMMERCIAL					INDUSTRIAL					TRANSPORTATION	
SP	ELEC	DIST	LPG	NATGAS	ELEC	DIST	RESID	NATGAS	COAL	ELEC	DIST	RESID	NATGAS	COAL	GASLNE	SP
1	0.92	0.89	0.89	0.91	0.92	0.89	0.91	0.91	0.92	0.92	0.89	0.90	0.91	0.93	0.89	1
2	1.75	1.70	1.70	1.76	1.76	1.69	1.74	1.75	1.77	1.76	1.69	1.74	1.77	1.80	1.69	2
3	2.51	2.46	2.46	2.56	2.53	2.45	2.51	2.54	2.55	2.52	2.46	2.52	2.58	2.60	2.44	3
4	3.20	3.18	3.17	3.32	3.21	3.17	3.24	3.30	3.26	3.21	3.17	3.27	3.36	3.34	3.14	4
5	3.81	3.84	3.84	4.06	3.83	3.84	3.93	4.03	3.93	3.82	3.85	3.98	4.12	4.03	3.78	5
6	4.37	4.48	4.48	4.76	4.39	4.49	4.59	4.72	4.54	4.38	4.50	4.66	4.85	4.67	4.40	6
7	4.88	5.09	5.09	5.44	4.90	5.12	5.21	5.40	5.10	4.88	5.12	5.30	5.56	5.26	4.98	7
8	5.34	5.66	5.67	6.08	5.36	5.72	5.79	6.04	5.61	5.34	5.72	5.91	6.25	5.81	5.53	8
9	5.75	6.21	6.23	6.70	5.78	6.29	6.34	6.65	6.09	5.75	6.30	6.49	6.91	6.32	6.05	9
10	6.13	6.73	6.75	7.29	6.16	6.83	6.86	7.24	6.52	6.12	6.84	7.05	7.55	6.79	6.54	10
11	6.47	7.22	7.25	7.85	6.51	7.35	7.35	7.80	6.93	6.47	7.36	7.57	8.15	7.22	7.00	11
12	6.79	7.68	7.71	8.37	6.83	7.84	7.81	8.32	7.30	6.79	7.86	8.06	8.73	7.62	7.43	12
13	7.09	8.11	8.15	8.87	7.13	8.30	8.25	8.82	7.64	7.08	8.33	8.52	9.28	7.99	7.83	13
14	7.36	8.52	8.57	9.33	7.40	8.73	8.67	9.29	7.95	7.36	8.77	8.96	9.80	8.32	8.20	14
15	7.61	8.91	8.96	9.78	7.65	9.14	9.07	9.74	8.24	7.61	9.20	9.38	10.30	8.63	8.55	15
16	7.84	9.27	9.33	10.19	7.88	9.53	9.44	10.16	8.50	7.84	9.59	9.77	10.77	8.92	8.87	16
17	8.05	9.61	9.67	10.58	8.10	9.89	9.79	10.55	8.75	8.05	9.97	10.14	11.22	9.18	9.17	17
18	8.24	9.93	9.99	10.95	8.29	10.23	10.12	10.92	8.97	8.25	10.32	10.48	11.64	9.42	9.45	18
19	8.42	10.23	10.29	11.29	8.47	10.55	10.42	11.27	9.17	8.42	10.66	10.80	12.04	9.63	9.71	19
20	8.58	10.51	10.58	11.62	8.63	10.85	10.71	11.60	9.36	8.59	10.97	11.11	12.42	9.83	9.95	20
21	8.72	10.77	10.84	11.93	8.78	11.14	10.99	11.91	9.53	8.74	11.27	11.39	12.78	10.02	10.18	21
22	8.86	11.02	11.09	12.21	8.91	11.40	11.25	12.21	9.69	8.87	11.55	11.66	13.12	10.19	10.39	22
23	8.98	11.26	11.33	12.49	9.03	11.66	11.49	12.48	9.83	8.99	11.82	11.92	13.45	10.34	10.59	23
24	9.08	11.48	11.55	12.74	9.14	11.89	11.73	12.75	9.96	9.11	12.07	12.16	13.75	10.48	10.77	24
25	9.18	11.69	11.76	12.98	9.24	12.12	11.95	12.99	10.08	9.21	12.31	12.39	14.04	10.61	10.95	25
*** Extended Series ***																
26	9.27	11.89	11.96	13.21	9.33	12.33	12.16	13.23	10.19	9.30	12.54	12.61	14.32	10.73	11.11	26
27	9.35	12.07	12.15	13.42	9.41	12.53	12.35	13.45	10.29	9.38	12.75	12.81	14.58	10.83	11.26	27
28	9.43	12.25	12.33	13.63	9.49	12.72	12.54	13.65	10.38	9.46	12.96	13.01	14.82	10.93	11.40	28
29	9.49	12.41	12.49	13.82	9.55	12.90	12.72	13.85	10.47	9.52	13.15	13.19	15.06	11.02	11.53	29
30	9.55	12.57	12.65	13.99	9.61	13.07	12.88	14.04	10.54	9.59	13.34	13.36	15.28	11.11	11.66	30

SAMPLE FACTORS

APPENDIX C

ENERGY PRICES AND PROJECTIONS

Note: **These are not up-to-date energy prices and projections for actual use in project evaluation.** They are presented solely to illustrate the LCC methods in this Handbook. To receive up-to-date energy prices and projections, request the latest edition on National Bureau of Standards Report NBSIR 85-3273, "Energy Prices and Discount Factors for Life-Cycle Cost Analysis," from the U.S. Department of Energy, Office of the Assistant Secretary for Conservation and Renewable Energy, Federal Energy Management Program, CE 10.1, Washington, D.C., 20585.

CONTENTS:

Table C-1. Average Mid-1985 Energy Prices Estimated by DOE. These are regional and national average energy prices for estimating annual energy costs and savings as of the base year. Use these prices as default values for the price per unit of energy in the base year only if you do not know the actual energy price. Note that the mixing of actual and these DoE-estimated base-year prices in the same evaluation should be avoided if possible because differences in the nature of the data could affect the results.

Tables Ca-1 through Ca-11. Projected Energy Price Indices for 1986 through 2010. These are multipliers which when applied to the 1985 prices provide estimates of the corresponding future-year prices in 1985 dollars. These indices are used in the year-by-year calculation procedure of Appendix G, and are used to construct the UPW* factors of Appendix B.

Tables Cb-1 through Cb-11. Projected Average Annual Energy Price Escalation Rates for 5-year Intervals from 1985 through 2010. These are provided to support an earlier version of an LCC computer program which was developed by the National Bureau of Standards and adopted for use by some agencies (listed in Appendix E, Handbook 135, 1982 edition). The new computer program described in Appendix E, (Handbook 135, 1987 edition) incorporates yearly rates of change derived from the indices of the Ca table series rather than the 5-year interval rates.

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

Table C-1. Regional Average Mid-1985 Energy Prices Estimated by the U.S. Department of Energy[a] (mid-1985 $/million Btu)[b]

Region/States	RESIDENTIAL Elec	RESIDENTIAL Dist	RESIDENTIAL LPG	RESIDENTIAL NATGAS	COMMERCIAL Elec	COMMERCIAL Dist	COMMERCIAL Resid	COMMERCIAL Natgas	COMMERCIAL Coal
1/ME, NH, VT, MA, CT, RI	$26.11	$7.84	$8.41	$7.90	$26.03	$6.85	$5.70	$6.28	$2.96
2/NY, NJ, PR, VI	29.05	8.02	8.61	7.88	28.05	6.64	5.49	6.71	2.50
3/PA, MD, WV, DC, DE	21.72	7.75	8.32	6.66	21.42	6.28	5.13	5.99	2.22
4/KY, TN, NC, SC, MS, AL, GA, FL, CANAL ZONE	19.32	7.73	8.29	6.08	19.55	6.10	5.33	5.38	2.03
5/MN, WI, MI, IL, IN, OH	21.49	7.38	7.93	5.96	21.21	6.16	6.32	5.49	2.22
6/TX, NM, OK, AR, LA	20.21	6.25	6.71	5.70	19.56	5.78	4.62	5.29	2.04
7/KS, MO, IA, NE	22.43	7.00	7.52	5.45	21.81	5.95	8.05	4.66	2.27
8/MT, ND, SD, WY, UT, CO	19.74	6.86	7.37	5.33	19.01	6.17	4.72	5.39	1.13
9/CA, NV, AZ, HI, PAC, ISL, AM. SAMOA, GU	20.07	7.19	7.71	5.53	19.83	5.77	5.80	6.32	2.17
10/WA, OR, ID, AK	10.46	7.70	8.26	7.42	10.42	6.16	6.69	6.85	2.80
11/US AVERAGE	20.54	7.75	7.81	6.16	20.78	6.34	5.32	5.68	2.16

[a]Compiled from Tables Ca-1 through CA-11 contained in Barbara C. Lippiatt, Stephen F. Weber, and Rosalie T. Ruegg, Energy Prices and Discount Factors for Life-Cycle Cost Analysis: Annual Supplement to NBS Handbook 135 and NBS Special Publication 709; 1985 Edition, National Bureau of Standards, NBSIR 85-3273, November 1985 (updated annually).

[b]To state the price in terms of some unit other than $/million Btu, use the following equivalencies:

3,412 Btu/kWh of electricity

95,500 Btu/gal of LPG

22,500,000 Btu/ton of steam coal

138,690 Btu/gal of distillate

1,016 Btu/ft^3 of natural gas

125,071 Btu/gal of gasoline

149,690 Btu/gal of residual

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-1. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL
DoE Region 1 (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00) 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	26.11	1.00	1.01	1.04	1.09	1.07	1.06	1.06	1.06	1.08	1.07	1.07
DISTILLATE FUEL	7.84	1.00	0.98	0.98	1.01	1.04	1.07	1.12	1.18	1.23	1.29	1.34
LIQUEFIED PETROLEUM GAS	8.41	1.00	0.98	0.98	1.01	1.04	1.07	1.12	1.18	1.23	1.29	1.34
NATURAL GAS	7.90	1.00	1.00	1.04	1.09	1.15	1.21	1.27	1.35	1.41	1.47	1.53
COMMERCIAL												
ELECTRICITY	26.03	1.00	1.01	1.04	1.09	1.07	1.06	1.06	1.06	1.08	1.07	1.07
DISTILLATE FUEL	6.85	1.00	0.98	0.98	1.01	1.05	1.08	1.14	1.20	1.26	1.33	1.39
RESIDUAL FUEL	5.70	1.00	1.00	1.01	1.04	1.07	1.11	1.15	1.20	1.24	1.28	1.33
NATURAL GAS	6.28	1.00	1.00	1.04	1.10	1.17	1.25	1.32	1.41	1.48	1.56	1.63
STEAM COAL	2.96	1.00	1.01	1.02	1.04	1.05	1.07	1.09	1.11	1.13	1.14	1.16
INDUSTRIAL												
ELECTRICITY	22.97	1.00	1.01	1.05	1.10	1.07	1.07	1.07	1.07	1.09	1.08	1.08
DISTILLATE FUEL	6.72	1.00	0.98	0.98	1.01	1.05	1.08	1.15	1.21	1.27	1.33	1.40
RESIDUAL FUEL	5.08	1.00	1.00	1.01	1.04	1.08	1.12	1.17	1.22	1.27	1.32	1.37
NATURAL GAS	5.16	1.00	1.00	1.07	1.13	1.21	1.31	1.39	1.48	1.56	1.65	1.72
STEAM COAL	2.48	1.00	1.01	1.03	1.04	1.05	1.08	1.10	1.11	1.13	1.15	1.17
TRANSPORTATION												
MOTOR GASOLINE	10.47	1.00	0.98	0.98	1.00	1.02	1.04	1.08	1.13	1.18	1.22	1.27

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00) 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-1, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL

DoE Region 1 (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	1.08	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.18	1.18	1.17	1.17	1.16
DISTILLATE FUEL	1.39	1.44	1.50	1.55	1.61	1.66	1.71	1.76	1.82	1.87	1.94	2.02	2.09	2.17	2.26
LIQUEFIED PETROLEUM GAS	1.39	1.44	1.49	1.55	1.60	1.65	1.70	1.76	1.81	1.87	1.93	2.01	2.08	2.16	2.24
NATURAL GAS	1.59	1.65	1.71	1.78	1.85	1.91	1.98	2.04	2.11	2.19	2.26	2.35	2.43	2.52	2.61
COMMERCIAL															
ELECTRICITY	1.08	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18	1.19	1.18	1.18	1.17	1.17	1.17
DISTILLATE FUEL	1.44	1.50	1.56	1.62	1.69	1.74	1.80	1.85	1.91	1.98	2.05	2.13	2.22	2.31	2.40
RESIDUAL FUEL	1.38	1.44	1.50	1.57	1.63	1.69	1.74	1.80	1.87	1.93	2.01	2.09	2.17	2.26	2.36
NATURAL GAS	1.70	1.77	1.84	1.91	1.99	2.06	2.14	2.21	2.29	2.38	2.47	2.56	2.66	2.76	2.87
STEAM COAL	1.18	1.19	1.21	1.22	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34
INDUSTRIAL															
ELECTRICITY	1.09	1.11	1.13	1.15	1.17	1.18	1.19	1.20	1.21	1.22	1.22	1.22	1.22	1.21	1.21
DISTILLATE FUEL	1.46	1.52	1.59	1.67	1.74	1.80	1.87	1.93	2.00	2.07	2.16	2.26	2.35	2.46	2.56
RESIDUAL FUEL	1.42	1.48	1.54	1.60	1.67	1.72	1.78	1.83	1.89	1.96	2.03	2.11	2.20	2.29	2.38
NATURAL GAS	1.80	1.89	1.98	2.07	2.17	2.27	2.36	2.45	2.55	2.66	2.77	2.89	3.01	3.14	3.27
STEAM COAL	1.18	1.20	1.21	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34
TRANSPORTATION															
MOTOR GASOLINE	1.30	1.34	1.37	1.41	1.45	1.48	1.51	1.55	1.58	1.62	1.67	1.71	1.76	1.81	1.87

	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)														
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-2. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL
DoE Region 2 (New York, New Jersey, Puerto Rico, Virgin Islands)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)										
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	29.05	1.00	0.98	1.01	1.05	1.03	1.01	1.00	0.99	0.98	0.98	0.97
DISTILLATE FUEL	8.02	1.00	0.98	0.98	1.01	1.04	1.07	1.12	1.17	1.23	1.28	1.33
LIQUEFIED PETROLEUM GAS	8.61	1.00	0.98	0.98	1.01	1.04	1.07	1.12	1.17	1.23	1.28	1.33
NATURAL GAS	7.88	1.00	1.00	1.02	1.04	1.09	1.13	1.18	1.23	1.29	1.34	1.39
COMMERCIAL												
ELECTRICITY	28.05	1.00	0.98	1.01	1.05	1.03	1.01	1.00	0.99	0.98	0.97	0.97
DISTILLATE FUEL	6.64	1.00	0.98	0.98	1.01	1.05	1.08	1.15	1.21	1.27	1.34	1.40
RESIDUAL FUEL	5.49	1.00	1.00	1.01	1.04	1.07	1.12	1.16	1.20	1.25	1.29	1.34
NATURAL GAS	6.71	1.00	1.00	1.01	1.04	1.08	1.14	1.19	1.25	1.30	1.37	1.42
STEAM COAL	2.50	1.00	1.01	1.02	1.03	1.05	1.07	1.08	1.09	1.10	1.12	1.13
INDUSTRIAL												
ELECTRICITY	22.61	1.00	0.98	1.02	1.06	1.04	1.02	1.00	0.98	0.97	0.97	0.97
DISTILLATE FUEL	6.70	1.00	0.98	0.98	1.01	1.05	1.08	1.15	1.21	1.27	1.33	1.40
RESIDUAL FUEL	5.00	1.00	1.00	1.01	1.04	1.08	1.13	1.18	1.22	1.27	1.32	1.37
NATURAL GAS	5.38	1.00	1.00	1.03	1.07	1.13	1.19	1.25	1.32	1.38	1.45	1.50
STEAM COAL	2.02	1.00	1.02	1.03	1.05	1.07	1.08	1.10	1.12	1.13	1.15	1.16
TRANSPORTATION												
MOTOR GASOLINE	10.38	1.00	0.98	0.98	1.00	1.02	1.04	1.09	1.13	1.18	1.23	1.27

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)										
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-2, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL
DoE Region 2 (New York, New Jersey, Puerto Rico, Virgin Islands)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	0.99	1.00	1.01	1.03	1.04	1.05	1.06	1.06	1.07	1.08	1.08	1.07	1.07	1.07	1.06
DISTILLATE FUEL	1.38	1.43	1.49	1.54	1.60	1.65	1.70	1.75	1.81	1.86	1.93	2.01	2.08	2.16	2.25
LIQUEFIED PETROLEUM GAS	1.38	1.43	1.48	1.54	1.60	1.64	1.69	1.75	1.80	1.85	1.92	2.00	2.07	2.15	2.23
NATURAL GAS	1.44	1.50	1.56	1.62	1.68	1.74	1.80	1.86	1.92	1.99	2.06	2.14	2.21	2.29	2.38
COMMERCIAL															
ELECTRICITY	0.99	1.00	1.01	1.03	1.04	1.05	1.06	1.06	1.07	1.08	1.08	1.07	1.07	1.07	1.06
DISTILLATE FUEL	1.46	1.51	1.58	1.64	1.70	1.76	1.81	1.87	1.93	2.00	2.07	2.15	2.24	2.33	2.42
RESIDUAL FUEL	1.40	1.46	1.52	1.58	1.65	1.71	1.76	1.82	1.88	1.95	2.03	2.11	2.20	2.29	2.38
NATURAL GAS	1.48	1.54	1.61	1.67	1.74	1.80	1.87	1.93	2.00	2.07	2.15	2.24	2.32	2.41	2.50
STEAM COAL	1.15	1.16	1.17	1.19	1.20	1.22	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30
INDUSTRIAL															
ELECTRICITY	0.98	1.00	1.01	1.03	1.05	1.06	1.07	1.08	1.09	1.10	1.10	1.09	1.09	1.09	1.09
DISTILLATE FUEL	1.46	1.53	1.59	1.67	1.74	1.80	1.87	1.93	2.00	2.08	2.17	2.26	2.36	2.46	2.57
RESIDUAL FUEL	1.43	1.49	1.55	1.61	1.67	1.73	1.78	1.84	1.90	1.96	2.04	2.12	2.21	2.29	2.39
NATURAL GAS	1.58	1.65	1.73	1.82	1.91	1.98	2.06	2.15	2.24	2.33	2.43	2.53	2.64	2.75	2.87
STEAM COAL	1.18	1.19	1.21	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34
TRANSPORTATION															
MOTOR GASOLINE	1.31	1.34	1.38	1.41	1.45	1.48	1.52	1.55	1.59	1.62	1.67	1.72	1.77	1.82	1.87

	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)														
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-3. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 3 (Pennsylvania, Maryland, West Virginia, Virginia, District of Columbia, Delaware)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)										
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	21.72	1.00	0.99	1.00	1.00	0.98	0.97	0.97	0.97	0.97	0.98	0.98
DISTILLATE FUEL	7.75	1.00	0.98	0.98	1.01	1.04	1.07	1.13	1.18	1.23	1.29	1.34
LIQUEFIED PETROLEUM GAS	8.32	1.00	0.98	0.98	1.01	1.04	1.07	1.13	1.18	1.23	1.29	1.34
NATURAL GAS	6.66	1.00	1.01	1.03	1.06	1.11	1.16	1.20	1.26	1.31	1.36	1.41
COMMERCIAL												
ELECTRICITY	21.42	1.00	0.99	1.00	1.00	0.98	0.97	0.97	0.97	0.97	0.98	0.98
DISTILLATE FUEL	6.28	1.00	0.98	0.98	1.01	1.05	1.09	1.16	1.22	1.29	1.36	1.43
RESIDUAL FUEL	5.13	1.00	1.00	1.01	1.04	1.07	1.12	1.17	1.22	1.27	1.32	1.36
NATURAL GAS	5.99	1.00	1.00	1.02	1.04	1.09	1.14	1.19	1.24	1.29	1.34	1.39
STEAM COAL	2.22	1.00	1.01	1.02	1.04	1.05	1.07	1.08	1.09	1.11	1.12	1.14
INDUSTRIAL												
ELECTRICITY	18.23	1.00	0.98	1.00	1.00	0.98	0.97	0.97	0.97	0.97	0.98	0.98
DISTILLATE FUEL	6.47	1.00	0.98	0.98	1.01	1.05	1.09	1.15	1.22	1.28	1.35	1.41
RESIDUAL FUEL	4.61	1.00	1.00	1.01	1.04	1.09	1.14	1.19	1.24	1.30	1.35	1.41
NATURAL GAS	4.83	1.00	1.00	1.03	1.07	1.13	1.20	1.25	1.31	1.36	1.43	1.48
STEAM COAL	1.81	1.00	1.01	1.02	1.03	1.05	1.07	1.09	1.10	1.11	1.13	1.14
TRANSPORTATION												
MOTOR GASOLINE	10.36	1.00	0.98	0.98	1.00	1.02	1.04	1.09	1.13	1.18	1.23	1.28

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)										
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-3, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 3 (Pennsylvania, Maryland, West Virginia, Virginia, District of Columbia, Delaware)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	1.00	1.01	1.02	1.04	1.05	1.06	1.07	1.08	1.09	1.09	1.09	1.09	1.08	1.08	1.07
DISTILLATE FUEL	1.39	1.45	1.50	1.56	1.61	1.66	1.71	1.77	1.82	1.88	1.95	2.02	2.10	2.18	2.26
LIQUEFIED PETROLEUM GAS	1.39	1.44	1.50	1.55	1.61	1.66	1.71	1.76	1.81	1.87	1.94	2.01	2.09	2.17	2.25
NATURAL GAS	1.46	1.52	1.58	1.64	1.71	1.76	1.82	1.89	1.96	2.02	2.09	2.17	2.25	2.33	2.41
COMMERCIAL															
ELECTRICITY	1.00	1.01	1.02	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.09	1.09	1.08	1.08	1.08
DISTILLATE FUEL	1.48	1.54	1.60	1.66	1.73	1.79	1.84	1.90	1.96	2.03	2.11	2.19	2.28	2.37	2.46
RESIDUAL FUEL	1.42	1.48	1.54	1.61	1.68	1.73	1.79	1.85	1.92	1.98	2.06	2.15	2.23	2.33	2.42
NATURAL GAS	1.45	1.51	1.57	1.64	1.70	1.76	1.83	1.89	1.96	2.03	2.11	2.19	2.27	2.36	2.45
STEAM COAL	1.15	1.16	1.18	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.29	1.30
INDUSTRIAL															
ELECTRICITY	1.00	1.01	1.03	1.05	1.06	1.07	1.08	1.09	1.11	1.12	1.11	1.11	1.11	1.11	1.10
DISTILLATE FUEL	1.47	1.54	1.61	1.68	1.76	1.82	1.89	1.96	2.02	2.10	2.19	2.28	2.38	2.48	2.59
RESIDUAL FUEL	1.46	1.52	1.58	1.64	1.71	1.77	1.82	1.89	1.95	2.01	2.09	2.17	2.26	2.35	2.44
NATURAL GAS	1.55	1.63	1.71	1.79	1.88	1.95	2.04	2.12	2.21	2.30	2.39	2.50	2.60	2.71	2.83
STEAM COAL	1.16	1.17	1.19	1.21	1.22	1.23	1.23	1.25	1.26	1.26	1.27	1.29	1.29	1.30	1.31
TRANSPORTATION															
MOTOR GASOLINE	1.31	1.34	1.38	1.41	1.45	1.48	1.52	1.55	1.59	1.62	1.67	1.72	1.77	1.82	1.87

	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)														
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-4. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 4 (Kentucky, Tennessee, North Carolina, South Carolina, Mississippi, Alabama, Georgia, Florida, Canal Zone)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)										
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	19.32	1.00	0.98	0.97	0.97	0.97	0.96	0.95	0.94	0.92	0.91	0.89
DISTILLATE FUEL	7.73	1.00	0.98	0.98	1.01	1.04	1.07	1.13	1.18	1.23	1.29	1.34
LIQUEFIED PETROLEUM GAS	8.29	1.00	0.98	0.98	1.01	1.04	1.07	1.13	1.18	1.24	1.29	1.35
NATURAL GAS	6.08	1.00	1.00	1.04	1.09	1.16	1.24	1.32	1.41	1.49	1.58	1.66
COMMERCIAL												
ELECTRICITY	19.55	1.00	0.98	0.97	0.97	0.97	0.96	0.95	0.94	0.92	0.91	0.89
DISTILLATE FUEL	6.10	1.00	0.97	0.98	1.01	1.05	1.09	1.16	1.23	1.30	1.37	1.44
RESIDUAL FUEL	5.33	1.00	1.00	1.01	1.04	1.07	1.12	1.16	1.21	1.26	1.30	1.35
NATURAL GAS	5.38	1.00	0.99	1.02	1.07	1.13	1.22	1.30	1.39	1.47	1.57	1.65
STEAM COAL	2.03	1.00	1.02	1.03	1.04	1.06	1.08	1.09	1.10	1.12	1.13	1.15
INDUSTRIAL												
ELECTRICITY	17.00	1.00	0.98	0.97	0.96	0.96	0.95	0.94	0.94	0.91	0.89	0.88
DISTILLATE FUEL	6.28	1.00	0.98	0.98	1.01	1.05	1.09	1.16	1.22	1.29	1.36	1.42
RESIDUAL FUEL	[illegible]	1.00	1.00	1.01	1.05	1.09	1.15	1.21	1.26	1.32	1.38	1.44
NATURAL GAS	4.31	1.00	0.99	1.02	1.08	1.15	1.25	1.34	1.45	1.54	1.64	1.73
STEAM COAL	2.01	1.00	1.02	1.03	1.05	1.07	1.09	1.11	1.12	1.14	1.16	1.18
TRANSPORTATION												
MOTOR GASOLINE	10.15	1.00	0.98	0.98	1.00	1.02	1.04	1.09	1.13	1.18	1.23	1.28

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)										
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-4, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 4 (Kentucky, Tennessee, North Carolina, South Carolina, Mississippi, Alabama, Georgia, Florida, Canal Zone)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	0.90	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.98	0.99	0.99	0.98	0.98	0.98	0.97
DISTILLATE FUEL	1.39	1.45	1.50	1.56	1.61	1.66	1.72	1.77	1.82	1.88	1.95	2.03	2.10	2.18	2.26
LIQUEFIED PETROLEUM GAS	1.39	1.45	1.50	1.55	1.61	1.66	1.71	1.76	1.82	1.87	1.94	2.02	2.09	2.17	2.25
NATURAL GAS	1.72	1.79	1.86	1.93	2.00	2.07	2.14	2.22	2.29	2.37	2.46	2.55	2.64	2.74	2.84
COMMERCIAL															
ELECTRICITY	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	0.99	0.99	0.99	0.98	0.98	0.98
DISTILLATE FUEL	1.49	1.55	1.61	1.68	1.74	1.80	1.86	1.92	1.98	2.04	2.12	2.21	2.30	2.39	2.48
RESIDUAL FUEL	1.41	1.47	1.53	1.59	1.66	1.72	1.77	1.83	1.90	1.96	2.04	2.13	2.21	2.30	2.40
NATURAL GAS	1.72	1.79	1.86	1.94	2.02	2.09	2.16	2.24	2.32	2.40	2.50	2.59	2.69	2.79	2.90
STEAM COAL	1.16	1.17	1.19	1.20	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32
INDUSTRIAL															
ELECTRICITY	0.89	0.91	0.92	0.93	0.95	0.96	0.97	0.98	0.99	1.00	0.99	0.99	0.99	0.99	0.99
DISTILLATE FUEL	1.49	1.56	1.63	1.70	1.77	1.84	1.90	1.97	2.04	2.12	2.21	2.30	2.40	2.51	2.61
RESIDUAL FUEL	1.50	1.56	1.62	1.68	1.75	1.81	1.87	1.93	2.00	2.06	2.14	2.23	2.31	2.41	2.50
NATURAL GAS	1.82	1.91	2.00	2.09	2.20	2.29	2.38	2.48	2.58	2.69	2.80	2.92	3.04	3.17	3.31
STEAM COAL	1.20	1.21	1.23	1.24	1.26	1.27	1.28	1.28	1.29	1.30	1.31	1.32	1.34	1.35	1.36
TRANSPORTATION															
MOTOR GASOLINE	1.31	1.35	1.38	1.42	1.46	1.49	1.52	1.56	1.59	1.63	1.68	1.73	1.78	1.83	1.88

PROJECTED WORLD OIL PRICE INDICES
(MID-1985 = 1.00)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

SAMPLE INDICES

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-5. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL
DoE Region 5 (Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)										
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	21.49	1.00	1.03	1.04	1.03	1.00	0.98	0.96	0.94	0.92	0.91	0.90
DISTILLATE FUEL	7.38	1.00	0.98	0.98	1.01	1.04	1.08	1.13	1.19	1.25	1.30	1.36
LIQUEFIED PETROLEUM GAS	7.93	1.00	0.98	0.98	1.01	1.04	1.08	1.13	1.19	1.24	1.30	1.36
NATURAL GAS	5.96	1.00	1.01	1.03	1.06	1.11	1.17	1.24	1.32	1.39	1.47	1.55
COMMERCIAL												
ELECTRICITY	21.21	1.00	1.03	1.04	1.03	1.00	0.98	0.96	0.94	0.92	0.90	0.90
DISTILLATE FUEL	6.16	1.00	0.97	0.98	1.01	1.05	1.09	1.16	1.23	1.29	1.36	1.43
RESIDUAL FUEL	6.32	1.00	1.00	1.01	1.03	1.08	1.10	1.14	1.18	1.22	1.26	1.30
NATURAL GAS	5.49	1.00	1.00	1.02	1.06	1.11	1.17	1.24	1.32	1.40	1.48	1.56
STEAM COAL	2.22	1.00	1.01	1.02	1.03	1.05	1.07	1.08	1.09	1.11	1.12	1.13
INDUSTRIAL												
ELECTRICITY	18.02	1.00	1.03	1.05	1.03	1.00	0.97	0.95	0.93	0.91	0.89	0.88
DISTILLATE FUEL	6.55	1.00	0.98	0.98	1.01	1.05	1.09	1.15	1.21	1.28	1.34	1.41
RESIDUAL FUEL	3.58	1.00	1.00	1.01	1.06	1.11	1.18	1.25	1.32	1.39	1.46	1.53
NATURAL GAS	4.95	1.00	1.00	1.02	1.06	1.11	1.18	1.25	1.34	1.42	1.50	1.58
STEAM COAL	1.92	1.00	1.01	1.02	1.03	1.04	1.06	1.08	1.09	1.10	1.11	1.12
TRANSPORTATION												
MOTOR GASOLINE	10.72	1.00	0.98	0.98	1.00	1.02	1.04	1.08	1.13	1.17	1.22	1.27

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)										
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-5, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 5 (Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	0.91	0.92	0.93	0.94	0.96	0.97	0.97	0.98	0.99	1.00	0.99	0.99	0.99	0.98	0.98
DISTILLATE FUEL	1.41	1.46	1.52	1.58	1.63	1.69	1.74	1.79	1.85	1.90	1.98	2.05	2.13	2.21	2.29
LIQUEFIED PETROLEUM GAS	1.41	1.46	1.52	1.57	1.63	1.68	1.73	1.78	1.84	1.89	1.96	2.04	2.11	2.19	2.27
NATURAL GAS	1.61	1.67	1.74	1.80	1.87	1.94	2.00	2.07	2.14	2.22	2.30	2.38	2.47	2.56	2.65
COMMERCIAL															
ELECTRICITY	0.91	0.92	0.93	0.94	0.96	0.96	0.97	0.98	0.99	1.00	0.99	0.99	0.99	0.98	0.98
DISTILLATE FUEL	1.49	1.55	1.61	1.67	1.74	1.79	1.85	1.91	1.97	2.04	2.12	2.20	2.29	2.38	2.47
RESIDUAL FUEL	1.35	1.41	1.47	1.53	1.59	1.65	1.70	1.76	1.82	1.88	1.96	2.04	2.12	2.21	2.30
NATURAL GAS	1.63	1.69	1.76	1.84	1.91	1.98	2.05	2.12	2.20	2.28	2.36	2.46	2.55	2.65	2.75
STEAM COAL	1.14	1.16	1.17	1.19	1.21	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30
INDUSTRIAL															
ELECTRICITY	0.89	0.91	0.92	0.93	0.95	0.96	0.97	0.98	0.99	1.00	1.00	0.99	0.99	0.99	0.99
DISTILLATE FUEL	1.47	1.53	1.60	1.68	1.75	1.81	1.88	1.95	2.02	2.09	2.18	2.27	2.37	2.47	2.58
RESIDUAL FUEL	1.59	1.65	1.72	1.79	1.86	1.92	1.98	2.05	2.12	2.19	2.27	2.36	2.46	2.55	2.65
NATURAL GAS	1.66	1.74	1.82	1.91	2.00	2.09	2.17	2.26	2.35	2.45	2.55	2.66	2.78	2.89	3.01
STEAM COAL	1.14	1.15	1.16	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.25	1.26	1.28	1.29
TRANSPORTATION															
MOTOR GASOLINE	1.30	1.33	1.37	1.40	1.44	1.47	1.51	1.54	1.58	1.61	1.66	1.71	1.76	1.81	1.86

	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)														
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-6. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 6 (Texas, New Mexico, Oklahoma, Arkansas, Louisiana)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00) 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	20.21	1.00	1.03	1.05	1.05	1.05	1.06	1.07	1.08	1.10	1.11	1.13
DISTILLATE FUEL	6.25	1.00	0.98	0.98	1.01	1.05	1.09	1.16	1.22	1.29	1.36	1.43
LIQUEFIED PETROLEUM GAS	6.71	1.00	0.98	0.98	1.01	1.05	1.09	1.16	1.22	1.29	1.36	1.43
NATURAL GAS	5.70	1.00	1.03	1.07	1.12	1.18	1.25	1.32	1.40	1.48	1.57	1.65
COMMERCIAL												
ELECTRICITY	19.56	1.00	1.03	1.05	1.06	1.06	1.06	1.08	1.09	1.10	1.11	1.14
DISTILLATE FUEL	5.78	1.00	0.97	0.98	1.02	1.06	1.10	1.17	1.24	1.32	1.39	1.46
RESIDUAL FUEL	4.62	1.00	1.00	1.01	1.04	1.09	1.14	1.19	1.24	1.30	1.35	1.41
NATURAL GAS	5.29	1.00	1.01	1.05	1.09	1.13	1.20	1.27	1.35	1.43	1.51	1.60
STEAM COAL	2.04	1.00	1.02	1.03	1.03	1.05	1.07	1.08	1.10	1.11	1.13	1.15
INDUSTRIAL												
ELECTRICITY	17.16	1.00	1.04	1.06	1.06	1.06	1.07	1.09	1.10	1.12	1.13	1.16
DISTILLATE FUEL	6.04	1.00	0.97	0.98	1.01	1.05	1.09	1.16	1.23	1.30	1.37	1.44
RESIDUAL FUEL	3.93	1.00	1.00	1.01	1.06	1.11	1.17	1.23	1.29	1.36	1.42	1.49
NATURAL GAS	3.91	1.00	1.02	1.07	1.13	1.19	1.28	1.37	1.48	1.58	1.69	1.79
STEAM COAL	2.59	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.15	1.16	1.18	1.20
TRANSPORTATION												
MOTOR GASOLINE	9.89	1.00	0.98	0.98	1.00	1.02	1.04	1.09	1.14	1.19	1.24	1.29

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)										
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-6, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL
DoE Region 6 (Texas, New Mexico, Oklahoma, Arkansas, Louisiana)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	1.15	1.16	1.18	1.19	1.21	1.22	1.23	1.24	1.25	1.26	1.25	1.25	1.24	1.24	1.23
DISTILLATE FUEL	1.48	1.54	1.59	1.65	1.71	1.77	1.82	1.88	1.93	1.99	2.07	2.15	2.23	2.32	2.40
LIQUEFIED PETROLEUM GAS	1.48	1.53	1.59	1.65	1.71	1.76	1.81	1.87	1.93	1.99	2.06	2.14	2.22	2.30	2.39
NATURAL GAS	1.72	1.78	1.85	1.92	2.00	2.07	2.14	2.21	2.29	2.37	2.45	2.54	2.63	2.73	2.83
COMMERCIAL															
ELECTRICITY	1.15	1.17	1.18	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.26	1.25	1.25	1.25	1.24
DISTILLATE FUEL	1.52	1.58	1.64	1.71	1.77	1.83	1.89	1.95	2.02	2.08	2.16	2.25	2.34	2.43	2.52
RESIDUAL FUEL	1.46	1.53	1.59	1.66	1.73	1.78	1.85	1.91	1.97	2.04	2.12	2.21	2.30	2.40	2.49
NATURAL GAS	1.66	1.73	1.80	1.88	1.95	2.03	2.10	2.17	2.25	2.33	2.42	2.51	2.61	2.71	2.81
STEAM COAL	1.16	1.18	1.19	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.29	1.30	1.31
INDUSTRIAL															
ELECTRICITY	1.17	1.19	1.21	1.23	1.25	1.26	1.28	1.29	1.30	1.31	1.31	1.31	1.30	1.30	1.30
DISTILLATE FUEL	1.51	1.57	1.64	1.72	1.80	1.86	1.93	2.00	2.07	2.14	2.24	2.33	2.43	2.54	2.65
RESIDUAL FUEL	1.54	1.61	1.67	1.74	1.81	1.87	1.93	1.99	2.06	2.12	2.21	2.30	2.39	2.48	2.58
NATURAL GAS	1.88	1.97	2.07	2.17	2.27	2.37	2.46	2.56	2.67	2.78	2.90	3.02	3.15	3.28	3.42
STEAM COAL	1.22	1.23	1.25	1.26	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38
TRANSPORTATION															
MOTOR GASOLINE	1.32	1.36	1.39	1.43	1.47	1.50	1.53	1.57	1.60	1.64	1.69	1.74	1.79	1.84	1.89
	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)														
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-7. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 7 (Kansas, Missouri, Iowa, Nebraska)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00) 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	22.43	1.00	1.05	1.02	0.98	0.96	0.95	0.94	0.92	0.91	0.90	0.88
DISTILLATE FUEL	7.00	1.00	0.98	0.98	1.01	1.05	1.08	1.14	1.20	1.26	1.32	1.38
LIQUEFIED PETROLEUM GAS	7.52	1.00	0.98	0.98	1.01	1.04	1.08	1.14	1.20	1.26	1.32	1.38
NATURAL GAS	5.45	1.00	1.00	1.04	1.10	1.15	1.23	1.31	1.39	1.47	1.56	1.64
COMMERCIAL												
ELECTRICITY	21.81	1.00	1.05	1.02	0.98	0.95	0.94	0.94	0.92	0.91	0.89	0.88
DISTILLATE FUEL	5.95	1.00	0.97	0.98	1.01	1.05	1.09	1.17	1.24	1.31	1.38	1.45
RESIDUAL FUEL	8.05	1.00	1.00	1.01	1.03	1.05	1.08	1.11	1.14	1.17	1.20	1.23
NATURAL GAS	4.66	1.00	0.99	1.04	1.10	1.15	1.24	1.32	1.42	1.50	1.59	1.68
STEAM COAL	2.27	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.10	1.11
INDUSTRIAL												
ELECTRICITY	19.41	1.00	1.06	1.02	0.98	0.95	0.94	0.93	0.91	0.90	0.88	0.87
DISTILLATE FUEL	6.33	1.00	0.98	0.98	1.01	1.05	1.09	1.16	1.22	1.29	1.35	1.42
RESIDUAL FUEL	3.49	1.00	1.00	1.01	1.06	1.11	1.18	1.25	1.32	1.39	1.47	1.54
NATURAL GAS	4.03	1.00	0.99	1.03	1.09	1.14	1.24	1.31	1.41	1.49	1.58	1.66
STEAM COAL	1.95	1.00	1.02	1.04	1.05	1.07	1.09	1.11	1.12	1.14	1.15	1.17
TRANSPORTATION												
MOTOR GASOLINE	10.13	1.00	0.98	0.98	1.00	1.02	1.04	1.09	1.14	1.18	1.23	1.28

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00) 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-7, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL
DoE Region 7 (Kansas, Missouri, Iowa, Nebraska)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.97	0.98	0.98	0.97	0.97	0.97	0.96
DISTILLATE FUEL	1.43	1.49	1.54	1.60	1.66	1.71	1.76	1.82	1.87	1.93	2.00	2.08	2.16	2.24	2.33
LIQUEFIED PETROLEUM GAS	1.43	1.48	1.54	1.59	1.65	1.70	1.75	1.81	1.86	1.92	1.99	2.07	2.14	2.22	2.31
NATURAL GAS	1.70	1.77	1.83	1.90	1.98	2.05	2.12	2.19	2.26	2.34	2.43	2.52	2.61	2.70	2.80
COMMERCIAL															
ELECTRICITY	0.89	0.90	0.92	0.93	0.94	0.95	0.96	0.96	0.97	0.98	0.98	0.97	0.97	0.97	0.96
DISTILLATE FUEL	1.51	1.56	1.63	1.69	1.76	1.81	1.87	1.93	2.00	2.06	2.14	2.23	2.31	2.40	2.50
RESIDUAL FUEL	1.28	1.34	1.40	1.45	1.52	1.57	1.62	1.68	1.73	1.79	1.86	1.94	2.02	2.10	2.19
NATURAL GAS	1.75	1.82	1.90	1.97	2.05	2.13	2.20	2.28	2.37	2.45	2.54	2.64	2.74	2.85	2.96
STEAM COAL	1.12	1.13	1.15	1.16	1.18	1.19	1.20	1.21	1.21	1.22	1.23	1.24	1.25	1.26	1.27
INDUSTRIAL															
ELECTRICITY	0.88	0.89	0.91	0.92	0.94	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.98	0.98	0.97
DISTILLATE FUEL	1.49	1.55	1.62	1.70	1.77	1.84	1.90	1.97	2.04	2.11	2.20	2.30	2.40	2.50	2.61
RESIDUAL FUEL	1.60	1.66	1.73	1.80	1.87	1.93	2.00	2.06	2.13	2.20	2.28	2.38	2.47	2.57	2.67
NATURAL GAS	1.74	1.83	1.92	2.01	2.11	2.19	2.28	2.38	2.47	2.57	2.68	2.80	2.92	3.04	3.17
STEAM COAL	1.19	1.20	1.22	1.23	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.31	1.32	1.34	1.35
TRANSPORTATION															
MOTOR GASOLINE	1.32	1.35	1.38	1.42	1.46	1.49	1.53	1.56	1.60	1.63	1.68	1.73	1.78	1.83	1.88

	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)														
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-8. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL
DoE Region 8 (Montana, North Dakota, South Dakota, Wyoming, Utah, Colorado)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00) 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	19.74	1.00	1.01	1.00	1.00	0.99	0.98	0.97	0.96	0.94	0.93	0.93
DISTILLATE FUEL	6.86	1.00	0.98	0.98	1.01	1.05	1.08	1.14	1.20	1.27	1.33	1.39
LIQUEFIED PETROLEUM GAS	7.37	1.00	0.98	0.98	1.01	1.05	1.08	1.14	1.20	1.26	1.32	1.39
NATURAL GAS	5.33	1.00	1.00	1.03	1.05	1.07	1.13	1.19	1.25	1.32	1.39	1.46
COMMERCIAL												
ELECTRICITY	19.01	1.00	1.01	1.01	1.00	0.99	0.98	0.97	0.96	0.94	0.93	0.93
DISTILLATE FUEL	6.17	1.00	0.97	0.98	1.01	1.05	1.09	1.16	1.23	1.29	1.36	1.43
RESIDUAL FUEL	4.72	1.00	1.00	1.01	1.04	1.08	1.13	1.19	1.24	1.29	1.35	1.40
NATURAL GAS	5.39	1.00	1.01	1.03	1.04	1.05	1.11	1.17	1.23	1.29	1.36	1.43
STEAM COAL	1.13	1.00	1.03	1.04	1.05	1.06	1.07	1.09	1.10	1.11	1.13	1.14
INDUSTRIAL												
ELECTRICITY	15.93	1.00	1.01	1.01	1.00	0.99	0.98	0.96	0.95	0.93	0.91	0.92
DISTILLATE FUEL	6.23	1.00	0.98	0.98	1.01	1.05	1.09	1.16	1.22	1.29	1.36	1.43
RESIDUAL FUEL	3.31	1.00	1.00	1.01	1.06	1.12	1.19	1.26	1.34	1.41	1.49	1.57
NATURAL GAS	4.27	1.00	1.00	1.02	1.05	1.05	1.14	1.20	1.28	1.35	1.44	1.52
STEAM COAL	1.16	1.00	1.02	1.04	1.04	1.05	1.07	1.09	1.11	1.13	1.13	1.14
TRANSPORTATION												
MOTOR GASOLINE	10.23	1.00	0.98	0.98	1.00	1.02	1.04	1.09	1.13	1.18	1.23	1.28

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00) 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-8, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL
DoE Region 8 (Montana, North Dakota, South Dakota, Wyoming, Utah, Colorado)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	0.94	0.96	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.03	1.03	1.03	1.02	1.02	1.01
DISTILLATE FUEL	1.44	1.49	1.55	1.61	1.67	1.72	1.77	1.83	1.88	1.94	2.02	2.09	2.17	2.25	2.34
LIQUEFIED PETROLEUM GAS	1.44	1.49	1.55	1.60	1.66	1.71	1.77	1.82	1.87	1.93	2.00	2.08	2.16	2.24	2.32
NATURAL GAS	1.52	1.58	1.64	1.70	1.77	1.83	1.89	1.96	2.02	2.09	2.17	2.25	2.33	2.41	2.50
COMMERCIAL															
ELECTRICITY	0.94	0.95	0.97	0.98	0.99	1.00	1.01	1.02	1.03	1.03	1.03	1.03	1.02	1.02	1.01
DISTILLATE FUEL	1.49	1.55	1.61	1.67	1.74	1.79	1.85	1.91	1.97	2.04	2.12	2.20	2.29	2.38	2.47
RESIDUAL FUEL	1.46	1.52	1.58	1.65	1.72	1.78	1.84	1.90	1.96	2.03	2.11	2.20	2.29	2.38	2.48
NATURAL GAS	1.49	1.55	1.61	1.68	1.75	1.81	1.88	1.94	2.01	2.08	2.16	2.25	2.33	2.42	2.52
STEAM COAL	1.15	1.17	1.17	1.19	1.21	1.22	1.23	1.24	1.26	1.26	1.27	1.28	1.28	1.29	1.30
INDUSTRIAL															
ELECTRICITY	0.93	0.94	0.96	0.98	0.99	1.00	1.01	1.02	1.03	1.04	1.04	1.04	1.03	1.03	1.03
DISTILLATE FUEL	1.49	1.56	1.63	1.70	1.78	1.84	1.91	1.98	2.05	2.12	2.21	2.31	2.41	2.51	2.62
RESIDUAL FUEL	1.63	1.70	1.76	1.83	1.91	1.97	2.03	2.10	2.17	2.24	2.33	2.42	2.52	2.62	2.72
NATURAL GAS	1.59	1.67	1.75	1.83	1.92	2.00	2.08	2.17	2.26	2.35	2.45	2.56	2.67	2.78	2.90
STEAM COAL	1.16	1.17	1.19	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.29	1.30	1.31
TRANSPORTATION															
MOTOR GASOLINE	1.31	1.35	1.38	1.42	1.45	1.49	1.52	1.56	1.59	1.63	1.67	1.72	1.77	1.82	1.88

	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)														
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-9. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 9 (California, Nevada, Arizona, Hawaii, Trust Territory of the Pacific Islands, American Samoa, Guam)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00) 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	20.07	1.00	1.06	1.06	1.05	1.04	1.05	1.06	1.07	1.08	1.11	1.13
DISTILLATE FUEL	7.19	1.00	0.98	0.98	1.01	1.04	1.08	1.14	1.19	1.25	1.31	1.37
LIQUEFIED PETROLEUM GAS	7.71	1.00	0.98	0.98	1.01	1.04	1.08	1.14	1.19	1.25	1.31	1.37
NATURAL GAS	5.53	1.00	0.97	1.01	1.04	1.16	1.23	1.30	1.38	1.45	1.53	1.60
COMMERCIAL												
ELECTRICITY	19.83	1.00	1.06	1.06	1.05	1.04	1.05	1.06	1.07	1.09	1.11	1.13
DISTILLATE FUEL	5.77	1.00	0.97	0.98	1.01	1.06	1.10	1.17	1.24	1.32	1.39	1.46
RESIDUAL FUEL	5.80	1.00	1.00	1.01	1.03	1.07	1.11	1.15	1.19	1.24	1.28	1.32
NATURAL GAS	6.32	1.00	0.95	0.97	0.98	1.09	1.14	1.18	1.23	1.27	1.33	1.37
STEAM COAL	2.17	1.00	1.11	1.11	1.13	1.15	1.17	1.20	1.22	1.23	1.26	1.29
INDUSTRIAL												
ELECTRICITY	18.19	1.00	1.06	1.07	1.05	1.05	1.06	1.06	1.08	1.09	1.12	1.14
DISTILLATE FUEL	6.00	1.00	0.97	0.98	1.01	1.05	1.09	1.16	1.23	1.30	1.37	1.44
RESIDUAL FUEL	4.97	1.00	1.00	1.01	1.05	1.09	1.14	1.19	1.24	1.29	1.35	1.40
NATURAL GAS	5.10	1.00	0.96	0.99	1.01	1.11	1.18	1.24	1.31	1.38	1.45	1.51
STEAM COAL	2.70	1.00	1.02	1.03	1.03	1.05	1.06	1.08	1.10	1.11	1.12	1.14
TRANSPORTATION												
MOTOR GASOLINE	9.90	1.00	0.97	0.97	1.00	1.02	1.04	1.09	1.14	1.19	1.24	1.29

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)										
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-9, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 9 (California, Nevada, Arizona, Hawaii, Trust Territory of the Pacific Islands, American Samoa, Guam)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	1.14	1.16	1.17	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.25	1.24	1.24	1.23	1.23
DISTILLATE FUEL	1.42	1.47	1.53	1.59	1.65	1.70	1.75	1.80	1.86	1.92	1.99	2.06	2.14	2.23	2.31
LIQUEFIED PETROLEUM GAS	1.42	1.47	1.53	1.58	1.64	1.69	1.74	1.80	1.85	1.91	1.98	2.05	2.13	2.21	2.29
NATURAL GAS	1.67	1.73	1.80	1.87	1.94	2.01	2.07	2.14	2.22	2.29	2.38	2.47	2.56	2.65	2.74
COMMERCIAL															
ELECTRICITY	1.14	1.16	1.17	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.25	1.24	1.24	1.24	1.23
DISTILLATE FUEL	1.52	1.58	1.64	1.71	1.78	1.83	1.89	1.95	2.02	2.08	2.16	2.25	2.34	2.43	2.53
RESIDUAL FUEL	1.38	1.44	1.50	1.56	1.62	1.68	1.74	1.80	1.86	1.92	2.00	2.08	2.17	2.25	2.35
NATURAL GAS	1.43	1.49	1.55	1.61	1.68	1.74	1.80	1.86	1.93	2.00	2.08	2.16	2.24	2.32	2.41
STEAM COAL	1.31	1.32	1.34	1.35	1.37	1.38	1.39	1.40	1.42	1.43	1.44	1.44	1.46	1.47	1.48
INDUSTRIAL															
ELECTRICITY	1.16	1.18	1.19	1.21	1.23	1.24	1.26	1.27	1.28	1.29	1.29	1.29	1.29	1.28	1.28
DISTILLATE FUEL	1.51	1.58	1.65	1.72	1.80	1.86	1.93	2.00	2.07	2.15	2.24	2.33	2.44	2.54	2.65
RESIDUAL FUEL	1.46	1.51	1.58	1.64	1.70	1.76	1.82	1.88	1.94	2.00	2.08	2.16	2.25	2.34	2.43
NATURAL GAS	1.58	1.66	1.74	1.83	1.91	1.99	2.08	2.16	2.25	2.34	2.44	2.54	2.65	2.76	2.88
STEAM COAL	1.15	1.17	1.18	1.20	1.22	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31
TRANSPORTATION															
MOTOR GASOLINE	1.32	1.36	1.39	1.43	1.46	1.50	1.53	1.57	1.60	1.64	1.69	1.74	1.79	1.84	1.89

	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)														
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-10. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 10 (Washington, Oregon, Idaho, Alaska)

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)										
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	10.46	1.00	0.95	0.95	0.96	0.96	0.97	1.00	1.02	1.00	1.02	1.05
DISTILLATE FUEL	7.70	1.00	0.98	0.98	1.01	1.04	1.07	1.13	1.18	1.24	1.29	1.35
LIQUEFIED PETROLEUM GAS	8.26	1.00	0.98	0.98	1.01	1.04	1.07	1.13	1.18	1.24	1.29	1.35
NATURAL GAS	7.42	1.00	0.99	0.99	0.99	1.05	1.10	1.13	1.18	1.23	1.28	1.33
COMMERCIAL												
ELECTRICITY	10.42	1.00	0.95	0.95	0.96	0.96	0.97	1.00	1.02	1.00	1.02	1.05
DISTILLATE FUEL	6.16	1.00	0.97	0.98	1.01	1.05	1.09	1.16	1.23	1.30	1.36	1.43
RESIDUAL FUEL	6.69	1.00	1.00	1.00	1.03	1.06	1.09	1.13	1.17	1.20	1.24	1.28
NATURAL GAS	6.85	1.00	1.00	1.00	1.00	1.06	1.12	1.16	1.22	1.27	1.33	1.38
STEAM COAL	2.80	1.00	1.00	1.01	1.02	1.03	1.04	1.06	1.07	1.08	1.09	1.11
INDUSTRIAL												
ELECTRICITY	7.91	1.00	0.94	0.93	0.94	0.94	0.96	0.99	1.02	0.99	1.02	1.06
DISTILLATE FUEL	6.30	1.00	0.98	0.98	1.01	1.05	1.09	1.16	1.22	1.29	1.36	1.42
RESIDUAL FUEL	5.84	1.00	1.00	1.01	1.04	1.07	1.11	1.15	1.19	1.24	1.28	1.32
NATURAL GAS	5.45	1.00	1.00	1.00	1.00	1.08	1.15	1.20	1.26	1.32	1.39	1.45
STEAM COAL	2.80	1.00	1.01	1.02	1.03	1.04	1.06	1.07	1.09	1.11	1.12	1.14
TRANSPORTATION												
MOTOR GASOLINE	10.21	1.00	0.98	0.98	1.00	1.02	1.04	1.09	1.13	1.18	1.23	1.28

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)										
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-10, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
DoE Region 10 (Washington, Oregon, Idaho, Alaska)

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)														
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	1.06	1.08	1.09	1.10	1.12	1.13	1.14	1.15	1.16	1.16	1.16	1.16	1.15	1.15	1.14
DISTILLATE FUEL	1.40	1.45	1.50	1.56	1.62	1.67	1.72	1.77	1.83	1.88	1.95	2.03	2.10	2.18	2.27
LIQUEFIED PETROLEUM GAS	1.40	1.45	1.50	1.55	1.61	1.66	1.71	1.77	1.82	1.87	1.94	2.02	2.09	2.17	2.25
NATURAL GAS	1.38	1.44	1.49	1.55	1.61	1.66	1.72	1.78	1.84	1.91	1.97	2.05	2.12	2.20	2.28
COMMERCIAL															
ELECTRICITY	1.06	1.08	1.09	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.16	1.16	1.15	1.15	1.15
DISTILLATE FUEL	1.49	1.55	1.61	1.67	1.74	1.79	1.85	1.91	1.98	2.04	2.12	2.20	2.29	2.38	2.47
RESIDUAL FUEL	1.33	1.39	1.45	1.51	1.57	1.63	1.68	1.74	1.80	1.86	1.93	2.01	2.10	2.18	2.27
NATURAL GAS	1.44	1.50	1.56	1.63	1.69	1.75	1.82	1.88	1.95	2.02	2.10	2.18	2.26	2.35	2.44
STEAM COAL	1.12	1.14	1.15	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.24	1.26	1.26	1.27
INDUSTRIAL															
ELECTRICITY	1.08	1.10	1.12	1.13	1.15	1.16	1.17	1.18	1.20	1.21	1.21	1.20	1.20	1.20	1.20
DISTILLATE FUEL	1.49	1.55	1.62	1.70	1.77	1.84	1.90	1.97	2.04	2.12	2.21	2.30	2.40	2.50	2.61
RESIDUAL FUEL	1.37	1.43	1.49	1.55	1.61	1.66	1.72	1.77	1.83	1.89	1.97	2.04	2.13	2.21	2.30
NATURAL GAS	1.52	1.60	1.68	1.76	1.84	1.92	2.00	2.08	2.17	2.25	2.35	2.45	2.55	2.66	2.77
STEAM COAL	1.15	1.17	1.18	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.30
TRANSPORTATION															
MOTOR GASOLINE	1.31	1.35	1.38	1.42	1.45	1.49	1.52	1.56	1.59	1.63	1.67	1.72	1.77	1.82	1.88

	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)														
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-11. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES BY END-USE SECTOR AND MAJOR FUEL
United States Average

SECTOR/FUEL	1985 AVERAGE FUEL PRICES (MID-1985 $/MILLION BTU)	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00)										
		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RESIDENTIAL												
ELECTRICITY	20.54	1.00	1.01	1.01	1.01	1.00	0.99	0.99	0.99	0.98	0.98	0.98
DISTILLATE FUEL	7.75	1.00	0.98	0.98	1.01	1.04	1.07	1.13	1.18	1.24	1.29	1.35
LIQUEFIED PETROLEUM GAS	7.81	1.00	0.98	0.98	1.01	1.04	1.08	1.13	1.19	1.25	1.31	1.36
NATURAL GAS	6.16	1.00	1.00	1.03	1.06	1.12	1.18	1.24	1.32	1.39	1.46	1.53
COMMERCIAL												
ELECTRICITY	20.78	1.00	1.01	1.02	1.02	1.01	1.00	0.99	0.99	0.99	0.98	0.99
DISTILLATE FUEL	6.34	1.00	0.97	0.98	1.01	1.05	1.09	1.15	1.22	1.28	1.35	1.42
RESIDUAL FUEL	5.32	1.00	1.00	1.00	1.04	1.07	1.11	1.16	1.20	1.25	1.30	1.35
NATURAL GAS	5.68	1.00	1.00	1.02	1.05	1.11	1.17	1.24	1.31	1.38	1.45	1.52
STEAM COAL	2.16	1.00	1.01	1.02	1.04	1.05	1.07	1.08	1.09	1.11	1.12	1.13
INDUSTRIAL												
ELECTRICITY	17.43	1.00	1.01	1.02	1.02	1.00	0.99	0.99	0.98	0.98	0.97	0.97
DISTILLATE FUEL	6.27	1.00	0.98	0.98	1.01	1.05	1.09	1.15	1.22	1.29	1.35	1.42
RESIDUAL FUEL	4.33	1.00	1.00	1.01	1.05	1.09	1.14	1.20	1.26	1.31	1.37	1.43
NATURAL GAS	4.46	1.00	1.00	1.03	1.08	1.14	1.22	1.30	1.39	1.47	1.56	1.65
STEAM COAL	2.04	1.00	1.03	1.05	1.07	1.09	1.11	1.13	1.16	1.18	1.20	1.22
TRANSPORTATION												
MOTOR GASOLINE	10.25	1.00	0.97	0.98	1.00	1.02	1.04	1.09	1.13	1.18	1.23	1.28

	1985 WORLD OIL PRICE (MID-1985 $/BARREL)	PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)										
OIL PRICE ASSUMPTION	29.03	1.00	0.96	0.96	1.00	1.04	1.07	1.14	1.21	1.29	1.36	1.43

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Ca-11, continued. 1985 AVERAGE FUEL PRICES AND PROJECTED AVERAGE FUEL PRICE INDICES
BY END-USE SECTOR AND MAJOR FUEL
United States Average

SECTOR/FUEL	PROJECTED AVERAGE FUEL PRICE INDICES (MID-1985 = 1.00) 1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RESIDENTIAL															
ELECTRICITY	0.99	1.00	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.08	1.08	1.07	1.07	1.07
DISTILLATE FUEL	1.40	1.45	1.50	1.56	1.62	1.67	1.72	1.77	1.82	1.88	1.95	2.03	2.10	2.18	2.27
LIQUEFIED PETROLEUM GAS	1.41	1.47	1.52	1.58	1.63	1.68	1.74	1.79	1.84	1.90	1.97	2.04	2.12	2.20	2.28
NATURAL GAS	1.59	1.65	1.71	1.78	1.85	1.91	1.97	2.04	2.11	2.19	2.26	2.35	2.43	2.52	2.61
COMMERCIAL															
ELECTRICITY	1.00	1.01	1.02	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.09	1.09	1.08	1.08	1.08
DISTILLATE FUEL	1.47	1.53	1.59	1.65	1.72	1.77	1.83	1.89	1.95	2.01	2.09	2.18	2.26	2.35	2.44
RESIDUAL FUEL	1.40	1.46	1.52	1.58	1.65	1.71	1.77	1.82	1.89	1.95	2.03	2.12	2.20	2.29	2.39
NATURAL GAS	1.58	1.65	1.72	1.79	1.86	1.93	2.00	2.07	2.14	2.22	2.30	2.39	2.48	2.58	2.68
STEAM COAL	1.14	1.16	1.18	1.19	1.21	1.22	1.23	1.24	1.25	1.25	1.26	1.27	1.28	1.29	1.30
INDUSTRIAL															
ELECTRICITY	0.99	1.00	1.02	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.10	1.10	1.10	1.09	1.09
DISTILLATE FUEL	1.48	1.55	1.62	1.69	1.77	1.83	1.90	1.97	2.04	2.11	2.20	2.29	2.39	2.50	2.60
RESIDUAL FUEL	1.49	1.55	1.61	1.67	1.74	1.79	1.85	1.91	1.98	2.04	2.12	2.21	2.29	2.39	2.48
NATURAL GAS	1.73	1.81	1.90	1.99	2.09	2.17	2.26	2.35	2.45	2.55	2.66	2.77	2.89	3.01	3.14
STEAM COAL	1.23	1.25	1.26	1.28	1.30	1.30	1.31	1.32	1.34	1.35	1.36	1.37	1.38	1.39	1.40
TRANSPORTATION															
MOTOR GASOLINE	1.31	1.34	1.38	1.42	1.45	1.49	1.52	1.55	1.59	1.63	1.67	1.72	1.77	1.82	1.87
PROJECTED WORLD OIL PRICE INDICES (MID-1985 = 1.00)															
OIL PRICE ASSUMPTION	1.49	1.56	1.63	1.71	1.79	1.85	1.92	1.99	2.06	2.14	2.23	2.33	2.43	2.53	2.64

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Cb-1. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS BY END-USE SECTOR AND MAJOR FUEL (PERCENTAGE CHANGE COMPOUNDED ANNUALLY)

DoE Region 1 (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	1.25	0.06	1.31	0.82	-0.39
DISTILLATE FUEL	1.39	4.57	3.72	3.09	3.80
LIQUEFIED PETROLEUM GAS	1.39	4.58	3.66	3.07	3.74
NATURAL GAS	3.93	4.71	3.88	3.42	3.64
COMMERCIAL					
ELECTRICITY	1.24	0.07	1.32	0.83	-0.37
DISTILLATE FUEL	1.58	5.13	5.95	3.23	3.94
RESIDUAL FUEL	2.09	3.66	4.21	3.42	4.10
NATURAL GAS	4.55	5.45	4.12	3.58	3.82
STEAM COAL	1.43	1.64	1.23	0.78	0.75
INDUSTRIAL					
ELECTRICITY	1.40	0.08	1.60	0.97	-0.22
DISTILLATE FUEL	1.61	5.21	4.49	3.58	4.31
RESIDUAL FUEL	2.34	4.03	4.02	3.28	3.95
NATURAL GAS	5.50	5.60	4.84	4.10	4.25
STEAM COAL	1.46	1.66	1.26	0.73	0.77
TRANSPORTATION					
MOTOR GASOLINE	0.74	4.15	2.63	2.26	2.89
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Cb-2. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
DoE Region 2 (New York, New Jersey, Puerto Rico, Virgin Islands)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	0.26	-0.79	1.80	0.83	-0.39
DISTILLATE FUEL	1.36	4.51	3.73	3.07	3.81
LIQUEFIED PETROLEUM GAS	1.36	4.47	3.68	3.06	3.74
NATURAL GAS	2.55	4.14	3.86	3.44	3.64
COMMERCIAL					
ELECTRICITY	0.27	-0.82	1.32	0.93	-0.37
DISTILLATE FUEL	1.63	5.27	3.96	3.24	3.92
RESIDUAL FUEL	2.21	3.77	4.20	3.41	4.09
NATURAL GAS	2.61	4.56	4.12	3.57	3.82
STEAM COAL	1.29	1.22	1.22	0.81	0.72
INDUSTRIAL					
ELECTRICITY	0.34	1.02	1.60	0.98	-0.22
DISTILLATE FUEL	1.62	5.22	4.49	3.59	4.31
RESIDUAL FUEL	2.41	4.04	4.01	3.28	3.96
NATURAL GAS	3.62	4.70	4.86	4.10	4.23
STEAM COAL	1.59	1.47	1.29	0.73	0.78
TRANSPORTATION					
MOTOR GASOLINE	0.75	4.20	2.62	2.28	2.88
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Cb-3. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
DoE Region 3
(Pennsylvania, Maryland, West Virginia, Virginia, District of Columbia, Delaware)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	-0.54	0.23	1.30	0.82	-0.40
DISTILLATE FUEL	1.41	4.62	3.73	3.09	3.79
LIQUEFIED PETROLEUM GAS	1.41	4.66	3.68	3.06	3.74
NATURAL GAS	2.99	4.00	3.89	3.43	3.63
COMMERCIAL					
ELECTRICITY	-0.54	0.24	1.32	0.83	-0.37
DISTILLATE FUEL	1.75	5.50	3.94	3.24	3.93
RESIDUAL FUEL	2.31	3.99	4.22	3.40	4.10
NATURAL GAS	2.66	4.08	4.12	3.59	3.82
STEAM COAL	1.36	1.19	1.28	0.76	0.73
INDUSTRIAL					
ELECTRICITY	-0.63	0.28	1.59	0.99	-0.23
DISTILLATE FUEL	1.67	5.38	4.48	3.60	4.30
RESIDUAL FUEL	2.60	4.35	3.98	3.30	3.96
NATURAL GAS	3.63	4.41	4.83	4.11	4.24
STEAM COAL	1.34	1.35	1.27	0.74	0.80
TRANSPORTATION					
MOTOR GASOLINE	0.75	4.20	2.62	2.27	2.89
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Cb-4. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
DoE Region 4 (Kentucky, Tennessee, North Carolina, South Carolina, Mississippi, Alabama, Georgia, Florida, Canal Zone)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	-0.87	-1.40	1.30	0.82	-0.39
DISTILLATE FUEL	1.41	4.63	3.72	3.08	3.80
LIQUEFIED PETROLEUM GAS	1.41	4.64	3.67	3.06	3.75
NATURAL GAS	4.46	5.90	3.87	3.44	3.64
COMMERCIAL					
ELECTRICITY	-0.86	-1.38	1.32	0.83	-0.37
DISTILLATE FUEL	1.77	3.65	3.94	3.24	3.94
RESIDUAL FUEL	2.23	3.90	4.18	3.40	4.11
NATURAL GAS	4.05	6.22	4.11	3.57	3.82
STEAM COAL	1.49	1.29	1.21	0.82	0.71
INDUSTRIAL					
ELECTRICITY	-1.01	-1.59	1.59	0.98	-0.22
DISTILLATE FUEL	1.72	3.51	4.49	3.60	4.31
RESIDUAL FUEL	2.80	4.63	4.02	3.27	3.97
NATURAL GAS	4.60	6.71	4.86	4.09	4.24
STEAM COAL	1.69	1.65	1.28	0.73	0.78
TRANSPORTATION					
MOTOR GASOLINE	0.76	4.26	2.62	2.28	2.89
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

TABLE Cb-5. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS BY END-USE SECTOR AND MAJOR FUEL (PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
DoE Region 5 (Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	-0.48	-1.68	1.50	0.82	-0.39
DISTILLATE FUEL	1.47	4.84	3.71	3.09	3.80
LIQUEFIED PETROLEUM GAS	1.47	4.79	3.68	3.05	3.74
NATURAL GAS	3.23	5.74	3.86	3.43	3.63
COMMERCIAL					
ELECTRICITY	-0.48	-1.70	1.32	0.83	-0.38
DISTILLATE FUEL	1.76	5.60	3.93	3.25	3.92
RESIDUAL FUEL	1.93	3.35	4.19	3.41	4.10
NATURAL GAS	3.19	5.97	4.10	3.57	3.83
STEAM COAL	1.28	1.20	1.29	0.76	0.74
INDUSTRIAL					
ELECTRICITY	-0.57	-2.02	1.60	0.99	-0.22
DISTILLATE FUEL	1.65	5.32	4.48	3.58	4.32
RESIDUAL FUEL	3.36	5.30	3.99	3.30	3.95
NATURAL GAS	3.33	6.05	4.86	4.10	4.23
STEAM COAL	1.16	1.10	1.32	0.71	0.77
TRANSPORTATION					
MOTOR GASOLINE	0.72	4.08	2.62	2.27	2.89
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

TABLE Cb-6. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
DoE Region 6 (Texas, New Mexico, Oklahoma, Arkansas, Louisiana)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	1.11	1.38	1.30	0.82	-0.39
DISTILLATE FUEL	1.73	5.53	3.73	3.08	3.81
LIQUEFIED PETROLEUM GAS	1.76	5.51	3.66	3.06	3.74
NATURAL GAS	4.58	5.73	3.87	3.43	3.63
COMMERCIAL					
ELECTRICITY	1.14	1.42	1.32	0.83	-0.37
DISTILLATE FUEL	1.90	5.90	3.92	3.24	3.94
RESIDUAL FUEL	2.60	4.34	4.19	3.40	4.09
NATURAL GAS	3.71	5.92	4.09	3.59	3.82
STEAM COAL	1.29	1.48	1.29	0.74	0.71
INDUSTRIAL					
ELECTRICITY	1.31	1.60	1.60	0.99	-0.22
DISTILLATE FUEL	1.79	5.70	4.49	3.60	4.31
RESIDUAL FUEL	3.12	4.96	4.00	3.28	3.97
NATURAL GAS	5.08	6.95	4.86	4.09	4.25
STEAM COAL	2.00	1.68	1.30	0.74	0.71
TRANSPORTATION					
MOTOR GASOLINE	0.78	4.38	2.62	2.27	2.88
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Cb-7. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
DoE Region 7 (Kansas, Missouri, Iowa, Nebraska)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	-1.11	-1.35	1.30	0.82	-0.39
DISTILLATE FUEL	1.55	5.04	3.74	3.07	3.80
LIQUEFIED PETROLEUM GAS	1.55	5.01	3.68	3.06	3.74
NATURAL GAS	4.29	5.82	3.87	3.43	3.64
COMMERCIAL					
ELECTRICITY	-1.14	-1.39	1.31	0.84	-0.37
DISTILLATE FUEL	1.81	5.76	3.96	3.23	3.92
RESIDUAL FUEL	1.52	2.72	4.21	3.39	4.11
NATURAL GAS	4.[illegible]8	6.17	4.11	3.59	3.82
STEAM COAL	0.98	1.02	1.29	0.76	0.74
INDUSTRIAL					
ELECTRICITY	-1.29	-1.58	1.60	0.98	-0.22
DISTILLATE FUEL	1.74	5.47	4.49	3.58	4.31
RESIDUAL FUEL	3.38	3.41	4.03	3.27	3.96
NATURAL GAS	4.34	6.08	4.86	4.10	4.24
STEAM COAL	1.65	1.52	1.33	0.75	0.73
TRANSPORTATION					
MOTOR GASOLINE	0.77	4.29	2.62	2.27	2.89
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Cb-8. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
DoE Region 8 (Montana, North Dakota, South Dakota, Wyoming, Utah, Colorado)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	-0.41	-1.01	1.30	0.82	-0.39
DISTILLATE FUEL	1.61	5.11	3.71	3.08	3.81
LIQUEFIED PETROLEUM GAS	1.58	5.12	3.65	3.07	3.73
NATURAL GAS	2.52	5.23	3.89	3.41	3.65
COMMERCIAL					
ELECTRICITY	-0.43	-1.04	1.32	0.83	-0.37
DISTILLATE FUEL	1.75	5.69	3.95	3.24	3.92
RESIDUAL FUEL	2.55	4.27	4.19	3.42	4.09
NATURAL GAS	2.17	5.11	4.12	3.58	3.83
STEAM COAL	1.43	1.17	1.26	0.75	0.72
INDUSTRIAL					
ELECTRICITY	-0.50	-1.26	1.60	0.98	-0.21
DISTILLATE FUEL	1.77	5.54	4.49	3.58	4.31
RESIDUAL FUEL	3.56	5.64	4.02	3.26	3.95
NATURAL GAS	2.58	5.99	4.84	4.09	4.25
STEAM COAL	1.39	1.30	1.37	0.72	0.69
TRANSPORTATION					
MOTOR GASOLINE	0.76	4.25	2.62	2.26	2.89
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Cb-9. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS
BY END-USE SECTOR AND MAJOR FUEL
(PERCENTAGE CHANGE COMPOUNDED ANNUALLY)
DoE Region 9 (California, Nevada, Arizona, Hawaii,
Trust Territory of the Pacific Islands, American Samoa, Guam)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	0.99	1.39	1.80	0.82	-0.39
DISTILLATE FUEL	1.51	4.93	3.78	3.08	3.80
LIQUEFIED PETROLEUM GAS	1.51	4.93	3.66	3.05	3.75
NATURAL GAS	4.27	5.41	3.85	3.43	3.65
COMMERCIAL					
ELECTRICITY	0.99	1.40	1.32	0.84	-0.37
DISTILLATE FUEL	1.87	5.94	3.93	3.23	3.95
RESIDUAL FUEL	4.06	3.61	4.20	3.40	4.10
NATURAL GAS	2.59	3.83	4.10	3.59	3.82
STEAM COAL	3.23	1.[illegible]9	1.30	0.76	0.73
INDUSTRIAL					
ELECTRICITY	1.09	1.52	1.60	0.98	-0.22
DISTILLATE FUEL	1.80	5.72	4.48	3.59	4.31
RESIDUAL FUEL	2.65	4.21	3.99	3.28	3.97
NATURAL GAS	3.38	5.04	4.86	4.11	4.23
STEAM COAL	1.20	1.41	1.32	0.75	0.72
TRANSPORTATION					
MOTOR GASOLINE	0.78	4.37	2.61	2.27	2.89
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Cb-10. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS BY END-USE SECTOR AND MAJOR FUEL (PERCENTAGE CHANGE COMPOUNDED ANNUALLY)

DoE Region 10 (Washington, Oregon, Idaho, Alaska)

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	-0.62	1.58	1.29	0.82	-0.38
DISTILLATE FUEL	1.41	4.64	3.73	3.08	3.81
LIQUEFIED PETROLEUM GAS	1.44	4.62	3.67	3.06	3.74
NATURAL GAS	1.88	3.93	3.88	3.43	3.64
COMMERCIAL					
ELECTRICITY	-0.62	1.59	1.31	0.84	-0.38
DISTILLATE FUEL	1.76	5.63	3.93	3.25	3.92
RESIDUAL FUEL	1.82	3.19	4.19	3.41	4.10
NATURAL GAS	2.31	4.31	4.13	3.57	3.82
STEAM COAL	0.73	1.39	1.24	0.74	0.77
INDUSTRIAL					
ELECTRICITY	-0.85	2.10	1.60	0.98	-0.22
DISTILLATE FUEL	1.72	5.49	4.50	3.59	4.30
RESIDUAL FUEL	2.11	3.58	3.99	3.29	3.96
NATURAL GAS	2.77	4.87	4.86	4.09	4.25
STEAM COAL	1.16	1.43	1.27	0.78	0.70
TRANSPORTATION					
MOTOR GASOLINE	0.74	4.26	2.62	2.27	2.90
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

NOTE: FOR ILLUSTRATION ONLY -- USE UPDATED TABLES FOR PROJECT EVALUATION

TABLE Cb-11. PROJECTED AVERAGE FUEL PRICE ESCALATION RATES FOR SELECTED PERIODS BY END-USE SECTOR AND MAJOR FUEL (PERCENTAGE CHANGE COMPOUNDED ANNUALLY) United States Average

SECTOR/FUEL	1985 to 1990	1990 to 1995	1995 to 2000	2000 to 2005	2005 to 2010
RESIDENTIAL					
ELECTRICITY	-0.16	-0.29	1.30	0.82	-0.38
DISTILLATE FUEL	1.43	4.62	3.73	3.08	3.80
LIQUEFIED PETROLEUM GAS	1.47	4.86	3.67	3.06	3.75
NATURAL GAS	3.43	5.23	3.86	3.44	3.64
COMMERCIAL					
ELECTRICITY	-0.05	-0.24	1.32	0.83	-0.37
DISTILLATE FUEL	1.65	5.46	3.95	3.23	3.93
RESIDUAL FUEL	2.17	5.86	4.19	3.40	4.10
NATURAL GAS	3.25	5.34	4.11	3.50	3.82
STEAM COAL	1.31	1.14	1.33	0.78	0.68
INDUSTRIAL					
ELECTRICITY	-0.19	-0.39	1.60	0.98	-0.22
DISTILLATE FUEL	1.69	5.48	4.49	3.58	4.31
RESIDUAL FUEL	2.72	4.55	3.99	3.30	3.94
NATURAL GAS	4.11	6.12	4.85	4.11	4.24
STEAM COAL	2.14	1.85	1.30	0.69	0.74
TRANSPORTATION					
MOTOR GASOLINE	0.74	4.23	2.62	2.28	2.88
WORLD OIL PRICE ASSUMPTION	1.39	5.92	4.58	3.64	4.35

APPENDIX D

WORKSHEETS FOR MAKING LCC EVALUATIONS

CONTENTS:

Appendix D-1.

RETROFIT WORKSHEETS
FOR CALCULATING
LIFE-CYCLE COSTS, NET SAVINGS, AND SAVINGS-TO-INVESTMENT RATIOS
(General Instructions)

These worksheets have been designed to cover a wide variety of retrofit projects. Not all parts of the worksheets usually will be required for any single project. Read the instructions for each part carefully to make sure it applies to your project.

Following the identifying information, Parts A through E are used to determine the Total Life-Cycle Costs (TLCC) without the Retrofit Project.

Parts F through J are used to determine the Total Life-Cycle Costs (TLCC) with the Retrofit Project.

Part K is used to determine the Net Savings (NS) of the Retrofit Project.

Part L is used to determine the Savings-to-Investment Ratio (SIR) of the Retrofit Project.

The principal data needed to complete these worksheets are: (1) investment costs, (2) nonfuel O&M and repair costs, (3) replacement costs, (4) resale, salvage, or reuse values, (5) quantity of energy consumed, (6) discount factors from Appendices A and B, (7) current energy prices paid by the agency (or default prices from Appendix C), and (8) estimated project life, building life, and holding period. Estimates of these data are required for the situation before the retrofit (Parts A-E), as well as for the case after the retrofit (Parts F-J), to provide a basis of comparison (Parts K & L).

If a project has important costs and/or benefits not covered in these worksheets, they should be included by the analyst on an attachment sheet. If the additional values are quantifiable in dollars, they may be incorporated into the TLCC, NS, and SIR calculations; if they are not, the worksheet results may be supplemented with a verbal description.

Appendix D-1. RETROFIT WORKSHEETS

IDENTIFYING INFORMATION

AGENCY: ______________________________

ADDRESS: Street ______________________________
City/County ______________________________
State ______________________________
DoE Region ______________________________

PROJECT CONTACT: Name ______________________________
Position ______________________________
Telephone ______________________________

BUILDING OR FACILITY DESCRIPTION: ______________________________

Classification for Energy Charges

[ ] Residential

[ ] Commercial

[ ] Industrial

EXPECTED BUILDING/FACILITY LIFE ____________

PROJECT DESCRIPTION: ______________________________

____

____

____

EXPECTED PROJECT LIFE: ____________

STUDY PERIOD: From ____________ (Base Year) To ____________ (End Year)

LENGTH OF STUDY PERIOD: ____________

Instructions, Parts A-C

A. This part calculates the present value of energy costs before the retrofit. It is appropriate to use when (1) the annual physical quantity of energy required by the existing building or building system is expected to remain about constant over the study period, and (2) the types of energy are not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the retrofit:

(1) Annual quantity of energy to be purchased expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Ba table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs before the retrofit.

B. This part calculates the investment costs for the existing building or building system before the retrofit. <u>It may be omitted if the existing system is to be left in place either "as is" or renovated at about the same cost whether or not the retrofit project is implemented.</u>[4]

(1) If the existing system will be sold, scrapped, or redirected to a new use if the retrofit project is implemented, enter in (1) the estimated resale, salvage, or reuse value of the existing system in the base year.

(2) If the existing system is to be left in place, but will require an initial renovation or repair cost that will be different in amount without the retrofit project than with it, enter in (2) the amount of the initial renovation or repair cost in base-year dollars that will be required if the retrofit project is <u>not</u> implemented.

C. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs for the existing building or building system before the retrofit. If these costs are expected to be the same whether or not the retrofit project is implemented, this part may be omitted.[4]

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs for the existing building or building system, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) = Column (1) x Column (2).

---

[1] Terms are defined in "Principal Definitions."

[2] Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$ Btu) only. If the quantity of energy in item A(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (= $\$20.00/10^6 \times 3412$ Btu/kWh).

[3] See Table 2-3 for the formula for calculating UPW* factors.

[4] Only those costs that will be affected by an investment decision need be considered in making that decision.

PARTS A-C

A. Calculating Energy Costs Before the Retrofit

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3) x (4)] PRESENT VALUE OF ENERGY COSTS
ELECTRICITY	______	$______	$______ BASE CHARGE = (1)X(2)	______	$______
			$______ DEMAND CHARGE	______	$______
			$______ TIME OF DAY CHARGE	______	$______
			$______ CONTRACT CAPACITY CHARGE	______	$______
			$______ OTHER CHARGE COMPONENT	______	$______
OIL		$	$		
GAS		$	$		$
OTHER ______		$	$		$
TOTAL					$

B. Calculating Investment Costs for the Existing System Before the Retrofit

(1) Base-Year Resale, Salvage, or Reuse Value of the Existing System $______

(2) Base-Year Renovation Costs for the Existing System if the Retrofit Project is Not Implemented $______

C. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs Before the Retrofit

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
$______	X	______	=	$______

Instructions, Parts D & E

D. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values for the existing building or building system before the retrofit. If these amounts are expected to be about the same whether or not the retrofit project is implemented, this part may be omitted.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur.

(2) "Base-Year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur in any year during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs for the existing building or system.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs for the existing building or system.

(8) Column (8) - Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values for the existing building or system.

E. This part calculates the total life-cycle cost (TLCC) before the retrofit.

(1) Transcribe from Part A, Column (5) Total.

(2) Transcribe from Part B, item (1) or (2).

(3) Transcribe from Part C, Column (3).

(4) Transcribe from Part D, Column (6) Total.

(5) Transcribe from Part D, Column (7) Total.

(6) Transcribe from Part D, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

PARTS D & E

D. Calculating Nonannually Recurring, Nonfuel O&M and Repair Costs, Replacement Costs, and Salvage Value Before the Retrofit.

(1) ELAPSED YEARS BEFORE OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
TOTAL					$	$	$

E. Calculating TLCC Before the Retrofit

(1) Present Value of Energy Costs: A(5) Total		$ ________
(2) Present Value of Investment Costs: B(1) or B(2)	+	$ ________
(3) Present Value of Annually Recurring, Nonfuel O&M Costs: C(3)	+	$ ________
(4) Present Value of Nonannually Recurring, Nonfuel O&M & Repair Costs: D(6) Total	+	$ ________
(5) Present Value of Replacement Costs: D(7) Total	+	$ ________
(6) Present Value of Salvage Values: D(8) Total	-	$ ________
(7) TLCC Before the Retrofit: (1)+(2)+(3)+(4)+(5)-(6)	=	$ ________

Instructions, Parts F & G

F. This part calculates the present value of energy costs after the retrofit. It is appropriate to use when (1) the annual physical quantity of energy requested by the existing building or building system is expected to remain about constant over the study period, and (2) the types of energy are not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the retrofit:

(1) Annual quantity of energy to be purchased expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Ba table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs after the retrofit.

G. This part calculates the investment costs attributable to the retrofit project.

(1) Costs of initial planning, design, engineering, purchase and installation, all in base-year dollars. If the existing system is to be left in place, but will require an initial renovation or repair cost that will be different with the retrofit project than without it, include in the initial investment costs the amount, in base-year dollars, of the initial renovation or repair costs required if the retrofit is performed.[4]

(2) Portion of amount in Line (1) which contributes to reducing energy consumption, in base-year dollars.

(3) Special adjustment to reduce energy conservation investment costs by 10%. It is intended to reflect estimated societal benefits from reducing the use of nonrenewable energy resources, not adequately reflected by market energy prices.

(4) Line (4) = Line (1) - Line (3).

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[1] Terms are defined in "Principal Definitions."

[2] Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$ Btu) only. If the quantity of energy in item F(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is $0.068/kWh (= $\$20.00/10^6 \times 3412$ Btu/kWh).

[3] See Table 2-3 for the formula for calculating UPW* factors.

[4] Only those costs that will be affected by an investment decision need be considered in making that decision.

PARTS F & G

F. Calculating Energy Costs After the Retrofit

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3)X(4)] PRESENT VALUE OF ENERGY COST
ELECTRICITY	______	$______	$______ BASE CHARGE=(1)X(2)	______	$______
			$______ DEMAND CHARGE	______	$______
			$______ TIME OF DAY CHARGE	______	$______
			$______ CONTRACT CAPACITY CHARGE	______	$______
			$______ OTHER CHARGE COMPONENT	______	$______
OIL		$	$		$
GAS		$	$		$
OTHER ______		$	$		$
TOTAL					$

G. Calculating Investment Costs Attributable to the Retrofit

(1) Estimated Actual Investment Costs for the Retrofit Project $ ______

(2) Portion of Investment Comprising Energy Conservation Expenditure $ ______

(3) Investment Cost Adjustment: Line (2) x 0.10 $ ______

(4) Adjusted Investment Costs attributable to the Retrofit Project: (1)-(3) $ ______

Instructions, Parts H-J

H. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs after the retrofit. If these costs are expected to be the same whether or not the retrofit project is implemented and have not been included in Part C, omit this part.

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) - Column (1) x Column (2).

I. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values for the building or building system after the retrofit. If these amounts are expected to be about the same whether or not the retrofit project is implemented and have not been included in Part D, omit this part.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur, assuming end-of-year cash flows.

(2) "Base-year \$" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur at any time during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs for the building or building system after the retrofit.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs for the building or building system after the retrofit.

(8) Column (8) = Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values for the building or building system after the retrofit.

J. This part calculates the TLCC after the retrofit.

(1) Transcribe from Part F, Column (5) Total.

(2) Transcribe from Part G, item (4).

(3) Transcribe from Part H, Column (3).

(4) Transcribe from Part I, Column (6) Total.

(5) Transcribe from Part I, Column (7) Total.

(6) Transcribe from Part I, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

PARTS H-J

H. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs After the Retrofit

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
$ ______	x	______	=	$ ______

I. Calculating Nonannually Recurring, Nonfuel O&M Costs and Repair Costs, Replacement Costs, and Salvage Value After the Retrofit

(1) ELAPSED YEARS BEFORE OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
TOTAL					$	$	$

J. Calculating TLCC After the Retrofit Project

(1) Present Value of Energy Costs: F(5) Total $ ______

(2) Present Value of Adjustment Investment Costs: G(4) + $ ______

(3) Present Value of Annually Recurring, Nonfuel O&M Costs: H(3) + $ ______

(4) Present Value of Nonannually Recurring, Nonfuel O&M and Repair Costs: I(6) Total + $ ______

(5) Present Value of Replacement Costs: I(8) Total + $ ______

(6) Present Value of Salvage: I(8) Total - $ ______

(7) TLCC After the Retrofit Project (1) + (2) + (3) + (4) + (5) - (6) $ ______

Instructions, Parts K & L

K. This part calculates the Net Savings (NS) (or Net Losses (-NS)) attributable to the retrofit project.

(1) Transcribe from Part E, item (7).

(2) Transcribe from Part J, item (7).

(3) Line (3) = Line (1) - Line (2).

L. This part calculates the Savings-to-Investment Ratio (SIR) for ranking the retrofit project.

(1) (a) Line (a) = (Part E, item (1)) - (Part J, item (1)).

(b) Line (b) = (Part E, Line (3) + Line (4)) - (Part J, Line (3) + Line (4)).

(c) Line (c) = Line (a) + Line (b). (Note that if O&M & repair costs are higher after the retrofit project than before it, Line (b) will be negative and will reduce the numerator.)

(2) (a) Line (a) = (Part J, Line (2)) - (Part E, Line (2)).

(b) Line (b) = (Part J, Line (5)) - (Part E, Line (5)).

(c) Line (c) = (Part J, Line (6)) - (Part E, Line (6)).

(d) Line (d) = Line (a) + Line (b) - Line (c). (Note that if replacement costs are lower after the retrofit than before it, Line (b) will be negative and will reduce the denominator, and if salvage value is lower, Line (c) will be negative and will increase the denominator.

(3) Line (3) = Line (1)(c) + Line (2)(d).

PARTS K & L

K. Calculating Net Savings or Net Losses of the Retrofit Project

(1) TLCC Before the Retrofit: E(7)		$ ______
(2) TLCC After the Retrofit: J(7)	−	$ ______
(3) Net Savings (+) or Net Losses (−): (1)−(2)	=	$ ______

L. Calculating the SIR for Ranking the Retrofit Project

(1) SIR Numerator		
(a) Energy Cost Savings Attributable to the Retrofit: E(1)−J(1)		$ ______
(b) Nonfuel O&M & Repair Cost Savings (+) or Cost Increase (−) Attributable to the Retrofit: E(3+4)−J(3+4)	+	$ ______
(c) SIR Numerator: (a) + (b)	=	$ ______
(2) SIR Denominator		
(a) Adjusted Increased Investment Cost Attributable to the Retrofit: J(2)−E(2)		$ ______
(b) Replacement Cost Increase (+) or Decrease (−) Attributable to the Retrofit: J(5)−E(5)	+	$ ______
(c) Salvage Value Increase (+) or Decrease (−) Attributable to the Retrofit: J(6)−E(6)	−	$ ______
(d) SIR Denominator: (a) + (b) − (c)	=	$ ______
(3) SIR for Ranking the Retrofit Project: (1)(c) ÷ (2)(d)		______

APPENDIX D-2.

NEW BUILDING DESIGN WORKSHEETS FOR CALCULATING LIFE-CYCLE COSTS (General Instructions)

All new Federal buildings are required by law to be life-cycle cost effective. This means that of alternative designs for a building, the one which meets requirements at lowest total life-cycle cost (TLCC) should be selected.

To compare the TLCC's of alternative building designs or of alternative building systems for a new building design, complete these worksheets (or perform an equivalent analysis) for each alternative.

The principal data required to complete these are: (1) investment costs, (2) nonfuel O&M and repair costs, (3) replacement costs, (4) resale, salvage, or reuse values, (5) quantity of energy consumed, (6) discount factors from Appendices A and B, (7) current energy prices paid by the Agency (or default prices from Appendix C), and (8) estimated building or system life and holding period.

If a design has important costs and/or benefits not covered in these worksheets, they should be included by the analyst on an attachment sheet. If the additional values are quantifiable in dollars, they may be incorporated into the TLCC calculation; if they are not, the worksheet results may be supplemented with a verbal description.

APPENDIX D-2. NEW BUILDING DESIGN WORKSHEETS

IDENTIFYING INFORMATION

AGENCY: ______________________________

ADDRESS: Street ______________________________

City/County ______________________________

State ______________________________

DoE Region ______________________________

PROJECT CONTACT: Name ______________________________

Position ______________________________

Telephone ______________________________

BUILDING, FACILITY, OR SYSTEM DESCRIPTION: ______________________________

____

____

Classification For Energy Charges

☐ Residential

☐ Commercial

☐ Industrial

Expected Building/Facility, or System Life: ________

STUDY PERIOD: From ________ (Base Year) To ________ (End Year)

LENGTH OF STUDY PERIOD: ________

Instructions, Parts A & B

A. This part calculates the present value of energy costs. It is appropriate to use when (1) the annual physical quantity of energy required for the design is expected to remain about constant over the study period, and (2) the type(s) of energy are not expected to change over the study period. To calculate the present value of energy costs when these two conditions do not hold, see Appendix G.

Complete for each type of energy affected by the choice of designs:

(1) Total annual quantity of energy to be purchased, expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Appendix Ba table should be applied to the sum of the separate charge components in Column (3).

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs.

B. This part calculates the investment costs for the building or system.

(1) Costs of initial planning, site acquisition, design, engineering, purchase and installation, all in base-year dollars.

(2) Portion of amount in Line (1) which contributes to reducing energy consumption, in base-year dollars.

(3) Special adjustment factor to reduce energy conservation investment costs by 10%. It is intended to reflect estimated societal benefits from reducing the use of nonrenewable energy resources not adequately reflected by market energy prices.

(4) Line (4) = Line (1) - Line (3).

---

[1] Terms are defined in "Principal Definitions."

[2] Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$) only. If the quantity of energy in item A(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton of steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (=$\$20.00/10^6$Btu x 3,412 Btu/kWh).

[3] See Table 2-3 for the formula for calculating UPW* factors.

PARTS A & B

A. Calculating Energy Costs

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3)x(4)] PRESENT VALUE OF ENERGY COST
ELECTRICITY	______	$ ______	$ ______ BASE CHARGE=(1)x(2)	______	$ ______
			$ ______ DEMAND CHARGE	______	$ ______
			$ ______ TIME OF DAY CHARGE	______	$ ______
			$ ______ CONTRACT CAPACITY CHARGE	______	$ ______
			$ ______ OTHER CHARGE COMPONENT	______	$ ______
OIL		$	$		$
GAS		$	$		$
OTHER ______		$	$		$
TOTAL					$

B. Calculating Investment Costs

(1) Estimated Actual Investment Costs for the New Building Design $ ______

(2) Part of Investment Comprising Energy Conservation Expenditure $ ______

(3) Investment Cost Adjustment: Line (2) x 0.10 $ ______

(4) Adjusted Investment Costs for the New Building Design $ ______

Instructions, Parts C-E

C. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs.

(1) State in base-year dollars the amount per year of annually recurring, nonfuel costs, such as for routine maintenance, that is expected to remain about the same from one year to the next when stated in dollars of constant purchasing power.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) = Column (1) x Column (2).

D. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur, assuming end-of-year cash flows.

(2) "Base-Year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur in any year during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs.

(8) Column (8) = Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values.

E. This part calculates the total life-cycle cost (TLCC).

(1) Transcribe from Part A, Column (5) Total.

(2) Transcribe from Part B, item (4).

(3) Transcribe from Part C, Column (3).

(4) Transcribe from Part D, Column (6) Total.

(5) Transcribe from Part D, Column (7) Total.

(6) Transcribe from Part D, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

PARTS C-E

C. Calculating Annually Recurring, Nonfuel Operation and Maintenance (O&M) Costs

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
$ ______	X	______	=	$ ______

D. Calculating Nonannually Recurring, Nonfuel O&M and Repair Costs, Replacement Costs, and Salvage Values

(1) ELAPSED YEARS UNTIL OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M AND REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COST (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUE (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)x(5)] PRESENT VALUE OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
TOTALS					$	$	$

E. Calculating the TLCC

(1) Present Value of Energy Costs: A(5) Total $ ______

(2) Present Value of Adjusted Investment Cost: B(4) + $ ______

(3) Present Value of Annually Recurring, Nonfuel O&M Costs: C(3) + $ ______

(4) Present Value of Nonannually Recurring, Nonfuel O&M Repair Costs: D(6) Total + $ ______

(5) Present Value of Replacement Costs: D(7) Total + $ ______

(6) Present Value of Salvage Values: D(8) Total − $ ______

(7) TLCC of the New Building or System Design: (1) + (2)+ (3) + (4) + (5) − (6) = $ ______

APPENDIX D-3.

SOLAR ENERGY WORKSHEETS

These worksheets have been designed to cover a wide variety of solar energy projects. Not all parts of the worksheets usually will be required for any single project. Instructions are provided for each part.

Parts A through E are used to calculate Total Life-Cycle Costs (TLCC) <u>without</u> the Solar Energy Project.

Parts F through K are used to calculate Total Life-Cycle Costs (TLCC) <u>with</u> the Solar Energy Project. To compare alternative designs or sizes of Solar Energy Systems, complete these parts for each alternative.

Part L is used to calculate Net Savings (NS) attributable to the Solar Energy Project.

Part M is used to calculate the Savings-to-Investment Ratio (SIR) for ranking the Solar Energy Project Relative to Other Projects Competing for Funding.

Part N is used calculate years to Simple Payback (SPB) as a supplementary measure of economic performance.

APPENDIX D-3. SOLAR ENERGY WORKSHEETS

IDENTIFYING INFORMATION

AGENCY: ______________________________

ADDRESS: ______________________________

PROJECT TITLE: ______________________________

____

PROJECT CONTACT PERSON: ______________________________

BUILDING DESCRIPTION: [ ] NEW [ ] EXISTING

Functional Use: ______________________________

Classification for Energy Charges
[ ] Residential
[ ] Commercial
[ ] Industrial

EXPECTED BUILDING/FACILITY LIFE: ____________

SOLAR APPLICATION (Check All Appropriate): Domestic Hot Water [ ], Space Heating [ ], Space Cooling [ ], Industrial Process Heat [ ]. If Process Heat,

Briefly Explain: ______________________________

____

____

TYPE SOLAR ENERGY SYSTEM: [ ] Active [ ] Passive [ ] Combined Active/Passive

Briefly Describe: ______________________________

____

____

EXPECTED PROJECT LIFE: ________

STUDY PERIOD: FROM ________ (Base Year) TO ________ (End Year)

LENGTH OF STUDY PERIOD: ____________

Instructions, PART A-C

In order to evaluate the cost effectiveness of a solar energy system, it is necessary to estimate a base-line against which to compare it. The purpose of this part is to estimate those base-line costs for the non-solar energy system that would be used if the solar energy project were not undertaken. This system may be identical to or different from the system that would be used as a backup to the solar energy system.

A. This part calculates the present value of fuel costs without solar. It should be completed for the type(s) of fuel(s) that solar will be displacing. Indicate in the appropriate columns:

(1) Annual quantity of energy to be purchased expressed in millions of Btu's (10^6 Btu's) or in sales units, e.g., gallons of oil, kWh of electricity, etc.
(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)
(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).
(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B1-a through B11-a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Ba table should be applied to the sum of the separate charge components in Column (3). Use a study period of 20 years unless (1) more accurate number for the particular system is available, or (2) the remaining life of the building is less than 20 years, in which case the study period should equal the remaining building life. Do not exceed a study period of 25 years.
(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs if solar is not used.

B. This part gives the investment costs for the non-solar energy system which would be used in lieu of the solar energy system. It should be completed only if the energy system which would be used in lieu of solar energy (1) differs from the system that would be used as a backup to the solar energy system, or (2) would require renovation costs to keep it in service that differ in amount if used without the solar energy system versus with it.

(1) For a new building, enter the costs of purchasing and installing the non-solar energy system, in base-year dollars.
(2) For an existing building, with an existing energy system which would be continued in use if the solar energy project were not undertaken, enter any renovation costs necessary to keep it in service.
(3) For an existing building whose existing energy system would not be continued in use regardless of the solar energy project, enter the costs of purchasing and installing the new non-solar energy system to be used in lieu of solar energy less any net proceeds from the existing system.

C. This part calculates the present value of annually recurring, nonfuel operating and maintenance (O&M) costs of the nonsolar energy sytem which would have been used in lieu of the proposed solar energy system. It should be completed only if the O&M costs of the non-solar energy system are expected to differ from the O&M costs of the backup system.

(1) Self-explanatory.
(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.
(3) Column (3) = Column (1) x Column (2).

---

[1]Terms are defined in "Principal Definitions."

[2]Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$ Btu) only. If the quantity of energy in item A(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (= $\$20.00/10^6 \times 3412$ Btu/kWh).

[3] See Table 2-3 for the formula for calculating UPW* factors.

PARTS A-C

A. Calculating Fuel Costs Without Solar

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3) x (4)] PRESENT VALUE OF ENERGY COSTS
ELECTRICITY	______	$______	$______ BASE CHARGE = (1)X(2)	______	$______
			$______ DEMAND CHARGE	______	$______
			$______ TIME OF DAY CHARGE	______	$______
			$______ CONTRACT CAPACITY CHARGE	______	$______
			$______ OTHER CHARGE COMPONENT	______	$______
OIL		$	$		
GAS		$	$		$
OTHER ______		$	$		$
TOTAL			$		$

B. Calculating Investment Costs Without Solar

(1) For New Building Only, Base-year Investment Costs for the Non-solar Energy System $______

(2) For Existing Building/Existing System Only, Base-year Renovation Costs for the Existing System if the Solar Energy Project is Not Implemented $______

(3) For Existing Building/New System Only, Base Year Investment Cost for the New Non-solar Energy System (Less Resale for Old System) $______

C. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs Before the Retrofit

(1) Amount of Annually Recurring Costs in Base Year Dollars		(2) UPW Factor		(3) Present Value of Annually Recurring Costs
$______	X	______	=	$______

Instructions, PARTS D & E

D. This part calculates the present value of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values of the non-solar system which would have been used in lieu of the proposed solar energy system. It should be completed only if these types of costs for the non-solar energy system are expected to differ from these same types of costs for the auxiliary system.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur, assuming end-of-year cash flows.

(2) "Base-Year $" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values may occur in any year during the study period in conjunction with replacements, as well as at the end of the study period.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs for the non-solar energy system.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs for the non-solar energy system.

(8) Column (8) - Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values for the non-solar energy system.

E. This part calculates the total life-cycle cost (TLCC) without solar.

(1) Transcribe from Part A, Column (5) Total.

(2) Transcribe from Part B, item (1), (2), or (3).

(3) Transcribe from Part C, Column (3).

(4) Transcribe from Part D, Column (6) Total.

(5) Transcribe from Part D, Column (7) Total.

(6) Transcribe from Part D, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

PARTS D-E

D. Calculating Nonannually Recurring, Nonfuel O&M and Repair Costs, Replacement Costs, and Salvage Values Without Solar.

(1) ELAPSED YEARS BEFORE OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
TOTALS					$	$	$

E. Calculating TLCC Without Solar

(1) Present Value of Energy Costs: A(5) Total + $ ________

(2) Present Value of Investment Costs: B(1), (2), or (3) + $ ________

(3) Present Value of Annually Recurring, Nonfuel O&M Costs: C(3) + $ ________

(4) Present Value of Nonannually Recurring, Nonfuel O&M & Repair Costs: D(6) Total + $ ________

(5) Present Value of Replacement Costs: D(7) Total + $ ________

(6) Present Value of Salvage Values: D(8) Total - $ ________

(7) TLCC Without Solar: (1)+(2)+(3)+(4)+(5)-(6) = $ ________

Instructions, PARTS F - H

F. This part identifies the types of fuel affected by the solar energy system, and the data needed to compute fuel quantities in Part G.

G. This part calculates the present value of fuel costs with solar.

(1) Annual Quantity of Energy Purchased = [(Annual Energy Load/Efficiency of Auxiliary System) x (1 - Solar Fraction)] + [Annual Energy for Operating Solar Pumps, etc.].

(2) Price per unit purchased, expressed in the same units as the quantity in (1) above. Use the estimated base-year[1] energy price to the Agency or, if this is not available, use the appropriate base-year price from Appendix C, Tables Ca-1 through Ca-11.[2] (Note that the prices in Appendix C are updated annually.)

(3) Column (3) = Column (1) x Column (2). Note that for Agency electricity prices, only the "base charge" component of Column (3) is derived as Column (1) x Column (2). Other charge components are entered directly into Column (3).

(4) Find the appropriate modified uniform present worth (UPW*) factor in Appendix B, Tables B-1a through B-11a. (Note that these UPW* factors are updated annually.) For electricity only, if Agency prices are used and there are separate charge components with component escalation rates provided by the energy supplier, UPW* factors should be constructed based on each component rate.[3] If component escalation rates are not available, the UPW* factor for electricity from the appropriate Ba table should be applied to the sum of the separate charge components in Column (3). Use a study period of 20 years unless (1) a more accurate number for the particular system is available, or (2) the remaining life of the building is less than 20 years in which case the study period should equal the remaining building life.

(5) Column (5) = Column (3) x Column (4). Sum Column (5) and place result in Column (5) Total line. This gives the total present value of energy costs if solar is used.

H. This part calculates the investment costs attributable to the solar energy system.

(1) Total of Site Planning, Design and Construction Costs.

(2) Complete this line only if an entry was made in Part B for the costs of the NON-SOLAR energy system to be used in lieu of solar energy. Enter the cost of purchase and installation or of renovation, whichever is applicable, of the non-solar energy system.

(3) Line (3) = Line (1) + Line (2).

(4) Portion of amount in line (3) which contributes to reducing nonrenewable energy consumption, in base-year dollars.

(5) Special adjustment to reduce investment costs for conservation of nonrenewable energy cost by 10%. The factor is intended to reflect estimated societal benefits from reducing the use of nonrenewable energy resources not adequately reflected by market energy prices.

(6) Line (6) = Line (3) - Line (5).

---

[1] Terms are defined in "Principal Definitions."

[2] Appendix C tables give base-year price in terms of price per million Btu ($\$/10^6$ Btu) only. If the quantity of energy in item F(1) is given in typical sales units, convert the Ca table-price per million Btu to price per sales unit by dividing the price by a million and multiplying by the Btu content of a sales unit of energy, assuming the following Btu contents per sales units of energy: 3,412 Btu/kWh of electricity; 138,690 Btu/gal of distillate; 95,500 Btu/gal of LPG; 1,016 Btu/ft^3 of natural gas; 149,690 Btu/gal of residual; 22,500,000 Btu/ton steam coal; and 125,071 Btu/gal of gasoline. For example, given a Table Ca price of $\$20.00/10^6$ Btu of electricity, an equivalent price in terms of kilowatt hours is \$0.068/kWh (= $\$20.00/10^6 \times 3412$ Btu/kWh).

[3] See Table 2-3 for the formula for calculating UPW* factors.

PARTS F-H

F. Calculating Fuel Costs with Solar

(1) Type of Fuel	____	____	____	____
(2) Annual Load (10^6 Btu/Yr)	____	____	____	____
(3) Efficiency of Auxiliary System	____	____	____	____
(4) Solar Fraction	____	____	____	____

G. Calculating Fuel Costs with Solar

TYPE	(1) ANNUAL QUANTITY OF ENERGY PURCHASED	(2) BASE-YEAR ENERGY PRICE PER UNIT	(3) BASE-YEAR ENERGY COSTS	(4) UPW* FACTOR	(5) [=(3)X(4)] PRESENT VALUE OF ENERGY COST
ELECTRICITY	____	$____	$____ BASE CHARGE=(1)X(2)	____	$____
			$____ DEMAND CHARGE	____	$____
			$____ TIME OF DAY CHARGE	____	$____
			$____ CONTRACT CAPACITY CHARGE	____	$____
			$____ OTHER CHARGE COMPONENT	____	$____
OIL		$	$		$
GAS		$	$		$
OTHER ____		$	$		$
TOTAL			$		$

H. Calculating Investment Costs with Solar

(1) Investment Costs of the Solar Energy System $ ____

(2) Investment Costs of the Non-Solar Energy Backup System $ ____

(3) Total Investment Costs Attributable to the Solar Energy System and its Backup $ ____

(4) Portion of Total Investment Cost Comprising Energy Conservation Expenditure $ ____

(5) Investment Costs Adjustment: Line (4) x 0.10 $ ____

(6) Adjusted Investment Costs Attributable to the Solar Project: (3) - (5) $ ____

Instructions, PARTS I & K

I. This part calculates the present value of annually recurring, nonfuel operating and maintenance costs (O&M) with the solar energy system. These are the total O&M costs associated with the solar energy system including the O&M costs of the auxiliary system. If the nonfuel O&M costs of the auxiliary system are assumed the same as those of the non-solar energy system used alone and are omitted in section C, they should also be omitted in this section. (For the solar system, typical O&M costs are between 1 and 4 percent of the system investment costs.)

(1) Self explanatory.

(2) Obtain a UPW factor for a 7% discount rate and the length of the study period from Appendix Table A-2.

(3) Column (3) = Column (1) x Column (2).

J. This part calculates the present values of nonannually recurring, nonfuel operating, maintenance, and repair costs, replacement costs, and salvage values with the solar energy system. Included are amounts for the auxiliary system. If these amounts for the auxiliary system are assumed the same as those of the non-solar energy sytem used alone and are omitted from section D, they should be omitted for the auxiliary system in this section.

(1) State the number of elapsed years of the study period before each nonannually recurring amount is expected to occur.

(2) "Base-Year \$" means stating the future amounts in dollars of constant purchasing power, fixed as of the beginning of the study period; e.g., a cost occurring in 1990 would be stated in 1987 dollars if 1987 were the base year.

(3) See (2) above.

(4) Note that salvage values for the solar energy system should be set equal to 0 unless more definitive information is available.

(5) Obtain a single present worth (SPW) factor from Appendix Table A-1 for a 7% discount rate for each elapsed number of years given in Column (1).

(6) Column (6) = Column (2) x Column (5). Sum Column (6) and place result in Column (6) Total line. This gives the total present value of nonannually recurring, nonfuel O&M and repair costs with the solar energy system.

(7) Column (7) = Column (3) x Column (5). Sum Column (7) and place result in Column (7) Total line. This gives the total present value of replacement costs with the solar energy system.

(8) Column (8) - Column (4) x Column (5). Sum Column (8) and place result in Column (8) Total line. This gives the total present value of salvage values with the solar energy sytem.

K. This part calculates the total life-cycle cost (TLCC) with the solar energy system.

(1) Transcribe from Part G, Column (5) Total.

(2) Transcribe from Part H, item 6.

(3) Transcribe from Part I, Column (3).

(4) Transcribe from Part J, Column (6) Total.

(5) Transcribe from Part J, Column (7) Total.

(6) Transcribe from Part J, Column (8) Total.

(7) Line (7) = Line (1) + Line (2) + Line (3) + Line (4) + Line (5) - Line (6).

PARTS I-K

I. Calculating Annually Recurring, Nonfuel Operating and Maintenance (O&M) Costs With Solar

(1) Amount of Annually Recurring Costs in Base Year Dollars	x	(2) UPW Factor	=	(3) Present Value of Annually Recurring Costs
$ ________		________		$ ________

J. Calculating Nonannually Recurring, Nonfuel O&M Costs and Repair Costs, Replacement Costs, and Salvage Values with Solar

(1) ELAPSED YEARS BEFORE OCCURRENCE	(2) AMOUNT OF NON-ANNUALLY RECURRING O&M & REPAIR COSTS (IN BASE-YEAR $)	(3) AMOUNT OF REPLACEMENT COSTS (IN BASE-YEAR $)	(4) AMOUNT OF SALVAGE VALUES (IN BASE-YEAR $)	(5) SPW FACTOR	(6) [=(2)X(5)] PRESENT VALUE OF NONANNUALLY RECURRING O&M & REPAIR COSTS	(7) [=(3)x(5)] PRESENT VALUE OF REPLACEMENT COSTS	(8) [=(4)X(5)] PRESENT VALUE OF SALVAGE VALUES
TOTALS					$	$	$

K. Calculating TLCC with Solar

(1) Present Value of Energy Costs: G(5) Total $ ________

(2) Present Value of Adjusted Investment Costs: H(6) + $ ________

(3) Present Value of Annually Recurring, Nonfuel O&M Costs: I(3) + $ ________

(4) Present Value of Nonannually Recurring, Nonfuel O&M and Repair Costs: J(6) Total + $ ________

(5) Present Value of Replacement Costs: J(7) Total + $ ________

(6) Present Value of Salvage Values: J(8) Total - $ ________

(7) TLCC With Solar (1) + (2) + (3) + (4) + (5) - (6) $ ________

Instructions, PARTS L & M

L. This part calculates the Net Savings or Net Losses of the solar energy system as a measure of its cost effectiveness.

(1) Transcribe from Part E, item (7).

(2) Transcribe from Part K, item (7).

(3) Line (3) = Line (1) + Line (2).

M. This part calculates the Savings-to-Investment Ratio (SIR) for ranking the solar energy project relative to other projects.

(1) (a) Line (a) = (Part E, item (1)) - (Part K, item (1)).

(b) Line (b) = (Part K, Lines (3) + (4)) - (Part E, Lines (3) + (4)).

(c) Line (c) = Line (a) + Line (b). (Note that if O&M and repair costs are higher with the solar energy project than without it, Line (b) will be negative and will reduce the numerator.)

(2) (a) Line (a) = (Part K, item (2)) - (Part E, item (2)).

(b) Line (b) = (Part K, Line (5)) - (Part E, Line (5)).

(c) Line (c) = (Part K, Line (6)) - (Part E, Line (6)).

(d) Line (d) = Line (a) + Line (b) - Line (c). (Note that if replacement costs are lower with the solar energy project than without it, Line (b) will be negative and will reduce the denominator, and if salvage value is lower, Line (c) will be negative and will increase the denominator.

(3) Line (3) = Line (1)(c) + Line (2)(d).

L. Net Savings or Net Losses of the Solar Project

(1) TLCC without Solar: E(7)	$ ________
(2) TLCC with Solar: K(7)	- $ ________
(3) Net Savings (+) or Net Losses (-): (1) - (2)	= $ ________

M. SIR Calculation

(1) SIR Numerator	
(a) Energy Cost Savings Attributable to Solar: E(1)-K(1)	$ ________
(b) Nonfuel O&M & Repair Cost Savings (+) or Cost Increase (-) Attributable to Solar: K(3+4)-E(3+4)	+ $ ________
(c) SIR Numerator (a) + (b)	= $ ________
(2) SIR Denominator	
(a) Adjusted Increased Investment Cost with Solar: K(2)-E(2)	$ ________
(b) Replacement Cost Increase (+) or Decrease (-) Attributable to Solar: K(5)-E(5)	+ $ ________
(c) Salvage Value Increase (+) or Decrease (-) Attributable to Solar: K(6)-E(6)	- $ ________
(d) SIR Denominator: (a) + (b) - (c)	= $ ________
(3) SIR for Ranking the Retrofit Project: (1)(c) ÷ (2)(d)	________

Instructions, PART N

N. This part describes two methods of calculating simple payback for the solar project, based on the type of cash flow anticipated. All applicants should complete either: (1) for uniform cash flow, or (2) for nonuniform cash flows.

(1) (a) Transcribe from Part M, item (2)(a).

(b) Line (b) = (Part A, Column (3) Total) - (Part G, Column (3) Total).

(c) Line (c) = (Part I, item (1)) - (Part C, item (1)).

(d) Line (d) = Line (b) - Line (c).

(e) Line (e) = Line (a) + Line (d).

(2) (a) Beginning with year 0 (at which time investment costs are entered) and progressing one year at the time, enter the number of elapsed years in the study period.

(b) Column (b) = (Part A, Column (3) Total) - (Part G, Column (3) Total) x (number of years accumulated).

(c) Column (c) = [Part I, item (1)) + (Part J, item (2) + (3)-(4)][1] - [Part C, item (1) + Part D, items (2) + (3)-(4)][1]. This should be accumulated by year.

(d) Column (d) = Column (b) - Column (c).

(e) Column (e) = Part M, item (2)(a).

(f) Column (f) = Column (d) - Column (e).

(g) Simple payback (SPB) occurs in the year indicated in Column (a) for which Column (f) changes from negative to positive.

[1]Items 2, 3, and 4 of Parts D and J refer to nonannually recurring costs which only have to be included in those years in which they occur.

N. Simple Payback (SPB)

(1) Calculating SPB when annual cash flows are uniform.[a]

(a) Adjusted Increased Investment Cost With Solar: M(2a)	(b) Base-Year Fuel Cost Savings With Solar: A(3)Total-G(3) Total	(c) Change in Base Year Nonfuel O&M Costs With Solar: I(1)-C(1)	(d) Net Yearly Savings: (b) - (c)	(e) SPB (Years): (a) ÷ (d)
$ ________	$ ________	$ ________	$ ________	________

[a]To provide a quick-to-compute, though rough, measure of simple payback, it is assumed that cash flows are uniform even though this ignores annual changes in energy prices.

(2) Calculating SPB when annual cash flows are not uniform.

(a) CUMULATIVE YEAR	(b) CUMULATIVE ENERGY SAVINGS	(c) CUMULATIVE CHANGE IN NONFUEL O&M, REPAIR, REPLACEMENT, AND SALVAGE VALUE WITH SOLAR	(d) CUMULATIVE SAVINGS	(e) ADJUSTED INCREASED INVESTMENT COSTS WITH SOLAR	(f) CUMULATIVE SAVINGS MINUS INVESTMENT COST	(g) SPB (Value of Col. (a) When Col. (f) Becomes Positive)

APPENDIX E

THE FEDERAL BUILDING LIFE-CYCLE COST (FBLCC) COMPUTER PROGRAM

The FBLCC Computer Program and accompanying User's Guide (NBS TN 1222) provide computational tools and energy price data for performing life-cycle cost (LCC) analyses of Federal buildings and related subsystems. Two kinds of Federal building projects can be evaluated with FBLCC: (1) LCC analysis of projects directly related to energy conservation and renewable energy, and (2) LCC analysis of projects which entail energy costs but are not considered primarily energy conservation or renewable energy projects. The methods and procedures used in the FBLCC Computer Program for the two kinds of projects are those described in this Handbook.

The FBLCC computer program and DoE energy price data are contained on a 5-1/4 inch diskette formatted for use on microcomputers with an MS-DOS operating system. A comparative LCC analysis of alternative building or subsystem designs can be performed by FBLCC in order to determine whether the additional costs of design improvements or retrofits to a Federal building are cost effective in terms of reduction in future costs when evaluated in present value dollars.

The FBLCC program was developed for the U.S. Department of Energy by the National Bureau of Standards and is the property of the United States Government. The programs and files on the FBLCC disk may be copied in unlimited numbers. Copies made for distribution to others should be carefully marked to identify the date and version of the program, because the files are updated annually. Neither the FBLCC program nor the information on the FBLCC diskette is subject to copyright.

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

DISKETTE AVAILABILITY

The FBLCC diskette and User's Guide, NBS TN 1222, can be ordered from:

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

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

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

Because the FBLCC diskette is not subject to copyright, it may be distributed by vendors having no connection with the United States Government. The following vendors have agreed to provide the FBLCC diskette at a nominal charge for copying, handling, and mailing. These vendors are listed as a public service. The United States Government assumes no responsibility or liability for their performance or for the diskettes that they may distribute. Price and ordering information may be obtained directly from these sources:

Technical Assessment Systems
1000 Potomac Street, N.W.
Washington, D.C. 20007
(202) 337-2625

PC Software Interest Group
1030D East Duane Avenue
Sunnyvale, CA 94086
(800) 245-6717
In CA: 800-222-2996

Any other vendor wanting to be included in this list should make a request in writing to:

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

APPENDIX F

CONVERTING A SIMPLE PAYBACK (SPB) TO A DISCOUNTED PAYBACK (DPB): NOMOGRAM METHOD[1]

Years to Simple Payback (SPB) is used in the evaluation of solar demonstration projects as a supplementary measure. As noted in the text, SPB is a rough measure both of cost effectiveness and of the time to payback. It neglects the time value of money and may result in an incorrect determination of the payback period. Use of SPB as a sole evaluation criterion may lead to decisions which are not cost effective. Years to Discounted Payback (DPB), though not a comprehensive measure, is somewhat more accurate than SPB. DPB incorporates the time value of money, and also facilitates the incorporation of differential rates of price escalation for energy.

Section 2.3.4 of this Handbook provides a simplified method of approximating DPB using the UPW* or UPW factor tables and the SPB. Like the factor table approach, the nomograph approach requires that yearly cash flows be sufficiently uniform to allow calculation of SPB by dividing investment cost by an average yearly savings, and that all future cash flows change at the same designated rate.

Use of Figure F-1 to calculate DPB is illustrated as follows: Assuming that the initial conservation investment is $35,000 and the annual energy savings is $5,000, draw a line from the "annual savings" vertical scale to the "investment costs" vertical scale (located to the right of the nomogram). Now project this line to the vertical axis of the graph labeled "Simple Payback." For this example, the projected line indicates a simple payback of 7 years.

Next, project a line from the 7 year point on the vertical axis, horizontally to the appropriate discount rate/energy price escalation rate curve. The nomogram has four discount rate/energy price escalation rate curves: (1) the curve labeled "0%" is for a 7 percent discount rate and a 0 percent energy price escalation rate. (Although none of these energy price escalation rates for which curves are provided match the EIA-projected energy price escalation rates, they may serve to bracket that rate. See Appendix Cb tables for EIA-projected rates.)

Then drop a third line from the point of intersection with the appropriate curve to the horizontal axis of the graph labeled "Discounted Payback." This intersection will give the discounted payback period for the investment. For

[1]For a series of graphs covering a wide range of discount rate/price change rate combinations, see Harold Marshall, Recommended Practice for Measuring Simple and Discounted Payback for Investments in Buildings and Building Systems, National Bureau of Standards, NBSIR 84-2850, March 1984.

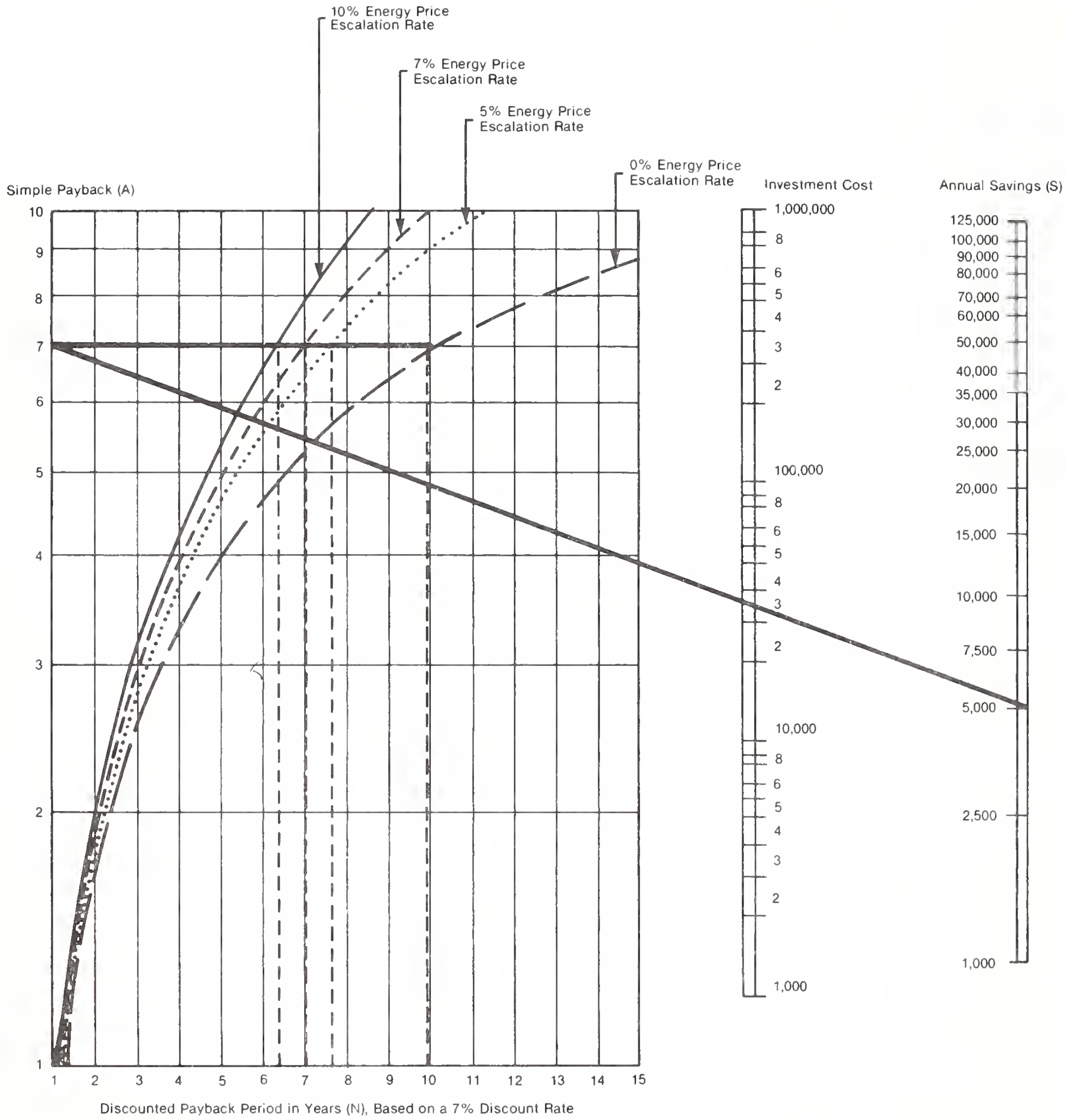

Figure F-1. Discounted Payback Nomogram

the example, the discounted payback is 7 years if a 7 percent energy price escalation rate is used. It is between 7 and 8 years if a 5 percent escalation rate is used, and 10 years if a 0 percent escalation rate is used. The values for other energy price escalation rates must be interpolated from the four curves shown.

APPENDIX G

YEAR-BY-YEAR METHOD OF CALCULATING PRESENT VALUE ENERGY COSTS

Note: This Method is for Use When the Quantiy or Type of Energy is Expected to Change During the Project Study Period.

This appendix describes the life-cycle costing methodology for calculating the present value of energy costs when conditions exist which cause the worksheet calculation procedure (as given in the energy sections of the worksheets of Appendix D) and the FBLCC computer program (information for which is given in Appendix E) to be insufficient. These conditions are as follows: (1) the annual physical quantity of energy used is expected to vary over the study period, e.g., due to declining technical efficiency of equipment over time, or (2) the energy source is expected to change in the future, e.g., a conversion from natural gas to coal may be planned later in the study period. Neither the worksheet approach nor the FBLCC computer program is designed to handle variable quantities or changing types of energy which occur past the beginning of the study period.

If either of the above two conditions exists, the present value of energy costs cannot be calculated simply by multiplying the base-year quantity of energy by the base-year price, and the product by the UPW* discount factor (as called for in the LCC worksheets in Appendix D). Instead, it will be necessary to adjust for future changes in quantity and/or source of energy. This can be done by using the seven-step calculation procedure described below.

Calculation Procedure

Step 1. Find in Appendix Tables Ca the table which applies to your geographical region as indicated by the heading (e.g., Table Ca-1 applies to DoE Region 1). Within that table find the sector which corresponds to your application for the purpose of pricing energy (i.e., residential, commercial, industrial, or transportation).

Step 2. Find the row of projected average fuel price indices corresponding to the first type of energy you wish to evaluate (if there is more than one type). Within that row find the price index for the year marking the beginning of <u>your</u> study period, i.e., the base year in your evaluation. (Note that if the price indices are fully up-to-date and if the year in which you are performing the evaluation is your base year, this index will be 1.00.)

Step 3. For the applicable energy type state your base-year price per unit and note in what year's dollars this price is given:

(Note that all future prices will be denominated in the same year's prices as the base-year price.)

Step 4. Divide the base-year price per unit given in Step 3 by the base-year price index found in Step 2. (Note that this step is to derive a price corresponding in the table of indices to an index of 1.00; hence this step is not needed if the index found in Step 2 is 1.00.) $___/___ _____ = $__/__

Step. 5. Calculate year-by-year over the entire study period the present value costs for the type of energy by completing the following table:

Energy Type __________

Year (Beginning with Base-Year of Study Period) (1)	Projected Price Per Unit (Result of Step 4 X Each Year's Price Index) (2)	Yearly Quantity of Energy Consumed (Same Units as (2)) (3)	SPW Discount Factor (App. A, Table A-1) (4)	Present Value of Energy Costs (5)=(2)x(3)x(4) (5)
19__	$________	______	______	$________
____	________	______	______	________
____	________	______	______	________
____	________	______	______	________
____	________	______	______	________
____	________	______	______	________
____	________	______	______	________
____	________	______	______	________
____	________	______	______	________

(6) Total Present Value Costs for this Energy Type Over the Study Period (Sum Col. (5)) $________

Step 6. Repeat Steps 2 through 5 for each type of energy associated with the alternative building system or base case being evaluated.

Step 7. Sum the total present value costs of all energy types associated with the alternative building system or base case being evaluated, i.e., sum line (6) of the table across energy types:

$ __________.

Use this result in the life-cycle cost evaluation. If the worksheets of Appendix D are being used, substitute the result of Step 7 for the corresponding energy sections of the worksheets.

Illustration of Procedure

Data and Assumptions: A life-cycle cost comparison is to be made between keeping an existing electric resistance heating system two more years and then replacing it with an advanced design gas furnace which is then expected to be available (the base case), versus replacing the existing system immediately with a conventional design heat pump (the alternative case). The building is a small Federal office building located in Illinois. The base-year of the evaluation is 1987. The building will be in use another 10 years. In 1987, electricity for this building is priced at $24.00 per million Btu and natural gas at $5.60 per million Btu. The efficiency of the existing heating system is 1.00, that of the advanced design gas furnace is expected to be 0.9, and that of the heat pump is 1.8. The annual heating load of the building is 1500 million Btu. The quantity of purchased energy is calculated as annual heating load divided by plant efficiency. For simplicity, only heating requirements, not cooling, are considered.

The Retrofit LCC Worksheets in Appendix D are to be used for other sections of the life-cycle cost comparison, and the procedure outlined in Steps 1-7 above is to be used to calculate present value energy costs, which will then be substituted for sections A and F of the worksheets.

Below is illustrated the computation of present value energy costs associated with keeping the existing system two more years and then switching to the advanced design gas furnace (the base case).

Implementation of Steps 1-7:

Step 1. Go to Appendix C, Table Ca-5 for Illinois and find the commercial sector.

[Carry out Steps 2-5 for Electricity]

Step 2. Locate the row of indices in Table Ca-5 for electricity, and find the index for 1987: 1.04 . (Note that because the data in this Handbook are not up-to date, the base-year index is not equal to 1.00. For your project evaluations, check to be sure you are using the latest available update of Appendix C.)

Step 3. State the base-year price per unit of electricity and note in what year's dollars the price is given: $24.00/mill. Btu (1987 $'s).

Step 4. Divide the base year price per unit by the base-year price index: $24.00/mill. Btu ÷ 1.04 = $23.08/mill. Btu .

(This is the agency price of electricity which corresponds to an index of 1.00 in Table Ca-5, i.e., it is the derived agency price for 1985 stated in 1987 $'s.)

Step 5. Calculate the present value costs of electricity by completing the following table:

Energy Type Electricity

Year (Beginning with Base-Year of Study Period) (1)	Projected Price Per Unit (Result of Step 4 X Each Year's Price Index) (2)	Yearly Quantity of Energy Consumed (Same Units as (2)) (3)	SPW Discount Factor (App. A, Table A-1) (4)	Present Value of Energy Costs (5)=(2)x(3)x(4) (5)
1987	$24.00	1500	.93	$33,480
1988	23.77	1500	.87	31,020
1989	23.08	0	.82[a]	0
1990	22.62	0	.76	0
1991	22.16	0	.71	0
1992	21.69	0	.67	0
1993	21.23	0	.62	0
1994	20.77	0	.58	0
1995	20.77	0	.54	0
1996	21.00	0	.51	0

(6) Total Present Value Costs for this Energy Type Over the Study Period (Sum Col. (5)) $64,500

[a]Prices and factors past 1988 are shown for illustration even though they are not required for the calculation.

Step 6. Repeat Steps 2 through 5 for Natural Gas.

[Carry out Steps 2-5 for Natural Gas]

Step 2. Locate the row of indices in Table Ca-5 for natural gas and find the index for 1987: 1.02.

Step 3. State the base-year price per unit of natural gas and note in what year's dollars the price is given: $5.60/mill. Btu (1987 $'s).

Step 4. Divide the base-year price per unit by the base-year price index: $5.60/mill. Btu ÷ 1.02 = $5.49/mill. Btu.

(This is the agency price of natural gas which corresponds to an index of 1.00 in Table Ca-5, i.e., it is the derived agency price for 1985 stated in 1987 $'s.)

Step 5. Calculate the present value costs of natural gas by completing the following table:

Energy Type Natural Gas

Year (Beginning with Base-Year of Study Period) (1)	Projected Price Per Unit (Result of Step 4 X Each Year's Price Index) (2)	Yearly Quantity of Energy Consumed (Same Units as (2)) (3)	SPW Discount Factor (App. A, Table A-1) (4)	Present Value of Energy Costs (5)=(2)x(3)x(4) (5)
1987	$5.60[a]	0	.93[a]	$ 0
1988	5.82	0	.87	0
1989	6.09	1667	.82	8,325
1990	6.42	1667	.76	8,134
1991	6.81	1667	.71	8,060
1992	7.25	1667	.67	8,097
1993	7.69	1667	.62	7,948
1994	8.13	1667	.58	7,861
1995	8.56	1667	.54	7,706
1996	8.95	1667	.51	7,609

(6) Total Present Value Costs for this Energy Type Over the Study Period (Sum Col. (5)) $63,740

[a]Prices and factors for the first two years are shown for illustration even though they are not required for the calculation.

Step 7. Sum the present value costs of electricity and natural gas: $64,500 + $63,740 = $128,240.

This amount, $128,240, will be substituted for the bottom line of section A of the retrofit worksheet.

APPENDIX H

OFFICE OF MANAGEMENT AND BUDGET CIRCULAR NO. A-94

CONTENTS: Circular No. A-94--This circular contains guidelines applicable to the evaluation of most Federal projects which are not primarily energy conservation or renewable energy projects. (Other exemptions are noted in the circular.)

March 27, 1972

CIRCULAR NO. A-94
Revised

TO THE HEADS OF EXECUTIVE DEPARTMENTS AND ESTABLISHMENTS

SUBJECT: Discount rates to be used in evaluating time-distributed costs and benefits

1. Purpose. This Circular prescribes a standard discount rate to be used in evaluating the measurable costs and/or benefits of programs or projects when they are distributed over time.

2. Rescission. This Circular replaces and rescinds Office of Management and Budget (OMB) Circular No. A-94 dated June 26, 1969.

3. Scope.

a. This Circular applies to all agencies of the executive branch of the Federal Government except the U.S. Postal Service. The discount rate prescribed in this Circular applies to the evaluation of Government decisions concerning the initiation, renewal or expansion of all programs or projects, other than those specifically exempted below, for which the adoption is expected to commit the Government to a series of measurable costs extending over three or more years or which result in a series of benefits that extend three or more years beyond the inception date.

b. Specifically exempted from the scope of this Circular are decisions concerning water resource projects (guidance for which is the approved Water Resources Principles and Standards), the Government of the District of Columbia, and non-Federal recipients of Federal loans or grants.

c. The remaining exemptions derive from the secondary nature of the decisions involved; that is, how to acquire assets or proceed with a program after an affirmative decision to initiate, renew, or expand such a program using this Circular. Thus:

(1) This Circular would not apply to the evaluation of decisions concerning how to obtain the use of real property, such as by lease or purchase.

(2) This Circular would not apply to the evaluation of decisions concerning the acquisition of commercial-type services by Government or contractor operation, guidance for which is OMB Circular No. A-76.

(3) This Circular would not apply to the evaluation of decisions concerning how to select automatic data processing equipment, guidance for which is OMB Circular No. A-54 and OMB Bulletin No. 60-6.

(d) The discount rates prescribed in this Circular are:

(1) Suggested for use in the internal planning documents of the agencies in the executive branch;

(2) Required for use in program analyses submitted to the Office of Management and Budget in support of legislative and budget programs.

This Circular does not supersede agency practices which are prescribed by or pursuant to law, Executive order, or other relevant Circulars. Agencies should evaluate their programs and projects in accordance with existing requirements and, in addition, summarize the present value costs and/or benefits using the discount rate prescribed in this Circular.

4. Definitions. Analytic documents submitted to the Office of Management and Budget should be based on the following concepts where relevant:

a. Expected annual cost means the expected annual dollar value (in constant dollars) of resources, goods, and services required to establish and carry out a program or project. Estimates of expected yearly costs will be based on established definitions and practices for program and project evaluation. However, all economic costs, including acquisition, possession, and operation costs, must be included whether or not actually paid by the Federal Government. Such costs not generally involving a direct Federal payment include imputed market values of public property and State and local property taxes foregone.

b. Expected annual benefit means the dollar value (in constant dollars) of goods and services expected to result from a program or project for each of the years it is in operation. Estimates of expected yearly benefits will be based on established definitions and practices developed by agencies for program and project evaluation.

c. Expected annual effects means an objective, non-monetary measure of program effects expected for each of the years a program or project is in operation. When dollar value cannot be placed on the effects of comparable programs or projects, an objective measure of effects may be available and useful to enable the comparison of alternative means of achieving specified objectives on the basis of their relative present value costs. These effects should be estimated for each year of the planning period and are not to be discounted.

d. Discount rate means the interest rate used in calculating the present value of expected yearly costs and benefits.

e. Discount factor means the factor for any specific discount rate which translates expected cost or benefit in any specific future year into its present value. The discount factor is equal to $1/(1+r)^t$ where r is the discount rate and t is the number of years since the date of initiation, renewal or expansion of a program or project.

f. Present value cost means each year's expected yearly cost multiplied by its discount factor and then summed over all years of the planning period.

g. Present value benefit means each year's expected yearly benefit multiplied by its discount factor and then summed over all years of the planning period.

h. Present value net benefit means the difference between present value benefit (item g) and present value cost (item f).

i. Benefit-cost ratio means present value benefit (item g) divided by present value cost (item f).

Attachment A contains an example that illustrates calculation of the present value information.

5. Treatment of inflation. All estimates of the costs and benefits for each year of the planning period should be made in constant dollars; i.e., in terms of the general purchasing power of the dollar at the time of decision. Estimates may reflect changes in the relative prices of cost and/or benefit components, where there is a reasonable basis for estimating such changes, but should not include any forecasted change in the general price level during the planning period.

6. Treatment of uncertainty. Actual costs and benefits in future years are likely to differ from those expected at the time of decision. For those cases for which there is a reasonable basis to estimate the variability of future costs and benefits, the sensitivity of proposed programs and projects to this variability should be evaluated.

The expected annual costs and benefits (or effects) should be supplemented with estimates of minimum and maximum values. Present value cost and benefits should be calculated for each of these estimates. The probability that each of the possible cost and benefit estimates may be realized should also be discussed, even when there is no basis for a precise quantitative estimate. Uncertainty of the cost and benefit (or effects) estimates should be treated explicitly, as described above. The prescribed discount rate should be used to evaluate all alternatives. Specifically, the evaluations should not use different discount rates to reflect the relative uncertainty of the alternatives.

7. Discount rate policy. The discount rates to be used for evaluations of programs and projects subject to the guidance of this Circular are as follows:

a. A rate of 10 percent; and, where relevant,

b. Any other rate prescribed by or pursuant to law, Executive order, or other relevant Circulars.

The prescribed discount rate of 10 percent represents an estimate of the average rate of return on private investments, before taxes and after inflation.

To assist in calculation, Attachment B contains discount factors for the discount rate of 10.0 percent for each of the years from one to fifty.

8. Interpretation. Questions concerning interpretation of this Circular should be addressed to the Assistant Director for Evaluation, Office of Management and Budget (395-3614).

GEORGE P. SHULTZ
DIRECTOR

Attachments

ATTACHMENT A
Circular No. A-94
Revised

SAMPLE FORMAT FOR DISCOUNTING DEFERRED COSTS AND BENEFITS

Assume a ten-year program which will commit the Government to the stream of expenditures appearing in column (2) of the table below and which will result in a series of benefits appearing in column (3). The discount factor for a 10 percent discount rate is presented in column (4). Present value cost for each of the ten years is calculated by multiplying column (2) by column (4); present value benefit for each of the ten years is calculated by multiplying column (3) by column (4). Present value costs and benefits are presented in columns (5) and (6), respectively.

Year since initiation, renewal or expansion (1)	Expected yearly cost (2)	Expected yearly cost (3)	Discount factor for 10 percent (4)	Present value cost [Col. (2) x Col. (4] (5)	Present value benefit [Col. (3) x Col. (4)] (6)
1	$10	$0	0.909	$9.1	$0.0
2	20	0	0.826	16.5	0.0
3	30	5	0.751	22.5	3.8
4	30	10	0.683	20.5	6.8
5	20	30	0.621	12.4	18.6
6	10	40	0.564	5.6	22.6
7	5	40	0.513	2.6	20.5
8	5	40	0.467	2.3	18.7
9	5	40	0.424	2.1	17.0
10	5	25	0.386	1.9	9.7
				$95.5	$117.7

The sum of column (5) is present value cost: $95.5
The sum of column (6) is present value benefit: $117.7

Present value net benefit is the difference between present value total benefit and present value total cost:
$117.7 - $95.5 = $22.2.

The benefit-cost ratio is 117.7/95.5 = 1.23

NOTE: For more difficult discounting problems, a recommended reference is Principles of Engineering Economy, by Eugene L. Grant and W. G. Ireson, Ronald Press Company, 1960.

DISCOUNT FACTORS

Year since initiation, renewal or expansion	Discount factors*	Year since initiation, renewal or expansion	Discount factors*
1	0.909091	26	0.083905
2	0.826446	27	0.076278
3	0.751315	28	0.069343
4	0.683013	29	0.063039
5	0.620921	30	0.057309
6	0.564474	31	0.052099
7	0.513158	32	0.047362
8	0.466507	33	0.043057
9	0.424098	34	0.039143
10	0.385543	35	0.035584
11	0.350494	36	0.032349
12	0.318631	37	0.029408
13	0.289664	38	0.026735
14	0.263331	39	0.024304
15	0.239392	40	0.022095
16	0.217629	41	0.020086
17	0.197845	42	0.018260
18	0.179859	43	0.016600
19	0.163508	44	0.015091
20	0.148644	45	0.013719
21	0.135131	46	0.012472
22	0.122846	47	0.011338
23	0.111678	48	0.010307
24	0.101526	49	0.009370
25	0.092296	50	0.003519

*The discount factors presented in the table above implicitly assume end-of-year lump-sum costs and returns. When costs and returns occur in a steady stream, applying mid-year discount factors may be more appropriate. Present value cost and benefit computed from this table can be converted to a mid-year discounting basis by multiplying them by the factor 1.048809.

For example, if the present value cost of a series of annual expenditures computed from the above table is $1,200.00, the present value cost on a mid-year discounting basis is $1,200.00 x 1.048809 or $1,258.57.

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Rosalie T. Ruegg

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☐ 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)*

The manual is a guide to understanding the life-cycle costing method and an aid to calculating the measures required for evaluating energy conservation and renewable energy investments in all Federal buildings. It expands upon the life-cycle costing criteria contained in the Program Rules of the Federal Energy Management Program (Subpart A of Part 436, Title 10, U.S. Code of Federal Regulations) and is consistent with those criteria. Its purpose is to facilitate the implementation of the Program Rules by explaining the life-cycle costing method, defining the measures, describing the assumptions and procedures to follow in performing evaluations, and giving examples. It provides worksheets, data tables, and other computational aids for calculating the required measurements. It is the first of a three-volume set. The second is an annual supplement of energy price projections; the third is a User's Guide to the companion computer program, "FBLCC."

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

cost effectiveness; economic evaluations; energy conservation; energy economics; Federal energy management programs; life-cycle costing; public buildings; renewable energy; solar energy

13. AVAILABILITY

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