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Project-Oriented Life-Cycle Costing Workshop for Energy Conservation in Buildings

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U.S. DEPARTMENT OF COMMERCE
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Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

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Disclaimer

Use of Non-Metric Units in NIST Internal Report No. 6806 2002r ED

The policy of the National Institute of Standards and Technology is to use metric units of measurement in all its publications. NISTIR 6806 is intended for a workshop audience that deals with energy projects for buildings and building systems. In construction-related industries in North America certain non-metric units are so widely used instead of metric units that it is more practical and less confusing to include in this workbook only measurement values for customary units.

Note

This publication is re-issued every year with the most recent DOE/FEMP discount rates and energy price escalation rates. If you intend to use the data in this publication in conducting life-cycle cost analyses, please be sure to use the current-year edition. You may request a copy of NISTIR 6806 200X ED from the Office of Applied Economics, BFRL, MS 8603, National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899. Fax: 301-975-5337; Phone: 301-975-6132.

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Preface

This student manual for the *Project-Oriented Life-Cycle Costing Workshop for Energy Conservation in Buildings* is a workbook for a two-day course on life-cycle costing developed by the National Institute of Standards and Technology (NIST) for the U.S. Department of Energy (DOE), Federal Energy Management Program (FEMP). The methodology and procedures in this manual are consistent with 10 CFR Part 436A and its amendments, which provide guidelines for the economic analysis of investments in energy and water conservation and renewable energy projects for federal buildings. These guidelines are explained in detail in *Life-Cycle Costing Manual for the Federal Energy Management Program, Handbook 135, 1995 edition.* The methodology is also consistent with American Society for Testing and Materials (ASTM) Standards on Building Economics, in particular ASTM Standard Practices E917, E964, E1057, E1074, E1121, and E1185.

The *Project-Oriented LCC Workshop* is one of three workshops conducted by NIST to provide energy managers with the knowledge and skills needed to perform quickly and correctly economic analyses required for building-related capital investments. The analytical methodology presented is equally useful for government and private-sector investment decisions. The *Basic Life-Cycle Costing Workshop* takes the participant through the steps of an LCC analysis, explains in detail the underlying theory of present-value analysis, and integrates it with the FEMP criteria. The *Project-Oriented LCC Workshop* builds on the basic workshop, focuses on the use of BLCC computer programs, and applies the LCC methodology to more complex issues. The third workshop is a two-hour, interactive distance teaching workshop that introduces the elements of LCC analysis to participants at downlink sites across the U.S.

This student manual is organized into seven teaching modules. The workshop begins with a thorough review of LCC principles and 10 CFR 436 criteria. Each of the remaining modules is based on a topic that has emerged from past life-cycle costing workshops and the consulting activities of the Office of Applied Economics at NIST as being of special interest to energy managers. The teaching material is organized around a representative example of an LCC analysis. A group exercise at the end of each module reinforces the students' knowledge gained during the presentation.

Visual materials (slides) used in the workshop are printed in the manual in the order they are presented to facilitate note taking. These visual materials are updated annually to reflect changes in the federal discount rate and projected energy price escalation rates used in federal LCC analyses of energy and water conservation projects.

Other materials used in the LCC workshop include the following:

(1) *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis*, Annual Supplement to NIST Handbook 135 and NBS Special Publication 709, National Institute of Standards and Technology, NISTIR 85-3273.

This report, which is updated annually, provides current DOE and OMB discount rates, projected energy price indices, and corresponding discount factors needed to estimate the present value of future energy and non-energy project-related costs. Request the latest edition when ordering.

(2) *NIST "Building Life-Cycle Cost" (BLCC) Computer Programs, BLCC5 and BLCC4*, National Institute of Standards and Technology. These programs use as default values the same

discount factors and energy price projections that underly the discount factor tables in the Annual Supplement. Use the latest BLCC versions, which are available at the DOE web site (see below).

The BLCC5 program is a windowed version of the DOS-based BLCC4. It is programmed in Java, making it platform-independent, and uses an xml file format. The BLCC5 User's Guide is part of its Help system. BLCC 5.1 has four modules, all of them consistent with the life-cycle cost methodology of 10 CFR 436A, but programmed to include default inputs and nomenclature for specific uses:

(1) **FEMP Analysis, Energy Project**
for energy and water conservation and renewable energy projects under the FEMP rules, agency-funded;

(2) **Federal Analysis, Financed Project**
for federal projects financed through Energy Savings Performance Contracts (ESPC) or Utility Energy Services Contracts (UESC) as authorized by Executive Order 13123 (6/99);

(3) **MILCON Analysis, Energy Project**
for energy and water conservation and renewable energy projects in military construction, agency-funded;

(4) **MILCON Analysis, ECIP Project**
for energy and water conservation projects under the Energy Conservation Investment Program (ECIP).

The remaining user-specific modules now in BLCC4 (i.e., for OMB and non-energy MILCON analyses, and private-sector analyses including taxes and mortgage financing) will be transferred to BLCC5 in the future.

NIST BLCC programs provide comprehensive economic analysis capabilities for the evaluation of proposed capital investments that are expected to reduce the long-term operating costs of buildings and building systems. They compute the LCC for project alternatives over their designated study period, compare project alternatives in order to determine which has the lowest LCC, perform annual cash flow analysis, and compute net savings (NS), savings-to-investment ratio (SIR), adjusted internal rate of return (AIRR), and Payback Period (PB). The BLCC programs can be used by federal, state, and local government agencies, as well as by the private sector (BLCC4). In their application to federal energy conservation and renewable energy projects, BLCC5 and BLCC4 are consistent with

- NIST Handbook 135, and the federal life-cycle cost methodology and procedures described in 10 CFR 436A,
- Circular A-94, and the
- Tri-Services Memorandum of Agreement on *Criteria/Standards for Economic Analysis/Life-Cycle Costing for MILCON Design.*

In their application to private-sector and non-federal public-sector projects, they are consistent with ASTM standards for building economics.

The Annual Supplement to Handbook 135 can be downloaded from the DOE/FEMP web site at
www.eren.doe.gov/femp (click on icon Technical Assistance and go to Life-Cycle Cost Analysis).

Handbook 135 can be downloaded from the NIST web site at
www.nist.bfrl.gov/oae/publications/handbooks/135.html.

The latest versions of BLCC5 and BLCC4, associated programs, and user guides can be downloaded from the DOE/FEMP web site at
www.eren.doe.gov/femp (click on icon Technical Assistance and go to Life-Cycle Cost Analysis).

To order diskettes of BLCC4 and associated programs and hard copies of the above publications, call the FEMP Help Desk:
Energy Efficiency and Renewable Energy Clearing House
(800) DOE-EREC (800-363-3732)

or write or fax your order to

U.S. Department of Energy
Federal Energy Management Program, EE-90
1000 Independence Avenue, S.W.
Washington, DC 20585-0121
Fax: (202) 586-3000

The programs may also be purchased from the following vendors:

FlowSoft
5 Oak Forest Court
Saint Charles, MO 63303-6622
(636) 922-FLOW (3569)
www.flowsoft.com

Energy Information Services
P.O. Box 381
St. Johnsbury, VT 05819-0381
(802) 748-5148

Acknowledgments

The authors are grateful to Dr. Robert Chapman and to Dr. Saul Gass for their review of this manual. Thanks are also due to the many workshop participants whose comments have been helpful in developing the course and the manual. The authors are especially indebted to Mr. Steven Petersen, formerly with the Office of Applied Economics, who initiated this effort and designed the first edition of this manual. J'aime Maynard assembled the latest revisions to the manuscript and managed its production.

Instructor Profiles

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Dr. Fuller joined NIST's Office of Applied Economics in 1979. Her areas of expertise include benefit-cost analysis, economic impact studies, and the pricing of publicly supplied goods and services. As project leader of the NIST/DOE collaborative effort to promote energy and water conservation in accordance with federal legislation, she has been involved in developing techniques, workshops, instructional materials, and computer software for calculating the life-cycle costs and benefits of energy and water conservation projects in buildings. She has participated in OAE projects to estimate the economic impacts of BFRL's research on U.S. industries and the return on BFRL's research investment dollars. Her doctoral studies focused on a public-sector pricing model in the Boiteux tradition, which calculates optimal prices and production plans for goods and services supplied by government agencies. She applied the model to NIST's Standard Reference Materials. Dr. Fuller has published manuals, reports, and articles related to these activities. In 1998 she was selected as a Twenty-First Century Citizenship Pioneer in DOE's "You Have the Power" Campaign.

Prior to her academic and professional work in economics, Dr. Fuller studied languages and linguistics in Germany and worked as an accredited translator and interpreter for industry representatives to the European Common Market, at trade exhibitions, and for commercial enterprises in Germany, Canada, and France.

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Ms. Rushing joined the Office of Applied Economics in May 1997. Her major interests are computer programming and web site design. Her current projects include Building for Environmental and Economic Sustainability (BEES), Economics of High-Performance Concrete, Life-Cycle Costing Methodology, Construction Waste Management Database, and Software for Cost-Effective Selection of Police Vehicles. Ms. Rushing also maintains the OAE web site.

Prior to joining the OAE staff, Ms. Rushing worked at Hood College utilizing her knowledge of computers to assist faculty, staff, and students. She also served as an intern at Frederick County Public Schools Technology Services where she initiated the design effort for the Frederick County Public Schools web site.

Ms. Rushing programs in C++ and Java. She is also proficient in HTML and web site design. In addition to her academic training, she has completed computer training courses in HTML, Java, Access, and the design of user-interfaces.

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Mr. Meyer is an instructor with Engineering Extension at Kansas State University. Mr. Meyer's background includes seven years as a consulting engineer doing power plant design, and for the last 18 years he has assisted business and industry with energy and environmental issues. His areas of expertise include building HVAC systems, lighting, boiler operations and maintenance, solar design, and economic analysis. Meyer has taught building life-cycle cost analysis classes for the states of Ohio, Montana, Iowa, and Kansas; assisted with numerous FEMP BLCC classes; and has provided short courses on life-cycle cost analysis for the American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Meyer has a B.S. in mechanical engineering from the University of Kansas and an M.S. in mechanical engineering from Kansas State University. He is also a registered professional engineer in Kansas and Missouri.

Workshop Objectives

Know how to ***use economic analysis to improve capital investment decisions*** related to energy and water conservation and renewable energy projects in buildings

Know the ***common methods and assumptions required*** for life-cycle cost analyses of energy- and water-related investments in federal buildings

Know how to ***use the BLCC programs*** for life-cycle cost analysis

Workshop Overview

The workshop begins with a review of the LCC principles that are the subject of the Basic LCC Workshop. The elements of performing a life-cycle cost evaluation are explained. Emphasis is placed on clarifying those issues that often confuse practitioners. Issues include why it is necessary to adjust cash flows for the time-value of money and how to do it, how to estimate costs and savings, and how to handle inflation. Students are shown, step-by-step, how to compute Life-Cycle Costs, Net Savings, and the Savings-to-Investment Ratio. Federal criteria for performing economic evaluations of energy-related building projects are presented. The NIST LCC software is introduced with focus on the windowed version BLCC5. The course uses BLCC5 examples to address specific topics of interest to LCC practitioners, such as how to structure for LCC analysis projects that require

- fuel switching and phased-in capital replacements
- replacement of functional systems
- decisions whether to replace equipment or purchase services, and
- evaluation of an alternative financing contract.

The issue of uncertainty is discussed and guidance is given on how to deal with it in an LCC analysis. Exercises are provided on each topic, to be solved by student teams.

Workshop Agenda

Topic

A. Review of LCC Method

B. NIST LCC Software: Overview and BLCC5

C. Fuel Switching and Phased-In Capital Replacements

D. Replacement of Functional Systems to Improve Energy Efficiency

E. Replace Chiller or Purchase Chilled Water

F. Evaluation of Alternative Financing Contracts

G. Exercises

Introduction

Why this course

The energy crisis of the 1970s, higher energy prices, and environmental concerns focused our attention on the critical need to include energy conservation as a major performance objective in the design or rehabilitation of buildings. In the last three decades, the Federal Government, as owner and operator of over a half-million buildings and the nation's largest user of energy, has played a leadership role in improving the energy efficiency of our nation's building stock. Through energy conservation alone, the Government has been able to save nearly a billion dollars a year since 1985, at a savings-to-investment ratio of 5:1 and an internal rate of return of 25 %. More recently, water conservation in buildings and the use of renewable energy and green building materials have also been included in the Government's goal of ensuring efficient resource allocation.

Congress and the President, through legislation and executive order, have mandated energy and water conservation goals for federal buildings and have required that these goals be met using cost-effectiveness measures. These measures include both improved operating procedures and the incorporation of energy and water conservation features in the design of new and existing buildings. The primary criterion mandated by Congress and the President for assessing the cost effectiveness of energy and water conservation measures is minimization of life-cycle costs. They have also instructed the Federal Government to make available to the public and private sector methods, computational tools, and data developed by the Federal Energy Management Program.

Scope

This workshop is complementary to the Basic LCC Workshop, which is theory-oriented. This workshop focuses more on project analysis and the use of LCC computer software. Each of the examples discussed provides a different insight into the application of economic analysis to energy and water conservation investments in buildings. The examples will also demonstrate how to structure an analysis for solution using the NIST BLCC computer programs.

The principles of economic evaluation taught in the Basic LCC Workshop, and reviewed at the beginning of this workshop, are applicable to investment decisions both in the public and private sectors. The decisions most relevant to building-related investments are (1) Is the higher initial cost of a project justified by the lower operating costs in later years? and (2) Of several potential alternative investments, which is the most economical in the long run? While this course focuses on investments in energy conservation and renewable resources in federal buildings, either agency-funded or financed through energy services companies or utility energy services companies, the principles are equally applicable to projects undertaken by state and local governments, non-profit organizations, and for-profit companies and corporations.

About this manual

The manual is intended as both an in-class workbook and as a future source of reference and review. It is divided into seven modules by subject matter. The subject matter is discussed by way of sample analyses performed in BLCC5, the windowed version of the NIST LCC software. At the end of Module A, there is a summary of the LCC principles reviewed in the first lecture. For all modules an exercise is provided to reinforce the material discussed in the lecture and to give students hands-on experience with BLCC5. Students are encouraged to work in small groups when solving these classroom exercises. The solution to each classroom exercise is included at the end of each corresponding module in the form of BLCC5 reports.

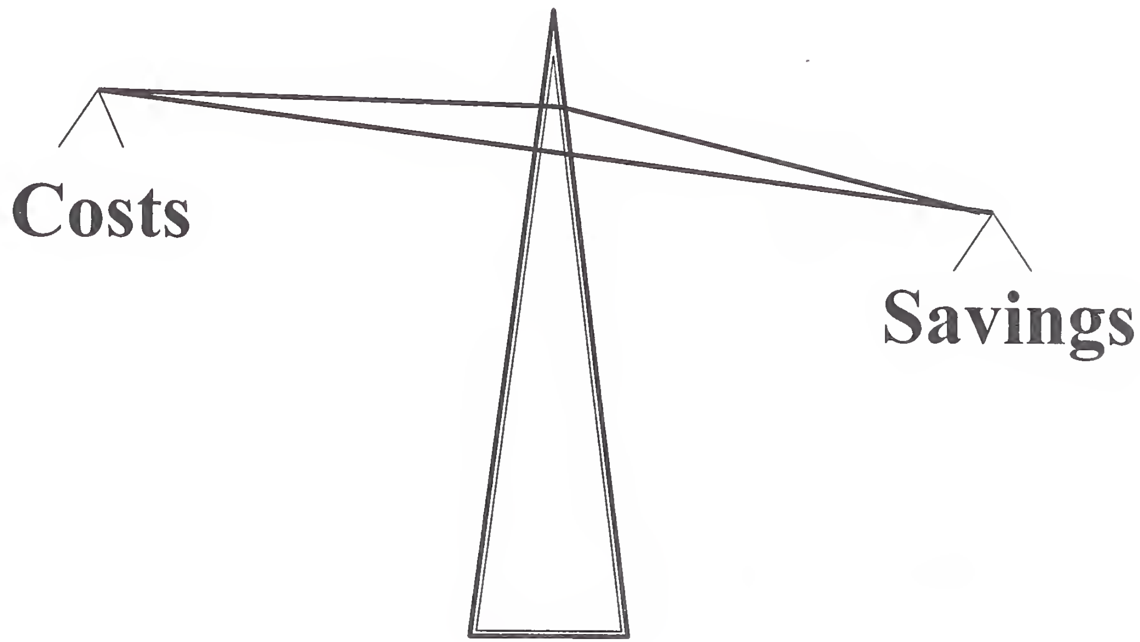
Module A

Review of LCC Method

Objectives: Upon completion of this module, you will understand

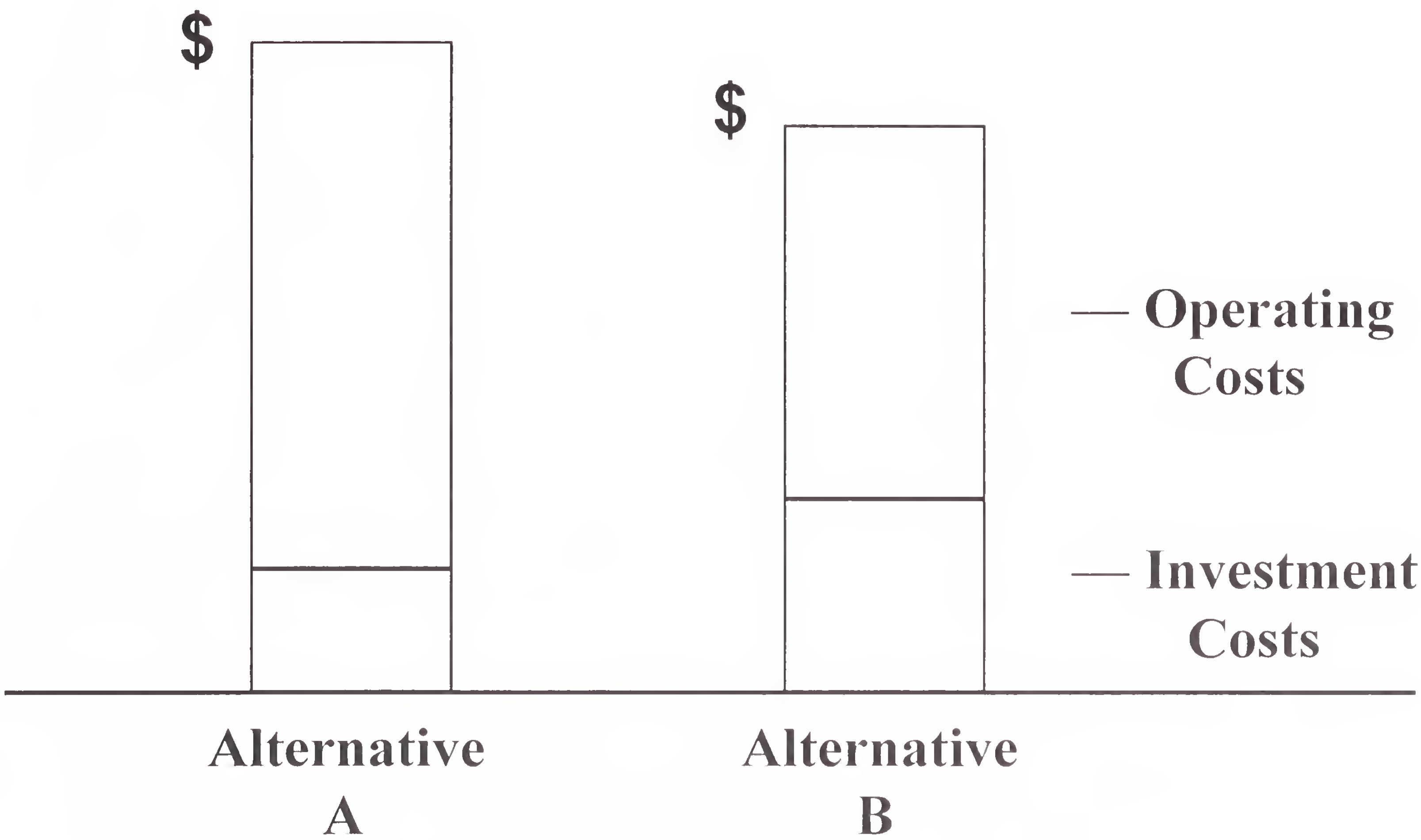
- rationale for Life-Cycle Cost Analysis
- basic LCC methodology
- federal LCC rules
- interpretation of analysis results

Basic Economic Criterion for Capital Investments that Reduce Future Operating Costs

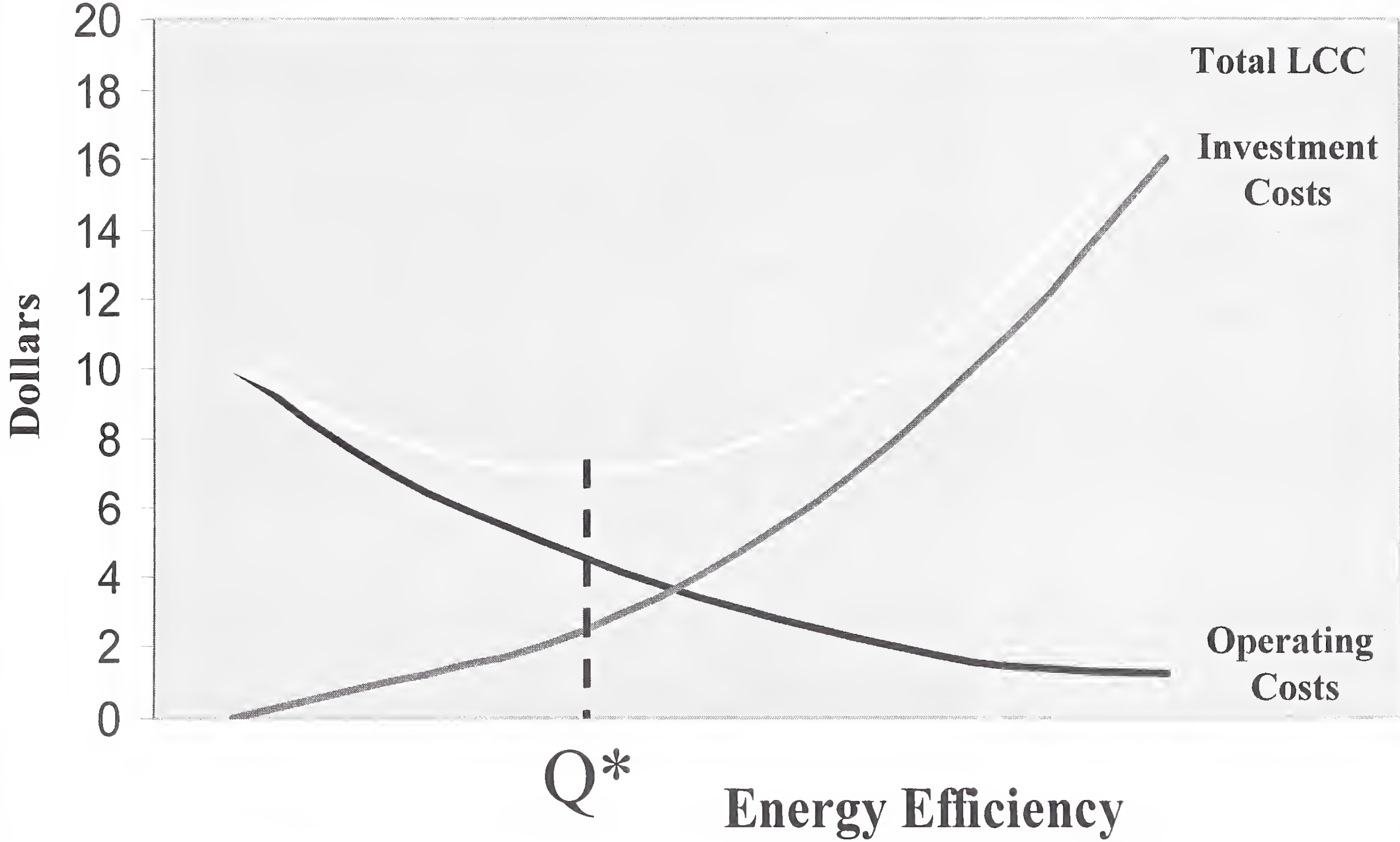


Savings must be greater than costs!

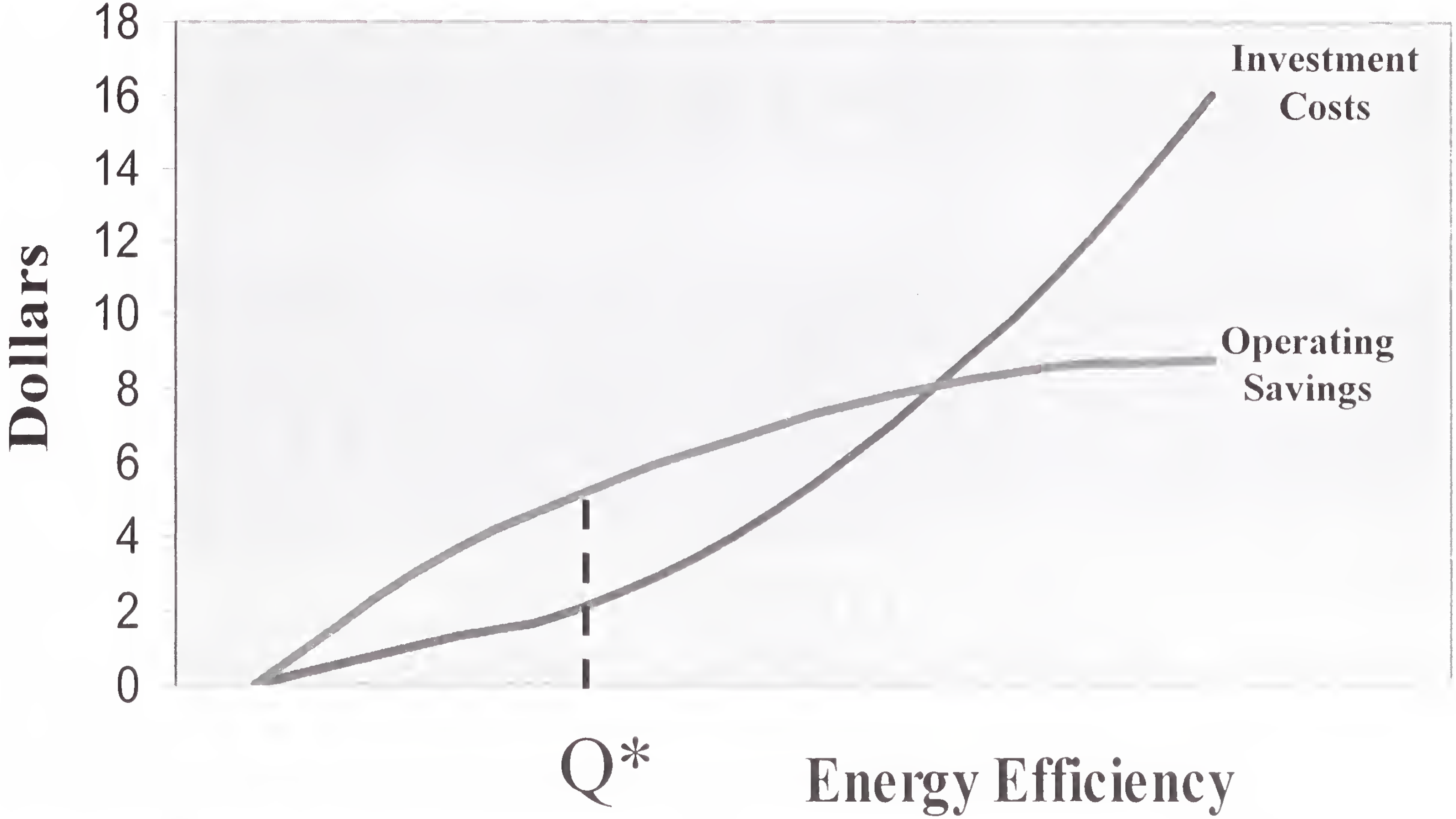
Life-Cycle Costs of Two Alternatives



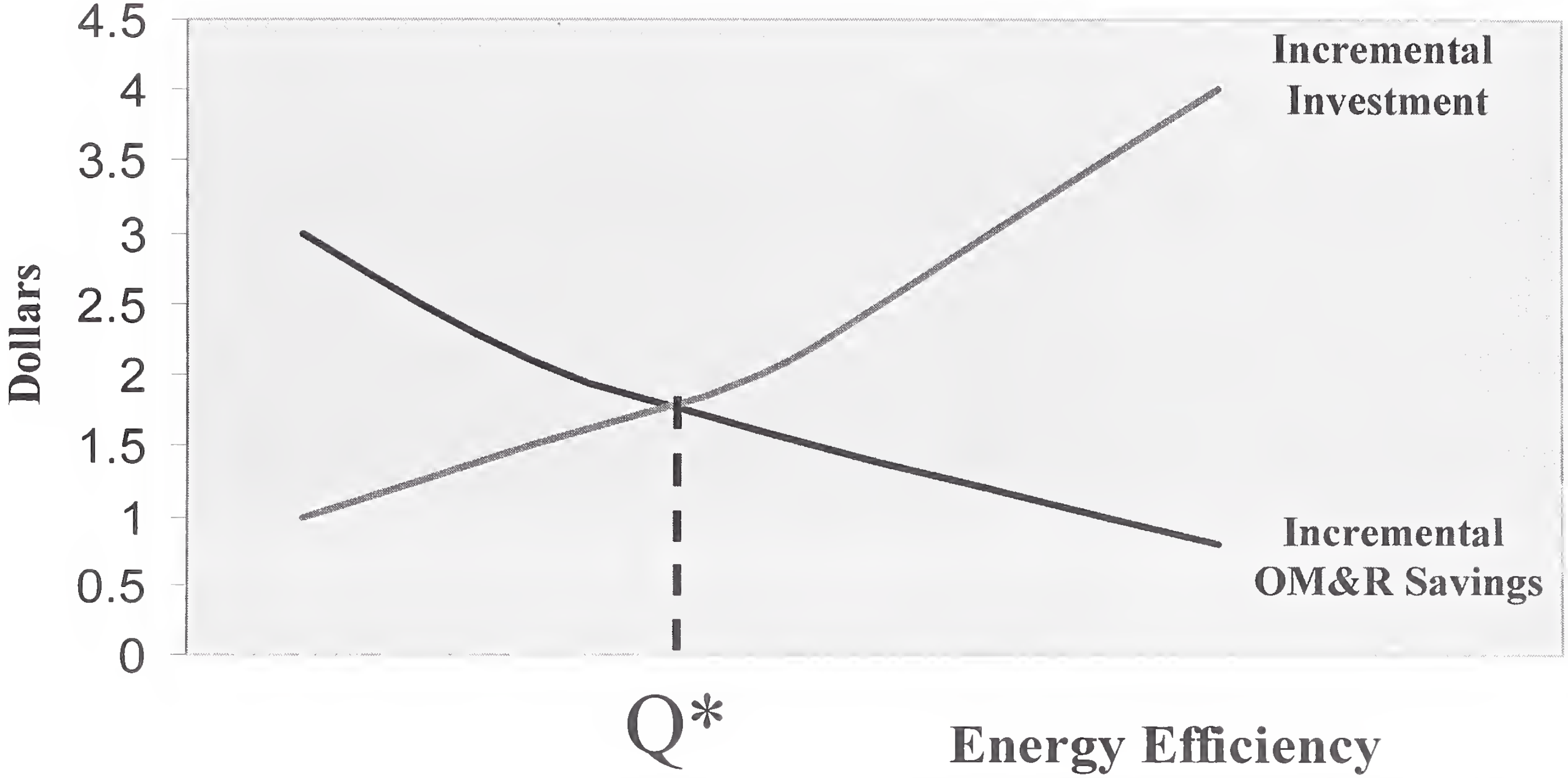
Total Life-Cycle Cost is Minimized



Net Savings are Maximized



Incremental Savings Equal Incremental Costs



Types of Decisions

- Accept/reject projects
- Optimal energy efficiency level
- Optimal system selection or design
- Optimal combination of interdependent systems
- Prioritization of independent projects

Life-Cycle Cost Analysis

LCCA is

- **a method of economic analysis that sums all *relevant* project costs over a *given study period* in *present-value* terms.**

- **most relevant when selecting among *mutually exclusive project alternatives* that provide the same functional performance but have different initial costs, OM&R costs, and/or expected lives.**

Typical Project Costs

- **Investment-related:**
  - **Acquisition costs**
  - **Replacement costs**
  - **Residual value (resale or disposal cost)**
- **Operating-related:**
  - **Operation, maintenance, and repair costs**
  - **Energy and water costs**
  - **Contract-related costs (for financed projects)**

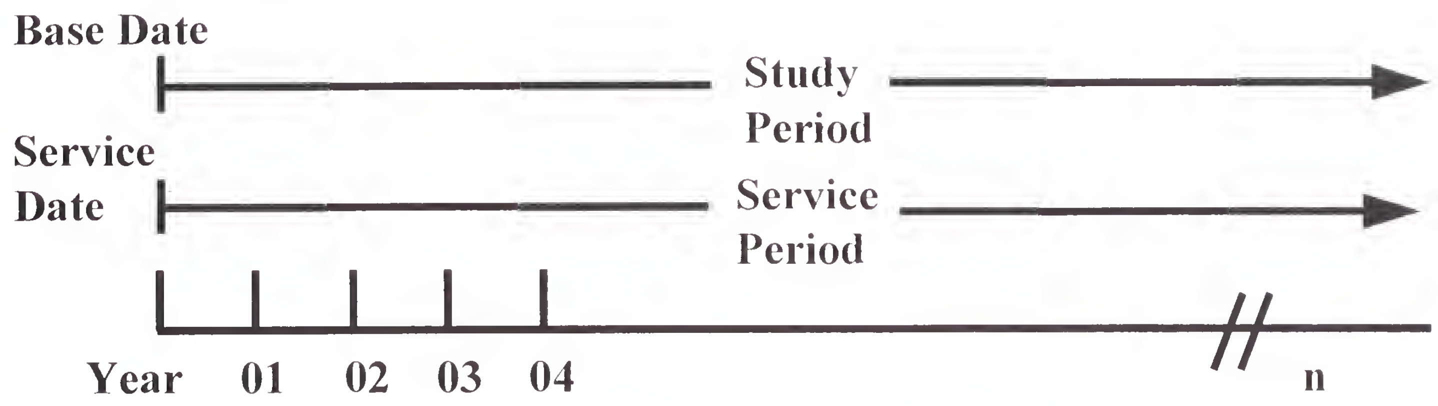
Generally, only amounts that are different need to be considered when comparing mutually exclusive alternatives.

The Study Period

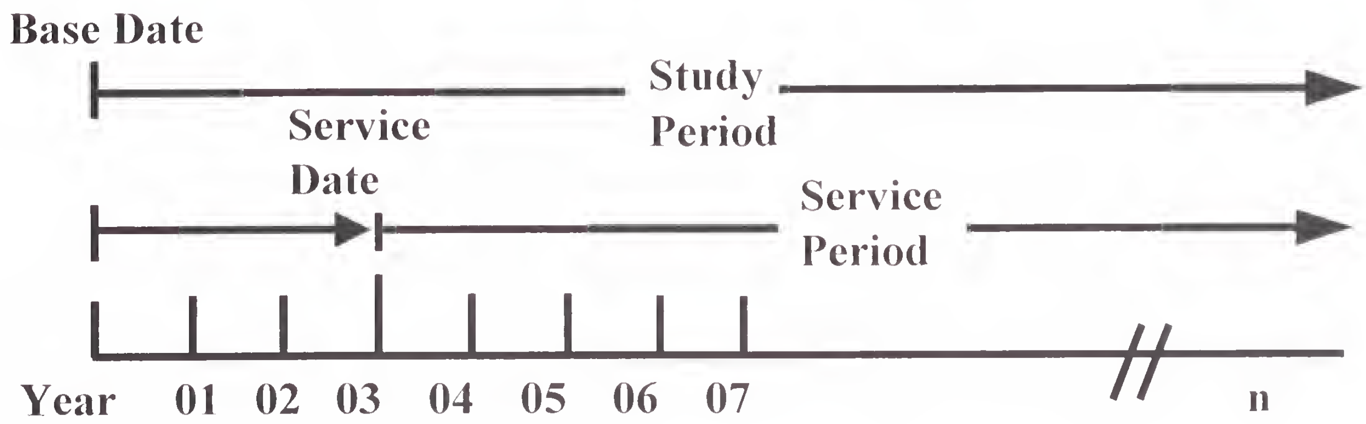
The study period

- is the length of time over which an investment is analyzed based on
  - the expected life of the project and/or
  - the investor's time horizon.
- Base Date: analysis date to which all cash flows are discounted.
- Service Date: date when building or system is occupied or becomes operational.
- Study period must be the same for all alternatives.

Study Period

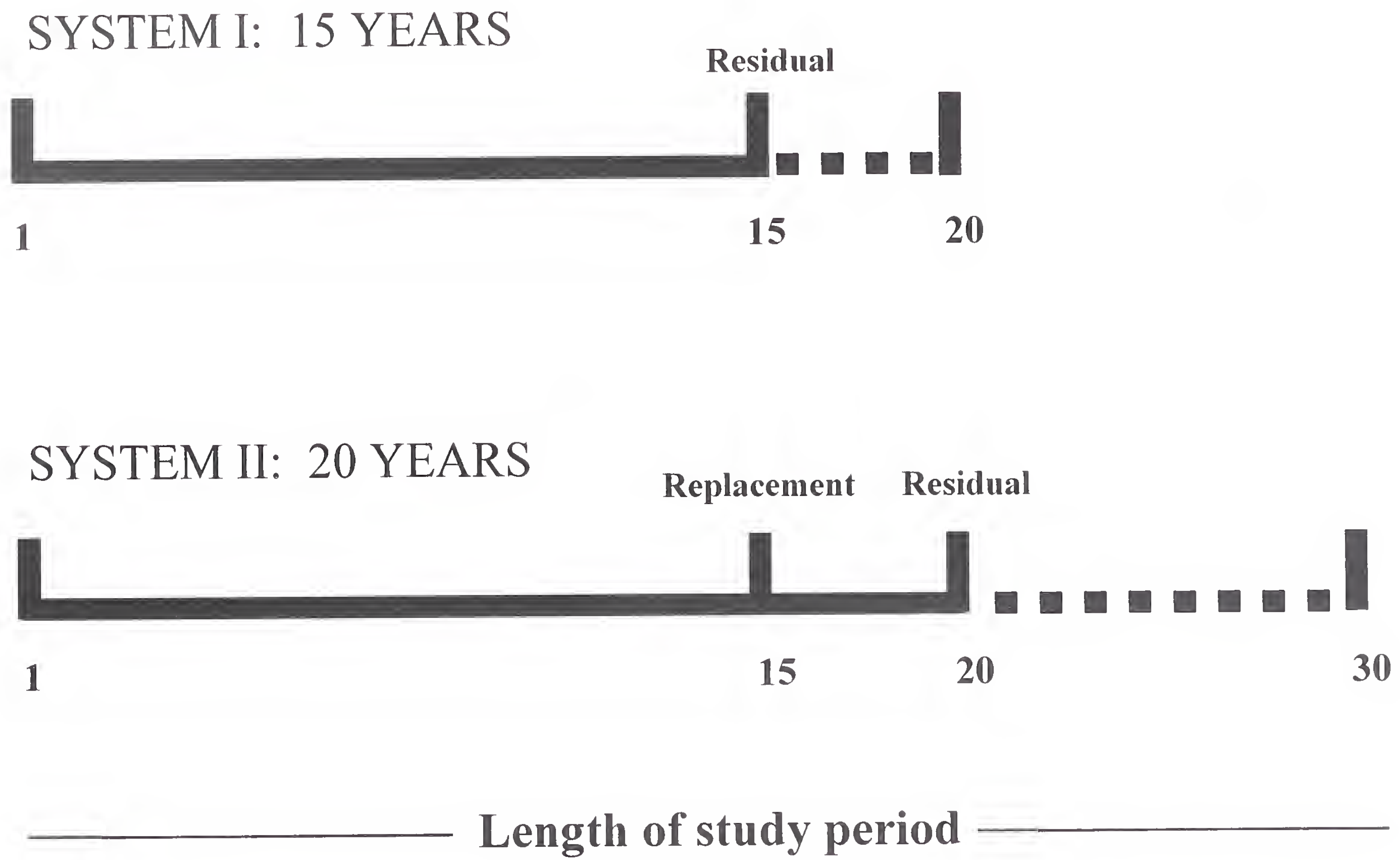


Coinciding Study Period and Service Period



Phased-in Planning/Construction/Implementation Period

Adjusting for Different System Lives



Present Value and Discounting

A present-value amount

- **is the equivalent value to an investor, as of the base date, of a cash amount paid or received at a future date.**

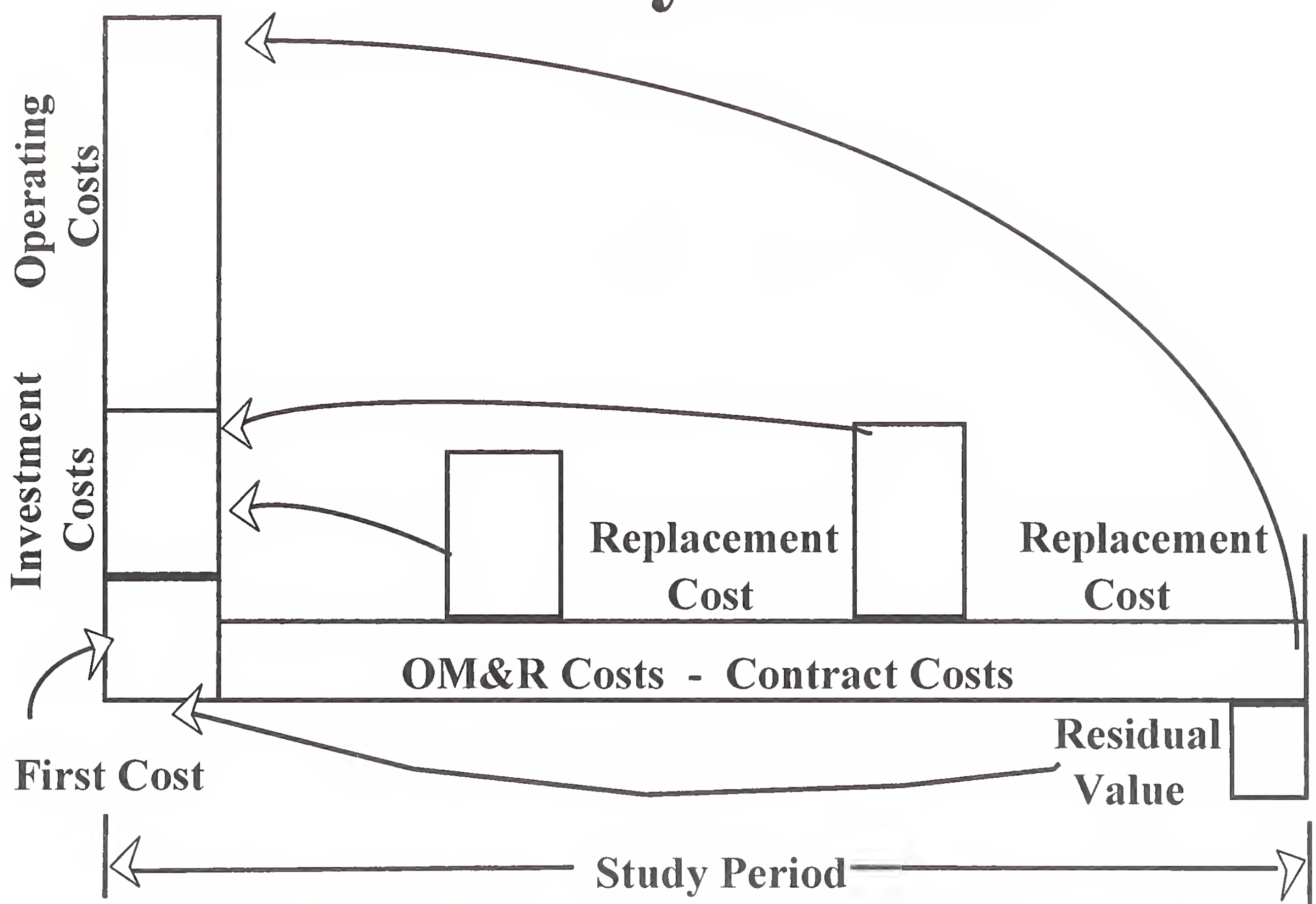
The present value of a future amount

- **is found by discounting;**
  discounting adjusts for the investor's time-value of money.

The discount rate

- **is the interest rate that makes an investor indifferent between cash amounts received or paid at different points in time.**

Life-Cycle Cost



Converting future amounts to present value:

$$PV = C_t \times \frac{1}{(1+d)^t}$$

$$LCC = \sum_{t=0}^{n} \frac{C_t}{(1+d)^t}$$

where n = length of study period.

Useful Discount Factors

(1) Single present value (SPV) factor for one-time amounts or non-annually recurring amounts:

$$PV = F_t \times SPV_{(t,d)}$$

(2) Uniform present value (UPV) factor for uniform annual amounts:

$$PV = A_0 \times UPV_{(n,d)}$$

where A_0 = annual amount at base-date prices

Useful Discount Factors (cont.)

(3) Modified uniform present value (UPV*) factor for changing annual amounts

$$PV = A_0 \text{ x } UPV^*_{(n,d,e)}$$

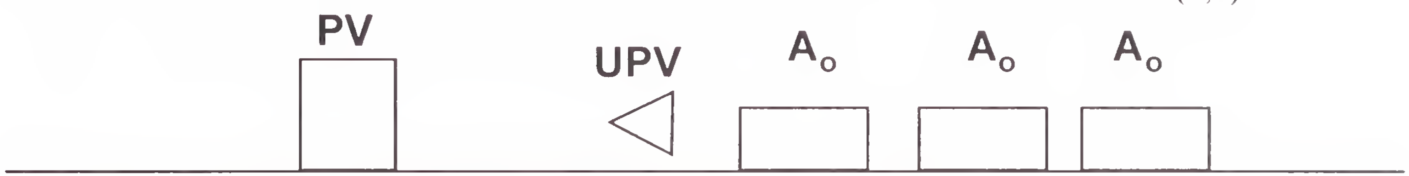
DOE Energy Price Projections

- DOE energy price escalation rates vary
  - by region (census region)
  - by fuel type (elec., oil, gas, LPG, coal)
  - by rate (residential, commercial, industrial)
  - by year

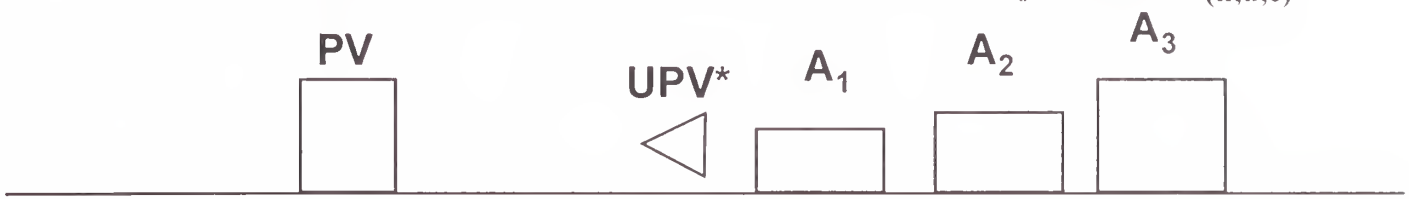
Summary of Present Value Factors

Single future amount (year t) $PV = F_t \times SPV_{(t,d)}$

Recurring annual amount (over n years) $PV = A_o \times UPV_{(n,d)}$



Changing annual amount (over n years) $PV = A_o \times UPV^*_{(n,d,e)}$



Single Present Value Factor

Example: Find the present value of $1,000 received at the end of year 10 when the discount rate is 3.2% (table A-1, Annual Supplement to HB135).

$$PV = F_t \times SPV$$

$$PV = \$1{,}000 \times SPV_{(d=3.2\%,\ t=10)}$$

$$= \$1{,}000 \times 0.730 = \$730$$

Uniform Present Value (UPV) Factor

Find the present value of an annually recurring operating cost of $1,000 each year for 10 years when the discount rate is 3.2% (table A-2, Annual Supplement to HB135).

$$PV = A_0 \times UPV$$

$$PV = \$1{,}000 \times UPV_{(d=3.2\%,\ n=10)}$$

$$= \$1{,}000 \times 8.44 = \$8{,}440$$

Modified Uniform Present Value (UPV*) Factor

Find the present value of an annually recurring operating cost of $1,000 over 10 years, when this cost is expected to escalate at 2%/yr and the discount rate is 3.2% (table A-3a, Annual Supplement to HB135).

$$PV = A_0 \times UPV^*$$

$$PV = \$1{,}000 \text{ (annual)} \times UPV^*_{(d=3.2\%,\ n=10,\ e=2\%)}$$

$$= \$1{,}000 \times 9.38 = \$9{,}380$$

FEMP UPV* Factor for Energy Costs

Find the present value of an annually recurring electricity cost of $1,000 over 10 years, given current DOE energy price escalation rates (Region 4, industrial rates) and the current DOE discount rate of 3.2% (table Ba-4, Annual Supplement to HB135).

$$PV = A_0 \times UPV^*$$

$$PV = \$1,000 \times UPV^*_{(d=3.2\%,\ n=10,\ \text{electr., industrial, region 4})}$$

$$= \$1,000 \times 7.19 = \$7,190$$

Sources of Discount Factors

- Discount factors can be hand-calculated, computer-calculated, or looked up.
- Sources:
  - Annual Supplement to Handbook 135 (for federal projects)
  - NIST DISCOUNT computer program, NISTIR 85-3273-xx
  - Generic discount factor tables, NISTIR 89-4203
- Available from:
  - DOE HELP Desk at 1-800-DOE-EREC (363-3732) or
  - www.eren.doe.gov/femp -- Technical Assistance – Life-Cycle Cost Analysis
  - Updated annually on April 1

Inflation Adjustment in LCCA

Definitions

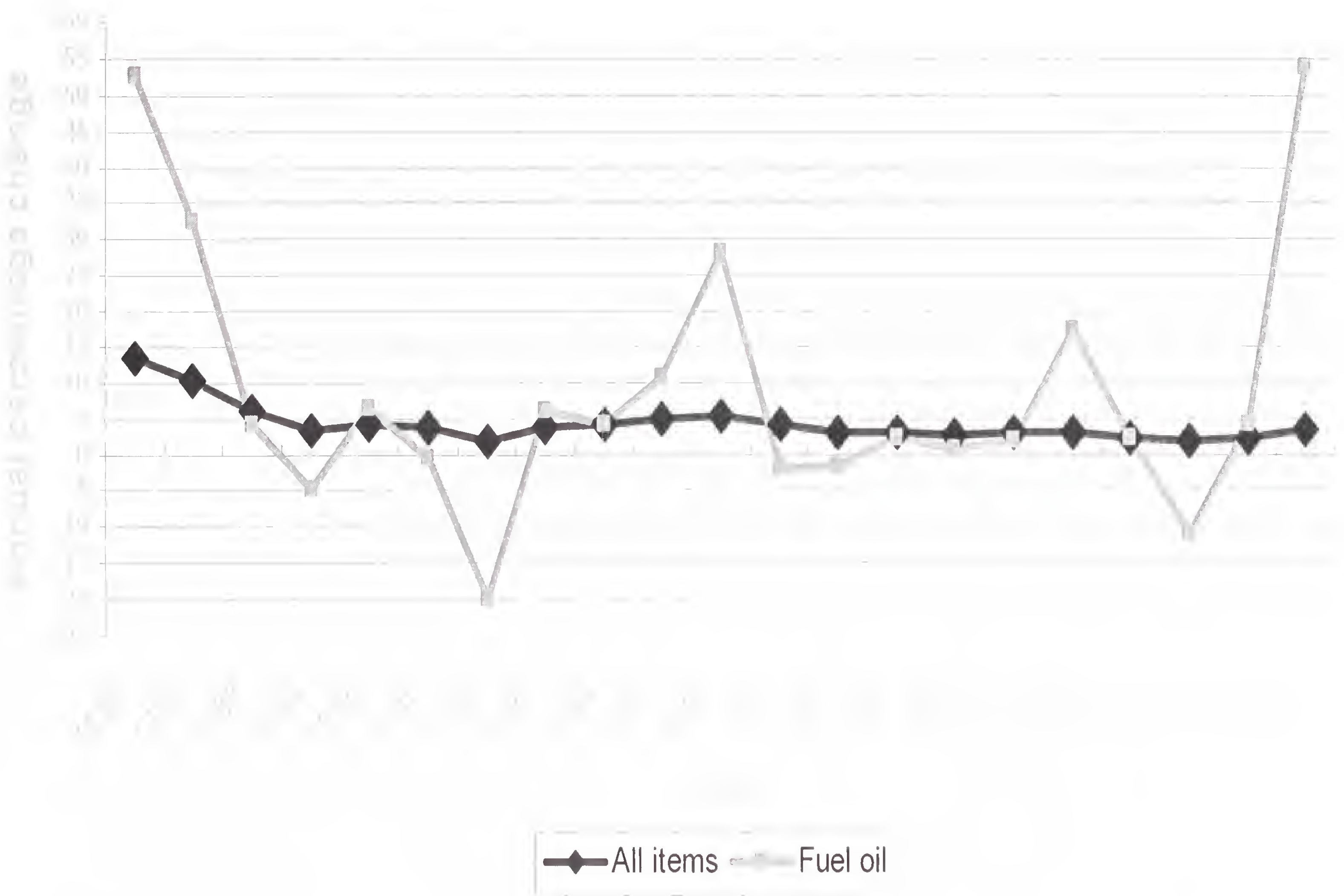
- Inflation: rate of increase of the general level of prices.
- Escalation: rate of increase in the price of a particular commodity.
- Differential escalation: rate of increase in the price of a particular commodity relative to the rate of increase in the general level of prices.

Inflation Adjustment in LCCA

Definitions (cont.)

- **Constant dollars: dollars of *uniform purchasing power* from year to year, exclusive of general inflation.**
- **Current dollars: dollars of purchasing power of year in which actual prices are stated, including general inflation.**

Change in Consumer Price Indexes: 1980 to 2000



Two Approaches for Dealing with Inflation

- **Exclude general price inflation:**
  - Specify all costs in constant dollars.
  - Use a real discount rate (excluding inflation).

- **Include general price inflation:**
  - Specify all costs in current dollars.
  - Use a nominal discount rate (including inflation).

Both approaches yield the same present values.

Comparing LCCs of Alternative Systems Requires a Common Analytical Perspective

- Base date
- Service date
- Study period
- Discount rate
- Inflation assumption (or constant dollar analysis)
- Cost estimating method(s)
- Operational schedule
- Energy analysis method

Federal Criteria for LCC Analysis

- Energy and Water Conservation Projects—10 CFR 436A/HB135
  - DOE discount rate (updated annually), published in Annual Supplement to Handbook 135
  - Maximum 25-year service period
  - Local energy prices, metered energy quantities
  - DOE energy price escalation rates
  - Analysis usually in constant base-year dollars (i.e., excluding inflation), except for financed projects
- Other federal projects—OMB Circular A-94
  - OMB discount rates, varying with length of study period and type of project
  - No limit on study period

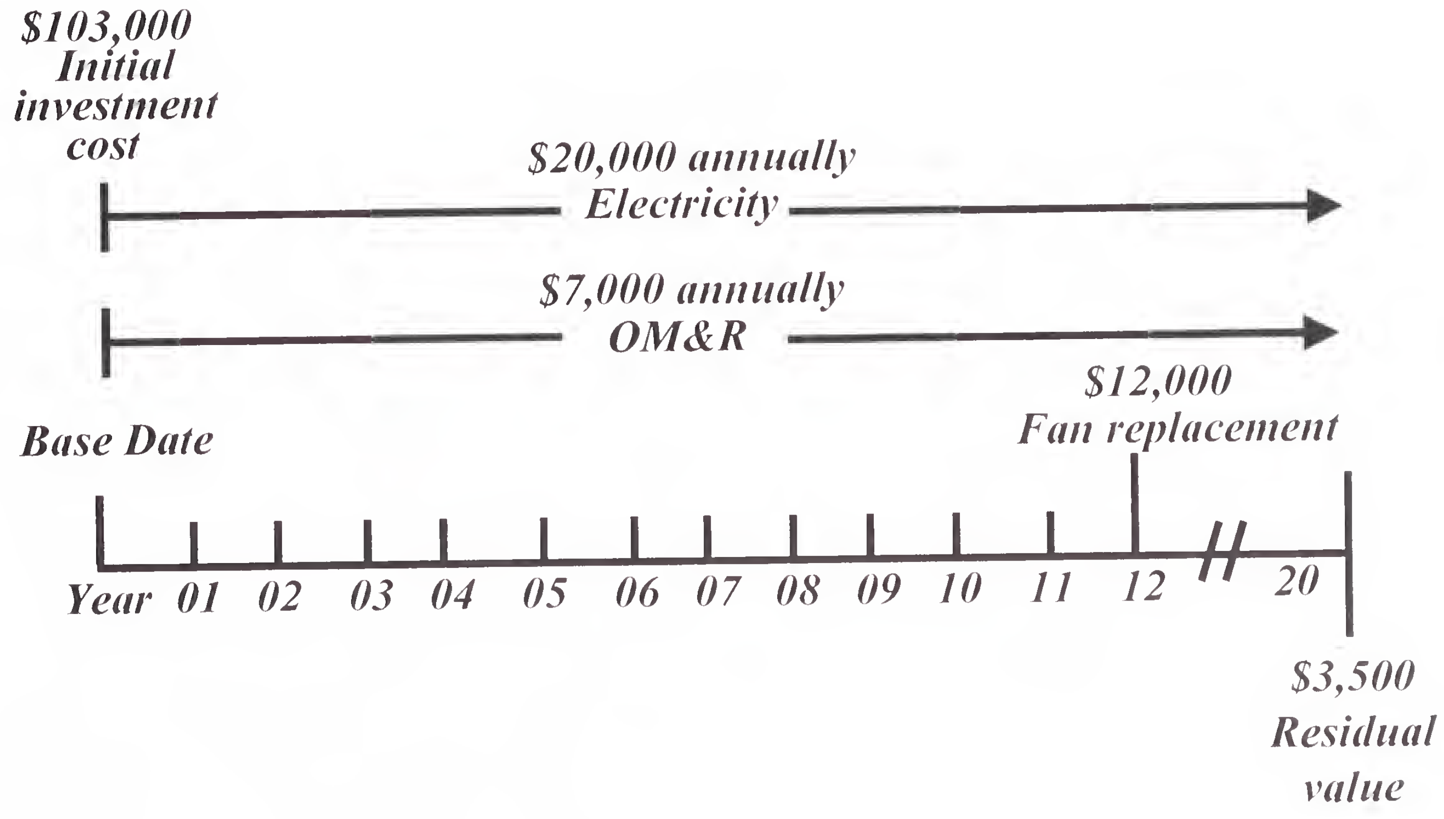
Example A1: Central AC System Selection for Office Building

Location:	**Federal building, Washington, DC; DOE Region 3**
Discount rate:	**2002 FEMP discount rate: 3.2% real (constant-dollar analysis)**
Fuel type:	**Electricity**
Price:	**$0.08/kWh, local rate as of base date**
Rate type:	**Commercial**
Useful life:	**20 years**
Study period:	**20 years**
Base date:	**June 2002**

Base Case: Conventional System w/o Computer Controls and Economizer

- $103,000 Initial investment costs
- $ 12,000 Replacement cost for fan at the end of year 12
- $ 3,500 Residual value at the end of the 20-year study period
- $ 20,000 Annual electricity costs (250,000 kWh at $0.08/kWh)
- $ 7,000 Annual OM&R costs

Cash-Flow Diagram for Base Case



LCC for Base Case
(Conventional System)

Cost Items (1)	Base Date Cost (2)	Year of Occurrence (3)	Discount Factor (4)	Present Value (5)=(2)x(4)
Initial investment	$103,000	Base date	already in present value	$103,000
Capital replacement (fan)	$12,000	12	SPV_{12} 0.685	$8,220
Residual value	($3,500)	20	SPV_{20} 0.533	($1,866)
Electricity: 250,000 kWh at $0.08/kWh	$20,000	annual	UPV^{*}_{20} 14.22	$284,400
OM&R	$7,000	annual	UPV_{20} 14.61	$102,270
Total LCC				$496,024

Alternative Case:

Energy-Saving System with Computer Controls and Economizer

- **$110,000** **Initial investment costs**
- **$ 12,500** **Replacement cost for fan at the end of year 12**
- **$ 3,700** **Residual value at the end of the 20-year study period**
- **$ 13,000** **Annual electricity costs (162,500 kWh at $0.08/kWh)**
- **$ 8,000** **Annual OM&R costs**

LCC for Alternative
(Energy-saving system)

Cost Items (1)	Base Date Cost (2)	Year of Occurrence (3)	Discount Factor (4)	Present Value (5)=(2)x(4)
Initial investment cost	$110,000	Base date	already in present value	$110,000
Capital replacement (fan)	$12,500	12	SPV_{12} 0.685	$8,563
Residual value	($3,700)	20	SPV_{20} 0.533	($1,972)
Electricity: 162,000 kWh at $0.08/kWh	$13,000	annual	UPV^*_{20} 14.22	$184,860
OM&R	$8,000	annual	UPV_{20} 14.61	$116,880
Total LCC				$418,331

Lowest LCC

LCC of Base Case :	$496,024
LCC of Alternative:	$418,331 ←

Alternative with the lowest LCC is the economic choice.

Uses of Life-Cycle Cost

Types of Decisions	LCC	Criterion
Accept /Reject	yes	lowest LCC
Optimal Performance	yes	lowest LCC
Optimal System/Design	yes	lowest LCC
Project Priority	no	---

Supplementary Economic Measures

- Net Savings (NS)
- Savings-to-Investment Ratio (SIR)
- Adjusted Internal Rate of Return (AIRR)
- Discounted Payback (DPB)

Net Savings (NS)

NS = PV of operational savings minus PV of additional investment

$$NS_{Alt} = LCC_{BC} - LCC_{ALT}$$

$$NS_{ALT} = \$496,024 - \$418,331$$

$$NS_{ALT} = \$\ 77,693$$

Alternative with the highest NS is the economic choice.

Uses of Net Savings

Types of Decisions	LCC	Criterion
Accept /Reject	yes	> 0 / < 0
Optimal Performance	yes	maximize
Optimal System/Design	yes	maximize
Project Priority	no	---

Savings-to-Investment Ratio (SIR)

SIR = Ratio of PV of operational savings to PV of additional investment costs

Savings-to-Investment Ratio

$$\text{SIR} = \frac{\text{PV operational savings}}{\text{PV of additional investment costs}}$$

$$\text{PV Operational savings} = \text{PV O\&M costs}_{BC} - \text{PV O\&M costs}_{ALT}$$

$$\text{PV}\Delta\ \text{Investment costs} = \text{PV investment}_{ALT} - \text{PV investment}_{BC}$$

$$\text{SIR} = \frac{(284{,}400 + 102{,}270) - (184{,}860 + 116{,}880)}{(110{,}000 + 8{,}563 - 1{,}972) - (103{,}000 + 8{,}220 - 1{,}866)}$$

$$\text{SIR} = \frac{84{,}930}{7{,}237} = 11.7$$

Uses of Savings-to-Investment Ratio

Types of Decisions	LCC	Criterion
Accept /Reject	yes	> 1 / < 1
Optimal Performance	no	---
Optimal System/Design	no	---
Project Priority	yes	descending order

Meaningful SIR cannot be computed for financed projects.

Adjusted Internal Rate of Return (AIRR)

AIRR = **Measure of performance of investment as a percentage yield, assuming reinvestment of cash flows at a given rate (r)**

$$AIRR = (1+r)SIR^{1/N} - 1$$

$$= (1+0.032)\,11.7^{1/20} - 1$$

$$= 16.7\%$$

Uses of Adjusted Internal Rate of Return

Types of Decisions	LCC	Criterion
Accept /Reject	yes	> d / < d
Optimal Performance	no	---
Optimal System/Design	no	---
Project Priority	yes	descending order

Meaningful AIRR cannot be computed for financed projects.

Discounted Payback (DPB)

DPB = **Minimum value of n, years, for which discounted savings in year t are at least equal to additional initial investment costs**

$$\sum_{t=1}^{n} \frac{\left(S_t - \Delta I_t\right)}{\left(1+d\right)^t} \geq \Delta I_0$$

Discounted Payback for Alternative

Base-year electricity savings:	$7,000
Base-year OM&R savings:	- $1000
Additional Initial Investment:	$7,000

Year	Cumulative PV Savings	ΔInitial Cost	Cumulative PV Net Savings
1	$ 5,680	$7,000	-$1,320
2	11,180	7,000	4,180

Discounted Payback occurs in year 2.

Uses of Discounted Payback

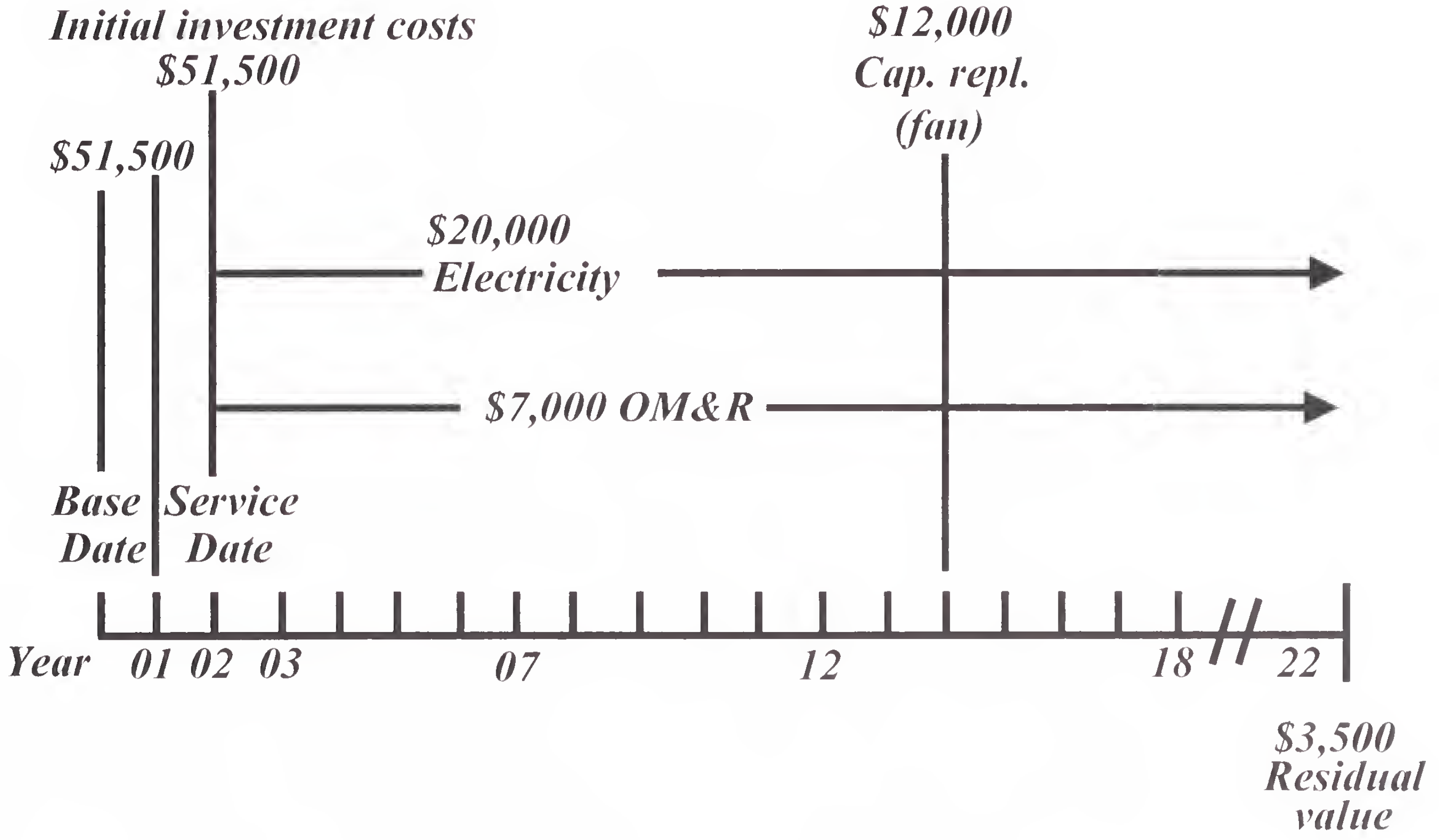
Types of Decisions	LCC	Criterion
Accept /Reject	yes	≤ / ≥ proj.life
Optimal Performance	no	---
Optimal System/Design	no	---
Project Priority	no	---

Meaningful DPB cannot be computed for financed projects.

Example A2: CAC System Selection for Office Building with Planning/Construction Period

- 2-year planning/construction period
- First half of investment cost incurred at end of year 1, second half at service date

Cash Flow Diagram for Base Case with P/C Period



LCC Calculation for Base Case with P/C Period

Cost Items (1)	Base Date Cost (2)	Year of Occurrence (3)	Discount Factor (4)	Present Value (5)=(2)x(4)
Initial investment cost:				
1st Installment at midpoint of construction	\$51,500	1	SPV_1 0.969	\$49,904
2nd Installment at beginning of service period	\$51,500	2	SPV_2 0.939	\$48,359
Capital replacement (fan)	\$12,000	14	SPV_{14} 0.643	\$7,716
Residual value	(\$3,500)	22	SPV_{22} 0.500	(\$1,750)
Electricity: 250,000 kWh at \$0.08/kWh	\$20,000	annual	UPV^*_{22-2} 15.24-1.87 = 13.37	\$267,400
OM&R	\$7,000	annual	UPV_{22-2} 15.62-1.91 = 13.71	\$95,970
Total LCC				\$467,599

LCC Calculation for Alternative with P/C Period

Cost Items (1)	Base Date Cost (2)	Year of Occurrence (3)	Discount Factor (4)		Present Value (5)=(2)x(4)
Initial investment cost:					
1st Installment at midpoint of construction	$55,000	1	SPV_1	0.969	$53,295
2nd Installment at beginning of service period	$55,000	2	SPV_2	0.939	$51,645
Capital replacement (fan)	$12,500	14	SPV_{14}	0.643	$8,038
Residual value	($3,700)	22	SPV_{22}	0.500	($1,850)
Electricity: 250,000 kWh at $0.08/kWh	$13,000	annual	UPV^*_{22-2}	13.37	$173,810
OM&R	$8,000	annual	UPV_{22-2}	13.71	$109,680
Total LCC					$394,618

Net Savings for Alternative with P/C Period

$$NS_{Alt} = LCC_{BC} - LCC_{ALT}$$

$$NS_{ALT} = \$467{,}599 - \$394{,}618$$

$$NS_{ALT} = \$72{,}981$$

Savings-to-Investment Ratio (with P/C period)

$$SIR = \frac{(267{,}400 + 95{,}970) - (173{,}810 + 109{,}680)}{(104{,}940 + 8{,}038 - 1{,}850) - (98{,}263 + 7{,}716 - 1{,}750)}$$

$$SIR = \frac{79{,}880}{6{,}899} = 11.6$$

Exercise A1

Attic Insulation

Materials required: *Annual Supplement to Handbook 135*
Four-function calculator

Note: *These problems are intended for manual solution.*

Use the worksheet on the next page to determine the level of insulation with the lowest life-cycle cost, which is to be installed in the attic of a house located in Northern California. The existing insulation level is R-11.

Location:	**West (Region 4)**
Base date:	**June 2002**
Service date:	**June 2002**
Discount rate:	**3.2%**
Expected life:	**25 years**
Replacements:	**none**
Residual value:	**none**
Electricity price:	**0.08/kWh**
Rate type:	**Residential**

Insulation Level	Annual energy consumption kWh	Installed Cost ($)
R-11	9602	0
R-19	7055	450
R-30	6804	650
R-38	6703	800

Worksheet for Exercise A1

(1)	(2)	(3)	(4)= (3)X$.08/kWh	(5)	(6)= (4)x(5)	(7)= (2)+(6)	(8)= $LCC_{R-0} - LCC_{R-N}$
			Energy Cost				
R-value	Initial Cost ($)	Annual kWh	Annual ($)	UPV*	Life ($)	Total LCC ($)	Net Savings ($)
R-11	0	9602	____	____	____	____	____
R-19	450	7055	____	____	____	____	____
R-30	650	6804	____	____	____	____	____
R-38	800	6703	____	____	____	____	____

Exercise A2

Selection of Heating System

Select the residential heating system with the lower life-cycle cost and calculate its Net Savings and Savings-to-Investment Ratio. Use the worksheet on the next page.

Annual space heating load:	50 MBtu
Fuel oil price:	$1.12/gallon ($8.00/MBtu)
Natural gas price:	$0.80/therm ($8.00/MBtu)
Rate type:	Residential
Location:	Midwest (Region 2)
Discount rate:	3.2%
Base date/service date:	April 2002
Study Period:	15 years

	Oil Furnace	Gas Furnace
Initial cost:	$4,500	$5,000
Annual maintenance cost	$125	$75
Annual efficiency (average)	82%	83%
Expected life (years)	15	15
Residual value	$500	$1,000

Worksheet for Exercise A2

LCC = Initial Cost + PV energy + PV maintenance - PV residual value

Oil Furnace:

LCC = ____________ + ____________ + ____________ - ____________

LCC = ____________

Gas Furnace:

LCC = ____________ + ____________ + ____________ - ____________

LCC = ____________

NS = ____________ - ____________

NS = ____________

SIR = **Net reduction in operating-related costs** / **Increase in investment-related costs**

SIR = ____

SIR = ____________

Solution to Exercise A1

R-value	Initial Cost ($)	Annual kWh	Energy Cost Annual ($)	Energy Cost Life ($)	Total LCC ($)	Net Savings ($)
R-11	0	9602	768	11,543	11,543	—
R-19	450	7055	564	8,477	8,927	2,616
R-30*	650	6804	544	8,176	8,826	2,717
R-38	800	6703	536	8,056	8,856	2,687

UPV* = 15.03

*R-30 has the lowest Life-Cycle Cost and the highest Net Savings.

Solution to Exercise A2

Lowest Life-Cycle Cost:

LCC = Initial Cost + PV energy + PV maintenance - PV residual value

Oil Furnace:
LCC = \$4,500 + (50/0.82 x \$8.00 x 11.08) + (\$125 x 11.77) - (\$500 x 0.623)
LCC = \$4,500 + \$5,405 + \$1,471 - \$312
LCC = \$11,064

Gas Furnace:
LCC = \$5,000 + (50/0.83 x \$8.00 x 11.63) + (\$75 x 11.77) - (\$1,000 x 0.623)
LCC = \$5,000 + \$5,605 + \$883 - \$623
LCC = \$10,865

Net Savings for Gas Furnace:
NS = \$11,064 - \$10,865
NS = \$ 199

SIR for Gas Furnace:

$$SIR = \frac{(\$5{,}405 + \$1{,}471) - (\$5{,}605 + \$883)}{(\$5{,}000 - \$623) - (\$4{,}500 - \$312)}$$

$$SIR = \frac{\$\,388}{\$\,189}$$

$$SIR = 2.05$$

Summary of the Life-Cycle Costing Method

Savings and investment costs

The basic criterion for determining whether a design alternative that increases capital investment and lowers future operating costs is cost effective is that **the savings generated by the investment must be greater than the additional investment cost**. The number of years over which the savings are accumulated and the weighting of future costs (or cost savings) relative to present costs are major considerations in life-cycle cost (LCC) analysis.

Life-cycle cost

The LCC concept requires that **all costs and savings related to a design decision be evaluated over a common study period and adjusted for the time value of money** before they can be meaningfully compared. Choosing building systems on the basis of first cost alone can increase the long-run owning and operating costs of a building. For example, the purchase of a low-efficiency heating system, while initially less expensive than a more efficient system, will incur higher energy costs when in use. The difference may be significant since for many building systems only a small part of the life-cycle cost is attributable to the initial purchase price. The greater part is usually attributable to ongoing operating, maintenance, repair, and energy costs.

The principles of present-value analysis, which are the basis for the life-cycle cost method, **apply to investments in federal, state, and local governments** whether they are funded by the government agency from tax appropriations or **financed through private-sector energy or utility services companies.**

To **supplement LCC analysis,** there are additional measures of economic effectiveness, such as Net Savings (NS), Savings-to-Investment Ratio (SIR), Adjusted Internal Rate of Return (AIRR) and Discounted Payback Period (DPB) period. If computed correctly, all of these measures are consistent with the LCC method.

Particular care must be given to the use of the DPB as a criterion for accepting or rejecting projects. The DPB is consistent with the LCC method only when nothing more is required than that payback occur before the end of the study period and if cumulative net savings after payback is achieved are positive. DPB is not consistent with the LCC method when an arbitrary payback period is specified as a cut-off point for project acceptance.

Comparing alternatives

From a decision standpoint, **the LCC of a design alternative only has meaning when it is compared against the LCC of a base case.** For example, Alternative B has a higher investment cost but lower operating-related costs than Base Case A, although both are expected to perform equally well with regard to their basic purpose. Since the sum of investment cost plus operating cost (including energy costs) for alternative B is less than that for A, alternative B is the more cost-effective choice. Note that in an existing building, the base case alternative (i.e., the existing design) may not require any investment; it may be the "do nothing" alternative. In that case, the life-cycle cost of the base case is made up entirely of operating-related costs, which must be compared against the combined investment and operating costs of the alternatives considered. In other cases (e.g., a new building design) the base case may be the design with the lowest first cost or the minimum level of performance that satisfies building code requirements.

Minimizing total owning and operating costs

The graph in slide A-4 is typical of energy conservation investments. It compares the owning and operating costs associated with a wide range of energy efficiency levels for a building system (e.g., exterior wall insulation or air conditioner efficiency). Generally, as the level of energy efficiency increases, initial costs increase at an increasing rate. Lower levels of efficiency can generally be achieved at low cost, but as the efficiency level is increased, structural, mechanical, or design modifications must be made to accommodate the added components. This quickly adds to the initial cost. For example, to increase the effective thermal resistance value of a wall, the wall thickness must be increased or a more costly type of insulation must be used; or, in the case of air conditioners, significantly larger heat exchangers or more costly compressors are necessary to increase energy efficiency. For some systems, such as fossil-fired furnaces, there are practical limits to the extent to which efficiency can be increased, causing the investment cost curve to bend sharply upwards.

The operating cost curve in the graph shows that as the energy efficiency of the system is increased, energy consumption is decreased, but at a decreasing rate. In fact, energy consumption is generally inversely proportional to energy efficiency so that additional units of improvement generate less savings than the ones before. For example, increasing the thermal resistance value of attic insulation from R-30 to R-40 only saves about 18 % as much energy as increasing the level from R-10 to R-20.

The total cost curve is the vertical summation of the investment cost and operating cost associated with any level of energy efficiency. **The lowest point on the total cost curve, Q^*, determines the level of energy efficiency that minimizes life-cycle costs.** It is important to recognize that there are a number of factors that contribute to this result. For example, longer study periods, more severe climates, lower conservation costs (say through technology improvements), and higher energy prices all tend to result in a higher level of energy efficiency becoming cost-effective.

Maximizing net savings

The graph in slide A-5 shows that the most cost-effective level of energy conservation can also be determined by finding the level that maximizes net savings, the difference between total costs and total savings. The slide shows two curves, the investment cost curve, which is identical to that shown in the previous slide, and a savings curve. The savings curve is determined by taking the difference between the operating cost at the zero level of investment and the operating cost at any other level of investment on the graph.

Note that total savings are greater than total costs anywhere between the origin and the point where the two curves cross. Thus we might conclude that any level of investment between these two points is justified. But in fact the **economically optimal** level of energy efficiency is that level for which **net savings is greatest**, again Q^*. This is the same point that was determined by finding the level with the lowest LCC. This is not surprising if you recognize that net savings at any point along the horizontal axis of the graph in slide A-4 is the difference between the LCC of the base case (measured at the zero investment level) and the LCC of the alternative at that point. Thus the energy efficiency level with the lowest LCC must have the highest net savings. By contrast, at the point where investment cost just equals savings (slide A-5), you are no better off than you were at the origin, since in both cases net savings is zero.

Incremental savings versus incremental costs

Graph A-6 provides an additional look at the relationship between the investment cost curve and the operating cost curve. Here incremental costs and incremental savings are plotted. Each additional unit of energy efficiency results in smaller and smaller increments in savings and greater and greater additions to cost. The shape of these curves is quite typical: conservation investment costs are increasing at an increasing rate and energy savings are decreasing at a decreasing rate. **The point where these two curves cross determines the economically optimal level of energy efficiency, again Q^*, the point at which the last increment in cost increases savings by the same amount.** This is the same point, Q^*, found by minimizing LCC or maximizing net savings. At any point to the left of Q^*, incremental savings are higher than incremental costs, so that **increasing** the energy efficiency level will reduce life-cycle costs and increase net savings. At any point to the right of Q^*, the intersection, incremental savings are less than incremental costs, so that **reducing** the energy efficiency level will reduce life-cycle costs and increase net savings.

Economic efficiency

It is essential to recognize that all three of these methods arrive at the same optimal level of energy efficiency. **In general, if the LCC methodology is applied correctly, all three of these methods arrive at the same optimal level of energy efficiency.** Economists refer to the level of investment where life-cycle cost is minimized, net savings is maximized, and incremental investment is equal to incremental savings as the "economically efficient" level of investment for a given project.

The above treatment of costs and savings assumes that the energy efficiency of building systems can be improved in a continuous fashion. In fact, commercially available systems are rarely available in a continuous range of efficiency ratings. However, the underlying concepts shown here are valid even when efficiency improvements come in "step" form. That is, the alternative with the lowest LCC will be the most cost-effective choice, given that it satisfies the other performance objectives of the system. **In every case, finding the alternative with the lowest LCC will provide sufficient information to choose the economically efficient level of investment.**

Types of decisions

There are five types of investment decisions related to energy conservation to which economic analysis can be usefully applied:

(1) An **accept/reject project** is a project that is optional from a building design standpoint and can be either implemented or not, depending on whether or not it is a good investment. A good example is the installation of standard storm windows over existing single-pane windows in a house. The comfort level of a house can be maintained at an acceptable level with or without storm windows, but with storm windows installed much less energy will be used. (If several options are available with different levels of energy performance, then this becomes a decision about the optimal efficiency level.)

(2) **Optimal efficiency level** refers to the problem of selecting the most cost-effective level of energy performance for a building system. For example, attic insulation can be installed over a

wide range of thermal resistance levels, an air conditioner can have a wide range of seasonal efficiency ratings, and a solar heating system can have a wide range of collector areas.

(3) **Optimal system selection** refers to the problem of selecting the most cost-effective system type for a particular application. System selection can directly impact the energy performance of a building. Examples include the choice of the heating and cooling system types for a building (e.g., electric heat pump or gas furnace with electric air conditioning), wall design (e.g., masonry or wood frame), or even insulation type (e.g., rigid foam or mineral wool).

(4) **Optimal combination of interdependent projects** refers to the problem of selecting two or more building systems at the same time, recognizing that the implementation of one system will have significant effects on the energy savings potential of the other, and vice-versa. For example, installing a high-efficiency furnace will reduce the energy savings potential of storm windows, while installing storm windows will reduce the energy savings potential of installing a high-efficiency furnace.

(5) **Prioritization of independent projects** is required when a number of cost-effective energy conservation investments have been identified but not enough funding is available to implement all of these projects. Economic analysis allows the ranking of these projects in decreasing order of cost effectiveness as a guideline to allocating available funding.

Basic steps in LCC analysis

The basic steps in an LCC analysis are to

- identify the alternatives under consideration,
- specify the data requirements and establish assumptions,
- estimate the costs in dollars,
- adjust costs for time value of money,
- compute total LCC for each alternative, and
- choose the alternative with the lowest total life-cycle cost.

Depending on the circumstances, you may also want to calculate supplementary measures of economic performance, perform an uncertainty assessment, and add a narrative describing non-economic issues. All of these steps will be covered during the workshop.

Typical project costs

Relevant effects

To make a decision about economic efficiency, it is important to measure the economic consequences of alternatives. Data requirements for making an economic decision are not the same as those for keeping an accounting system. For an LCC analysis, you need, in general, **evaluate only costs that change** from one alternative to another. Costs that remain the same do not decrease or increase the life-cycle costs of an alternative relative to the base case and thus need not be included.

Because collecting cost data can be expensive, you want to focus on collecting those data which are likely to have a **significant effect** on the life-cycle costs of an alternative. You do not want to spend your limited resources on collecting data that have little impact.

Do not include "sunk" costs in your analysis. Sunk costs are those costs that have already been incurred and cannot be avoided by future decisions. Only amounts that can be changed by the decision need to be included in the analysis.

Non-tangible costs are costs or benefits that cannot easily be expressed in dollar amounts. Even though they cannot be explicitly included in an LCC analysis, their effects should be described in a narrative so that they will not be overlooked when making a decision.

Types of costs
Life-cycle costs typically include **investment-related costs** and **operational costs**. Acquisition costs, including costs for planning, design, and construction, are investment-related, as are residual values such as resale value, salvage value, or disposal costs. Under the FEMP rule, capital replacement costs are also defined as investment-related. Energy costs, maintenance costs, and repair costs are considered operational costs, that is, non-investment-related costs. This definition is useful when computing economic measures that evaluate long-run savings in operational costs in relation to total capital investment costs.

Some of the costs included in an LCC analysis are **annually recurring**, such as energy, and routine maintenance and repair costs. **Non-annually recurring** costs are those that may occur only one time during the life-cycle, such as acquisition costs and residual values, or several times, such as replacement costs. This definition is needed for choosing the appropriate discount factors used to convert future costs to present values.

In a third classification, acquisition costs are designated as **initial costs** and all other costs as **future costs**, a useful classification both for selecting discount factors and for relating initial investment costs to the operating costs of a project.

All costs included in the analysis are expressed in **base-year dollars**. These base-year amounts will be multiplied by **discount factors** that incorporate the discount rate and any applicable escalation rate.

Energy and water costs
Special criteria apply to energy costs in analyses of conservation measures considered for federal buildings:

Current prices: It is essential to get current energy prices from local suppliers. It is better not to use regional or national average energy or water cost data, since they do not reflect local supply and demand conditions. Prices should take into account, where applicable, rate type, rate structure, summer and winter differentials, block rates, and demand charges to reflect an estimate as close as possible to today's actual price.

Energy price projections: Energy prices are assumed to increase or decrease at a rate different from general price inflation. To avoid inconsistencies in LCC analyses throughout the government, it is required under the FEMP rule (10 CFR 436A) to adjust today's energy price estimates by the energy price projections published annually by DOE. These energy price projections are embedded in the discount factors updated annually and published on April 1 of each year in *Energy Prices and Discount Factors for Life-Cycle Cost Analysis 20xx*, Annual Supplement to NBS Handbook 135 and

NBS Special Publication 709. These projections are also included in the NIST BLCC computer programs.

Water costs: In 1995 water conservation was added to energy conservation as a designated goal for the Federal Energy Management Program. No special water usage/disposal escalation rates are projected by DOE.

Setting the study period

The study period is the time over which the effects of a decision are of interest to the decision-maker. There is no one correct study period, but it must be sufficiently long to enable a correct assessment of long-run economic performance. Often the life of the system under analysis is used as the study period. However, the Federal Government limits the study period for energy and water conservation projects to a maximum of 25 years from the service date (Beneficial Occupancy Date in MILCON analyses). Apart from the 25-year maximum limit, there are other factors that determine the length of the study period:

(1) **Compare all alternatives over the same study period.** Present-value cash flows calculated for one time period would not be comparable with those calculated for a longer or shorter period.

(2) **Calculate all measures of economic evaluation (LCC, NS, SIR, AIRR) using the same study period**, otherwise they would not be consistent with each other.

(3) **Consider the time horizon of the investor**. The study period may be shorter or longer depending on whether the investor is, for example, the builder or the occupant of a building.

(4) **Adjust for different expected lives of buildings or systems**. In order to fit different expected lives into the same study period, equalize the differing time periods by using replacement values and residual values, such as a resale value, salvage value, or disposal costs.

Discounting future costs to present value

Before we can compare or sum costs occurring at different points over the study period, they must be converted to a common point in time to reflect the time value of money. This means that future costs (or savings) have to be **discounted to present value** so that they can be directly compared with initial investment costs.

Cash-flow conventions

There are several **cash-flow conventions** that may be used when discounting costs occurring over the study period to present value. One-time costs are usually discounted from the actual time of occurrence. Annually recurring costs are discounted from the end of the year (FEMP) or the middle of the year (DoD). Costs occurring at the beginning of the study period do not need to be discounted since they are already in present value.

Discount rate

The **discount rate** used to adjust future costs to present value is the rate of interest that makes the investor indifferent between cash amounts received at different points in time. The discount rate adjusts for inflation and the real earning power of money. This rate is often referred to as the **minimum acceptable rate of return** (MARR). It is important to recognize that every investor has his or her own time preference for money, and thus his or her own discount rate.

Discount factors

Pre-calculated discount factors can be used to calculate present values by multiplying the base-year dollar amounts by the appropriate discount factor. NIST publication *Discount Factor Tables for Life-Cycle Cost Analyses* (NISTIR 89-4203) contains pre-calculated discount factors that incorporate FEMP and OMB discount rates and DOE energy price escalation rates. These discount factors are also embedded in the NIST BLCC programs or may be calculated using the NIST DISCOUNT program.

Common discount factor applications

When performing an LCC analysis, three types of future cash flows are most commonly encountered, each requiring a different type of present-value factor:

(1) The **one-time cash flow** is multiplied by the **Single Present Value (SPV)** factor to find its present value. An example of a one-time cash flow is a replacement cost or a residual value at the end of the study period.

(2) The **uniform annual amount** is multiplied by the **Uniform Present Value (UPV)** factor to find the present value. An example of a uniform annual amount is an annual operating and maintenance cost that remains the same from year to year.

(3) The **changing annual amount** varies from year to year at some known rate, which can be either constant or variable from year to year. The base-year amount (A_0) is multiplied by the **Modified Uniform Present Value (UPV*)** factor to find the present value. An example of an amount that changes at a variable rate each year is the annual energy cost of a building when the physical amount of energy consumed is expected to be reasonably constant but energy prices are expected to change from year to year. An amount changing at a constant rate may be an operating cost that increases annually due to expected higher maintenance costs.

UPV* factors for energy costs

For LCC analyses related to energy conservation in federal facilities, NIST publishes UPV* factors specifically for use with future energy costs. The NIST UPV* factors explicitly incorporate the FEMP discount rate and DOE projections of energy price increases over the next 30 years. They are published in NISTIR 85-3273, *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis 20xx*, tables B-1a through B-5a. Because the FEMP discount rate and the DOE projections of energy price escalation rates change from year to year, this publication is updated by NIST each year on April 1. The UPV* factors in this publication are differentiated by fuel type, rate type (residential, commercial, industrial), and by region (Northeast, Midwest, South, and West). The UPV* factor for energy costs is used with the annual energy cost computed in base-year dollars

How to handle inflation in LCC analysis

Definitions

An economic evaluation of capital investments over time needs to consider both the earning power of money, and the changing purchasing power of the dollar as reflected by the discount rate. The following five terms will be used in the discussion of how to handle inflation in life-cycle cost analysis:

- ***Price inflation*:** A rise in the general price level, tantamount to a decline in the general purchasing power of the dollar.

- ***Price escalation:*** Increase in the price of a particular commodity, such as energy.

- ***Differential (or real) price escalation:*** The difference between the rate of general inflation and the rate of escalation in the price of a particular commodity. For example, if the price of a particular commodity increases at exactly the same rate as general inflation, the differential price escalation rate is 0%. Energy prices are a type of cost that has deviated significantly from general inflation since the early 1970s. For this reason, the FEMP LCC methodology for evaluating energy conservation investments requires that projected increases in energy prices be explicitly included in the economic analysis, while other categories of costs are generally assumed to increase at the rate of general inflation.

- ***Current dollars*** and ***constant dollars:*** Current dollars include the rate of general price inflation, constant dollars exclude the rate of general price inflation.

- ***Nominal discount rates*** and ***real discount rates:*** Nominal discount rates include the rate of general price inflation, real discount rates exclude the rate of general price inflation.

Treatment of inflation

There are **two basic approaches for dealing with inflation** in an economic analysis.

(1) **Use current dollars and a nominal discount rate and price escalation rates**. The rate of inflation is included in the future dollar amounts, and in the discount and price escalation rates. This is the approach that is generally used when tax considerations are included in the economic analysis, or when current-dollar cash flows need to be compared with current-dollar savings, as is the case for ESPC projects.

(2) **Use constant dollars and a real discount rate and price escalation rates**. Future dollar amounts, as well as the discount and escalation rates, **exclude inflation**. In this case a real discount rate and **differential** price escalation rates are included in the analysis. Constant-dollar analyses are generally used in agency-funded government studies.

Both constant- and current-dollar analyses, if conducted properly, will **yield exactly the same present-value result**, and thus support the same conclusion. However, it is generally easier to conduct an economic analysis in constant dollars because the underlying rate of inflation from year to year over the study period does not need to be estimated.

It is important to differentiate between a **present-value analysis** of a capital investment and a **budget analysis**, where funds must be appropriated for year-to-year disbursement. The purpose of a present-value analysis is to determine whether the overall savings appear to justify the required investment at the time that the investment decision is being made. A budget analysis must include general inflation to assure that sufficient funding will be appropriated in future years to cover actual expenses.

Relationship between real and nominal rates:

$$d = (1 + D)/(1 + I) - 1$$
$$D = (1 + d)(1 + I) - 1$$
$$e = (1 + E)/(1 + I) - 1$$
$$E = (1 + e)(1 + I) - 1$$

where
d = real discount rate, excluding inflation
D = nominal discount rate, including inflation
e = real rate of escalation, excluding inflation
E = nominal rate of escalation, including inflation
I = rate of inflation

Supplementary measures of economic performance

Supplementary measures of economic performance can be used to determine the comparative cost effectiveness of capital investment. Several widely used measures are presented in this workshop. These are **Net Savings, Savings-to-Investment Ratio, Adjusted Internal Rate of Return, and Payback Period**. Except for the Payback Period, these measures are consistent with and build upon the Life-Cycle Cost methodology. All of these supplementary measures are comparative rather than absolute measures of performance; they are calculated for the alternative course of action in relation to a base case.

Net Savings (NS)
NS is a measure of long-run profitability of an alternative relative to a base case. The NS can be calculated as an extension of the LCC method to show the difference between the LCC of a base case and the LCC of an alternative. It can also be calculated directly from differences in the individual cash flows between a base case and an alternative.

The NS can be used like the LCC measure to determine a project's cost-effectiveness. **For a project alternative to be cost effective with respect to the base case, it must have an NS of greater than zero.** But with a zero Net Savings, the minimum required rate of return (MARR) has been achieved because the required rate of return is built into the net savings computation through the discount rate. NS is not useful for ranking projects.

Savings-to-Investment Ratio (SIR)
The SIR is a dimensionless measure of performance that expresses the ratio of savings to costs. The numerator of the ratio contains the operation-related savings; the denominator contains the increase in investment-related costs. **An SIR > 1.0 means that an alternative is cost-effective relative to a base case.** For selecting the optimal energy efficiency level or the optimal system or design, the SIR method is reliable only if based on **incremental SIRs**.

The SIR is recommended for setting priority among projects when the budget is insufficient to fund all cost-effective projects. The projects are ranked in descending order of their SIRs.

Adjusted Internal Rate of Return (AIRR)
The AIRR is calculated as a percentage yield. The yield rate is compared with the investor's MARR. **The AIRR has to be higher than the MARR for an investment to be considered cost effective.** (The AIRR is a modified version of the Internal Rate of Return (IRR); it uses the discount rate rather than the calculated rate of return as the reinvestment rate for saved cash flows.) The AIRR is used in the same way as the SIR.

Discounted Payback (DPB)
The DPB measures how long it takes to recover initial investment costs. It is calculated as the number of years elapsed between the initial investment and the time at which cumulative savings, net of accrued costs, are just sufficient to offset investment costs. The DPB takes the time value of money into account by using discounted cash flows. If the discount rate is assumed to be zero, the method is called Simple Payback (SPB), a measure of evaluation less accurate than the DPB.

Both the DPB and the SPB ignore all costs and savings that occur after payback has been reached. They should be used only as a rough screening measure for accept/reject decisions.

Uncertainty assessment in LCC analysis

Decisions about energy conservation investments in buildings typically involve a great deal of uncertainty about their costs and potential savings. **Performing an LCC analysis greatly increases the likelihood of choosing an alternative that saves money in the long run.** Yet, there may still be some uncertainty associated with the LCC results; LCC analyses are usually performed early in the design process when only estimates of costs and savings are available rather than dollar amounts that are certain. Uncertainty in input values creates the risk that a decision will have a less favorable outcome than expected.

Even though you may be uncertain about some of the input values, especially those occurring in the future, it is still better to include them in an economic evaluation than to base your evaluation on first costs only. Ignoring uncertain long-run costs implies the assumption that they are zero, a poor assumption to make.

There are techniques that allow you to estimate the cost of choosing the "wrong" alternative. **Sensitivity analysis and breakeven analysis are two approaches that are so simple to perform** that they should be part of every LCC analysis. These and a number of other approaches to risk and uncertainty assessment are described in detail in *Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Building Investments* by Harold E. Marshall, NIST Special Publication 757, September 1988.

Sensitivity analysis
Sensitivity Analysis measures the impact on the analysis results of changing one or more key input values about which there is uncertainty. Sensitivity analysis can be performed with respect to any measure of worth (LCC, NS, SIR, AIRR, PB). The sensitivity of these measures can be compared among alternatives.

Identifying critical inputs: It is important to know which of the uncertain input parameters have the greatest effect on LCC results. To identify the critical inputs, simply increase the value of each of them in turn by a certain percentage and, holding all others constant, recalculate the economic measure to be tested. The higher the percentage change in outcome for a given change in input value, the greater the effect.

Estimating the range of results: To arrive at an estimate of the upper and lower bounds of an economic measure, it can be recalculated using the lowest and highest likely estimates of its input variables, corresponding to the most optimistic or pessimistic scenarios.

"What if" scenarios: Identifying critical input values and determining the range of economic measures answers a number of "what if" questions. Sensitivity analysis is a good technique for taking a closer look at the most plausible "what if" scenarios, in order to be prepared to answer these types of questions when they arise during the decision-making process.

Breakeven analysis
Decision makers sometimes want to know the maximum cost of an input that will allow the project to still break even, or, conversely, what minimum benefit a project can produce and still cover the cost of the investment.

To perform breakeven analysis, benefits and costs are set equal; all variables are specified, except the breakeven variable; and the breakeven variable is solved for algebraically.

Advantages and disadvantages of sensitivity and breakeven analyses
Results of sensitivity analysis and breakeven analysis can be presented in text, tables, or graphs. **They are easy to perform and easy to understand and require no additional methods of computation beyond those needed for LCC analysis.** The breakeven value can serve as a benchmark value to be compared against its predicted performance. The disadvantages of sensitivity analysis and breakeven analysis are that they do not give a probabilistic measure of the risk of choosing an uneconomic project and do not include an explicit measure of risk attitude.

Summary of FEMP LCC criteria

The following criteria, consistent with the FEMP rules outlined in 10 CFR 436A, specifically apply to the economic evaluation of energy and water conservation and renewable energy projects in federal buildings:

Constant-dollar analysis
In general, use **constant dollar analysis and real discount and escalation rates**. The DOE/FEMP discount rate and energy price escalation rates are real rates, that is, they exclude the rate of general price inflation. If, as for example, in the case of alternative financing projects, the analysis is performed in current dollars, the inflation rate has to be added to the discount rate and price escalation rates.
100

The DOE discount rate and corresponding discount factors are updated annually on April 1 and published in NISTIR 85-3273, *Energy Price Indices and Discount Factors for Life-Cycle Cost*

Analysis, the Annual Supplement to NIST Handbook 135, and in the NIST LCC computer programs, BLCC4 and BLCC5.

Discounting convention
Cash flows are discounted from the **end of the year**. (In MILCON analyses cash flows are discounted from the middle of the year.)

Present values
For reasons of consistency, the FEMP rule prescribes the use of present-value analysis for evaluating energy- and water-related projects. All future dollar amounts should be **discounted to the base date** of the project. Note that "present-value" amounts are not the same as constant dollar amounts as of the base date, since the latter do not reflect the adjustment for the time value of money.

Energy prices
The FEMP LCC method uses **local energy and water prices at the building site** in calculating the **annual dollar value** of the energy or water consumed by a building or building system. Local energy and water prices should reflect the type of rate charged (residential, commercial, or industrial), differences between summer and winter rates, the impact of block rates on marginal energy and water costs, and demand charges. The analyst should not artificially adjust energy or water prices to reflect environmental externalities.

If fuel is purchased for on-site electricity generation, the costs of the fuel at the point of generation, plus the costs incurred in generating and distributing the electricity, should be used in the analysis.

Quantity of energy and water usage
Since the FEMP LCC method uses local energy and water prices at the building site, energy and water quantities should be stated **in units consistent with unit prices at the point of metering**. Equivalent quantities of energy or water at some earlier point in the supply chain (e.g., oil or coal prices before conversion to electricity) should not be used.

DOE energy price escalation rates
Energy prices are assumed to change at rates different from the rate of general price inflation. DOE annually projects real (differential) energy price escalation rates for the next three years, by Census region, rate type, and fuel type. These **real energy price escalation rates** and the real DOE discount rate are used to calculate the **modified present value factors (UPV* factors)** for use in FEMP LCC analyses. The UPV* factors are updated and published annually as a set of tables in NISTIR 85-3273, the Annual Supplement to Handbook 135. At present there are no equivalent DOE projections of escalation rates for water costs.

The real price escalation rates for energy costs are incorporated into LCC evaluations in the following ways:

(1) by multiplying the appropriate UPV* factor by the base-year annual energy cost (or savings) to calculate a present value; or
(2) by using the most recent version of the NIST BLCC computer programs, which read the DOE-projected differential escalation rates from a file on the diskette and automatically compute the present value of energy costs

Note: FEMP suggests that DOE energy price projections be replaced with appropriately documented projections provided by your utility company for the years for which they are available.

Items other than energy and water costs in FEMP studies **are generally assumed to have a zero real escalation rate** unless there is documentable evidence to the contrary. This is equivalent to saying that the prices of non-energy items are assumed to change at the same rate as general price inflation.

Study period

The maximum study period for federal energy conservation projects is 25 years from the date of occupancy of a building or the date of operation of a system. Any lead time for planning, design, or construction may be added to the 25-year maximum study period.

The study period should be the same for all alternatives under consideration and the lesser of 25 years, or the estimated use of the building or life of the system. Replacement costs and residual values, such as a salvage value, a disposal cost, or a resale value, are used to equalize the study period for the various alternatives.

For evaluating energy use and related investments in a leased federal building, the study period is the lesser of 25 years or the effective remaining term of the lease, including renewal options likely to be exercised.

Uncertainty assessment

If uncertainty analysis casts substantial doubt on the results of LCC analysis, federal agencies are advised to obtain more reliable input data or eliminate the project. Federal agencies are directed to use the DOE discount rate as published, without testing for sensitivity.

No evaluation required

The FEMP rule states that

(1) A project is presumed **cost-effective** if it saves energy and if the costs of implementing the energy conservation measure are insignificant, and

(2) a project is presumed **not cost-effective** if the building is

- (a) occupied under a one-year 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 one year.

Suggested Cost Estimating Guides for LCC Analysis*

BNI CONSTRUCTION ESTIMATING COSTBOOKS
BNI Building News
1612 S. Clementine St., Anaheim, CA 92802
1-888-264-2665
http://www.bni-books.com

DODGE COST ESTIMATING SERVICES
McGraw-Hill Construction Information Group
http://www.dodge.construction.com

DOLLARS AND CENTS OF SHOPPING CENTERS
DOLLARS AND CENTS OF MULTIFAMILY HOUSING
The Urban Land Institute
1025 Thomas Jefferson St., NW, Suite 500, Washington, DC 20007
(202) 624-7000, 1-800-321-5011
http://www.uli.org

EXPERIENCE EXCHANGE REPORTS (EER)
Building Owners & Managers Association International (BOMA)
1201 New York Ave., N.W., Ste. 300, Washington, DC 20005
(202) 408-2662
http://www.boma.org

MS/B UNDERWRITING ESTIMATORS
Marshall & Swift/Boeckh
911 Wilshire Blvd., 16th Floor, Los Angeles, CA 90017
1-800-421-8042
http://www.msbinfo.com/underwriting.asp

MEANS BUILDING CONSTRUCTION COST DATA-MEANS FACILITIES M&R DATA
MEANS FACILITIES MAINTENANCE AND REPAIR COST DATA
R. S. Means Co., Inc.
100 Construction Plaza, Box 800, Kingston, MA 02364-0800
(617) 585-7880
http://www.rsmeans.com/means/demo/shortlst.html

NATIONAL CONSTRUCTION ESTIMATOR-BUILDING COST MANUAL-BERGER BUILDING COST FILE
Craftsman Book Company
6058 Corte del Cedro, Carlsbad, CA 92009
1-800-829-8123
http://www.craftsman-book.com

RICHARDSON'S GENERAL CONSTRUCTION ESTIMATING STANDARDS
RICHARDSON'S PROCESS PLANT CONSTRUCTION ESTIMATING STANDARDS
T&M Concepts
P.O. Box 34284, Las Vegas, NV 8913-4284
1-877-653-2678
http://www.tandmconcepts.com/richardsons.htm

SWEET'S DIRECTORY
McGraw-Hill Construction Information Group
http://www.sweets.construction.com

THE WHITESTONE BUILDING MAINTENANCE & REPAIR COST REFERENCE
Whitestone Research
P.O. Box 1250, Seattle, WA 98101
1-800-210-0137
http://www.whitestoneresearch.com

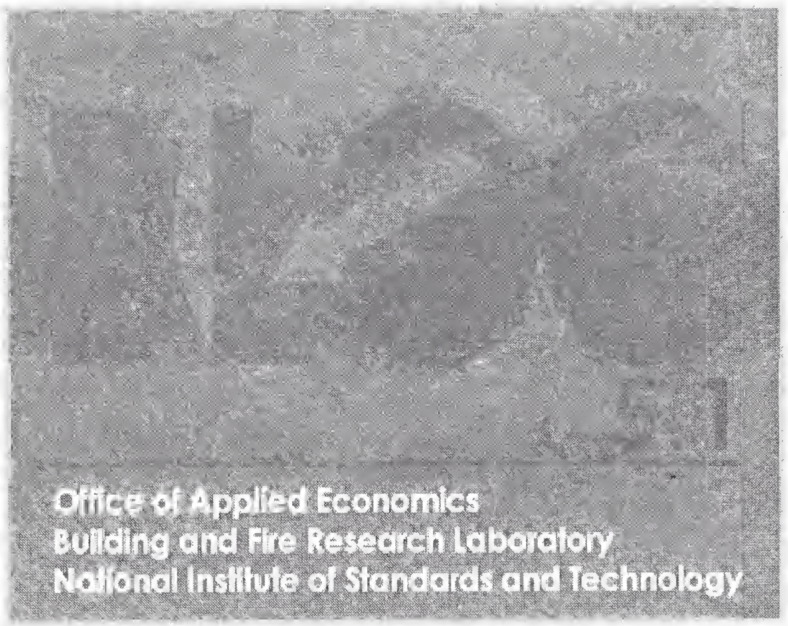
*Most of the listed publishers issue additional more specialized cost guides.

Module B

NIST LCC Software: Overview and BLCC5

Objectives: Upon completion of this module, you will be able to

- **use BLCC5 to evaluate energy and water conservation projects.**
- **describe the features of other NIST LCC computer programs.**



BLCC 5.1-02

Building Life-Cycle Cost Program

for Energy and Water Conservation and Renewable Energy Projects

Overview – BLCC5

- Economic analysis of capital investments that reduce future costs
- Focus on energy and water conservation in buildings
- Downloadable from DOE/FEMP web site

Current Modules – BLCC5

- FEMP Analysis, Energy Project
  - for energy and water conservation and renewable energy projects under the FEMP rules, agency-funded
- Federal Analysis, Financed Project
  - for federal projects financed through Energy Savings Performance Contracts (ESPC) or Utility Energy Services Contracts (UESC)
- MILCON Analysis, Energy Project
  - for energy and water conservation and renewable energy projects in military construction, agency-funded
- MILCON Analysis, ECIP Project
  - for energy and water conservation projects under the Energy Conservation Investment Program (ECIP)

Future Modules – BLCC5

- **Remaining BLCC4 modules to be transferred to BLCC5:**
  - **OMB**
  - **non-energy MILCON**
  - **private-sector analyses including taxes and mortgage financing**

Data Requirements

- Project Information
  - name, location, analyst, comment, discounting convention, constant or current dollars, discount rate, base date, service date, and length of study period
- Capital Investment Costs
  - investment costs
  - cost-phasing
  - escalation rates
  - replacement costs and timing
  - residual values

Data Requirements (cont.)

- Operating-Related Costs
  - annually recurring operating, maintenance, & repair costs
  - non-annually recurring operating, maintenance, & repair costs
  - energy consumption and cost data
  - water consumption and cost data
  - escalation rates
- Contract Costs
  - annually recurring (annual contract payment, debt service, performance period expense)
  - non-annually recurring (implementation cost, financing procurement cost)

MILCON Modules

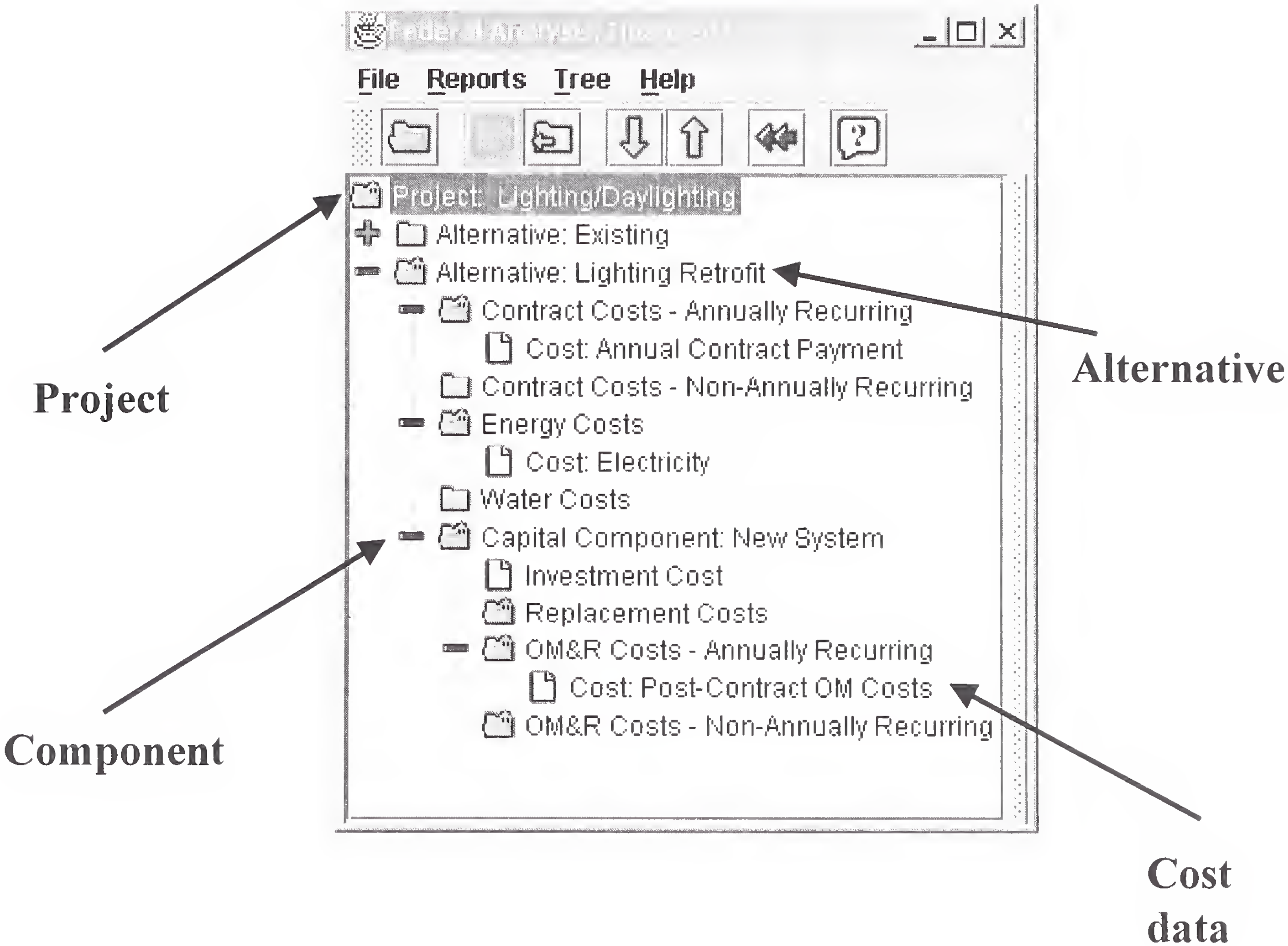
- Energy Project
  - "Service Date" is referred to as "Beneficial Occupancy Date"
  - "OM&R Costs" as "Routine OM&R Costs"
  - "Replacement Costs" as "Major Repair and Replacement Costs"

- ECIP Project
  - "Service Date" is referred to as "Beneficial Occupancy Date"
  - inputs are investment cost differences and operational cost savings

Creating a BLCC5 Input File

- Input general information for the project
- Input data for each alternative
- Use tree as a guideline and checklist
- Go to Help - Creating and Editing Data Files - for definitions of all input variables
- Print reports
  - LCC computations are made each time a report is opened
- Save project file using user-supplied filename

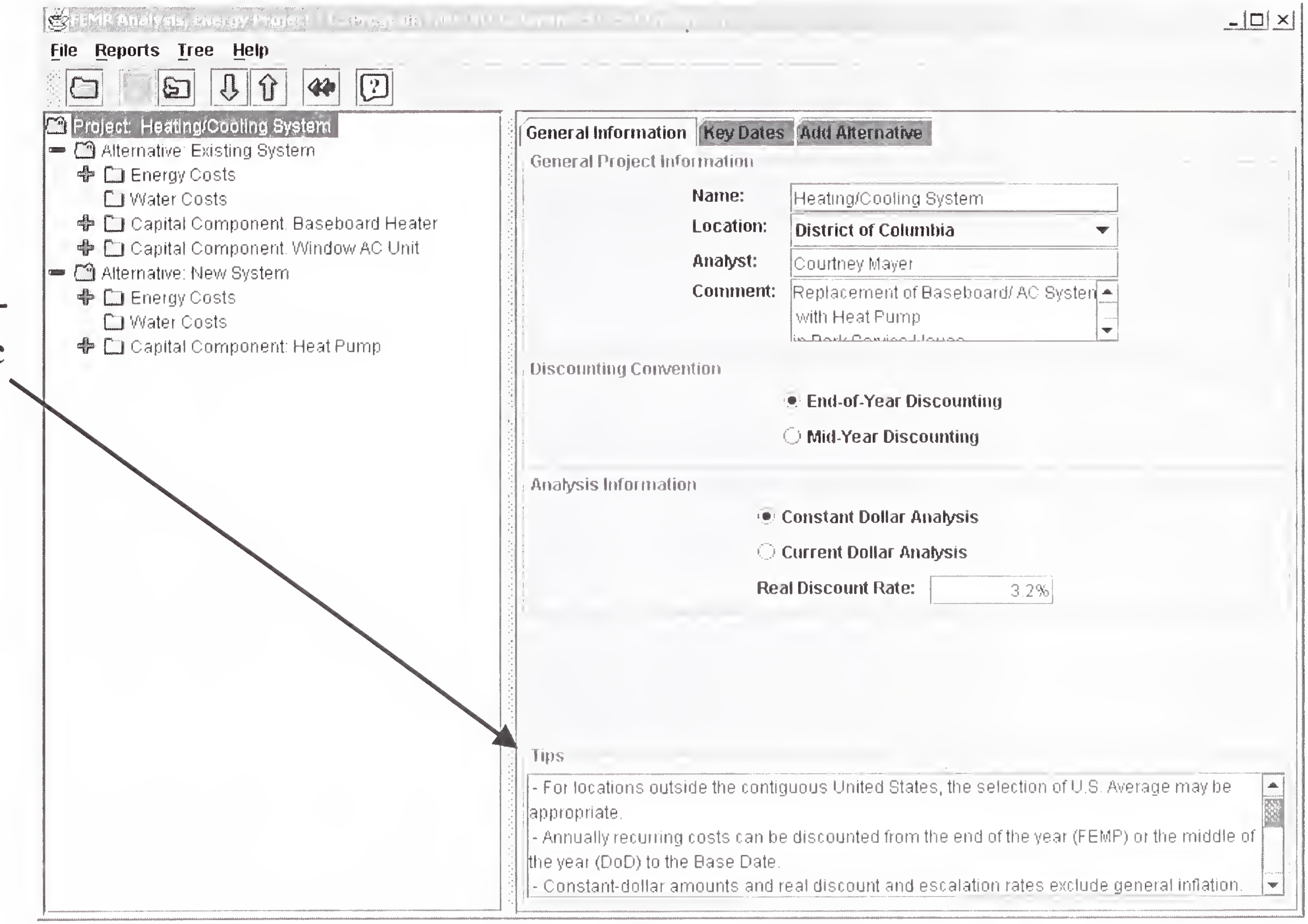
BLCC5 Tree



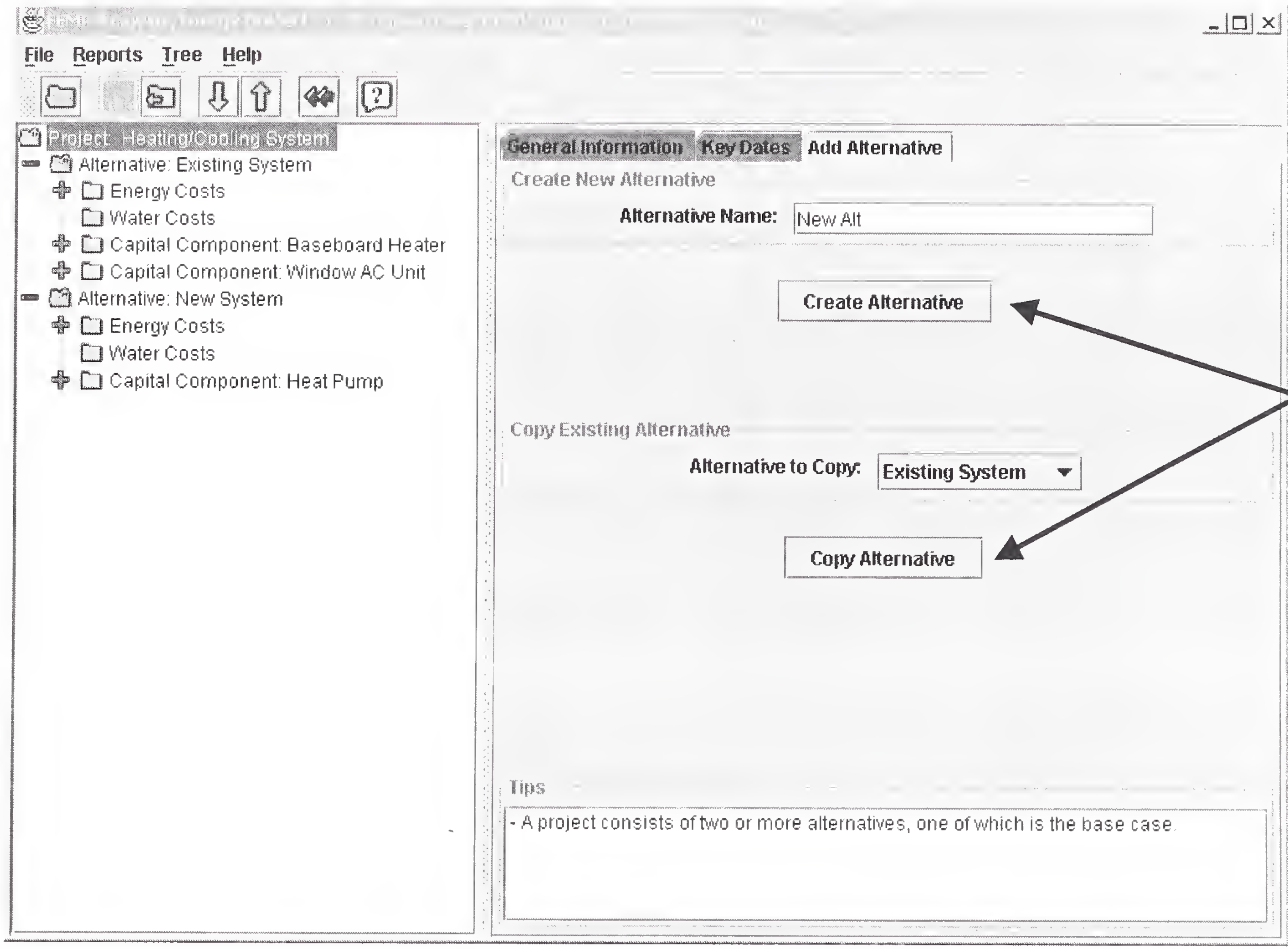
File
Reports
Tree
Help
Project: Lighting/Daylighting
Alternative: Existing
Alternative: Lighting Retrofit
Contract Costs - Annually Recurring
Cost: Annual Contract Payment
Contract Costs - Non-Annually Recurring
Energy Costs
Cost: Electricity
Water Costs
Capital Component: New System
Investment Cost
Replacement Costs
OM&R Costs - Annually Recurring
Cost: Post-Contract OM Costs
OM&R Costs - Non-Annually Recurring
Project
Alternative
Component
Cost data

Project Data

Screen-specific help



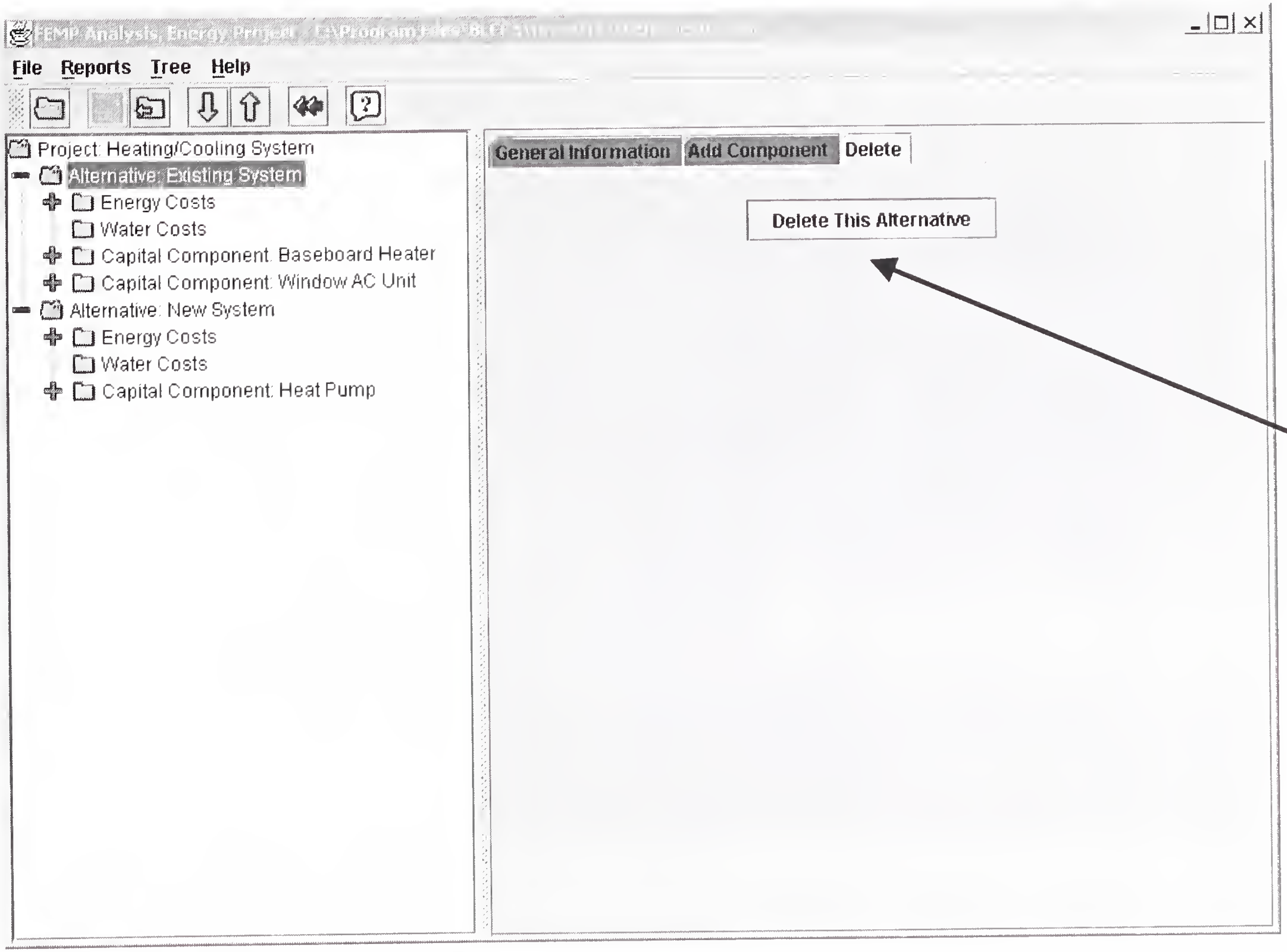
Add/Copy Feature



You can add/copy:

- •Alternatives
- •Capital Components
- •All cost items

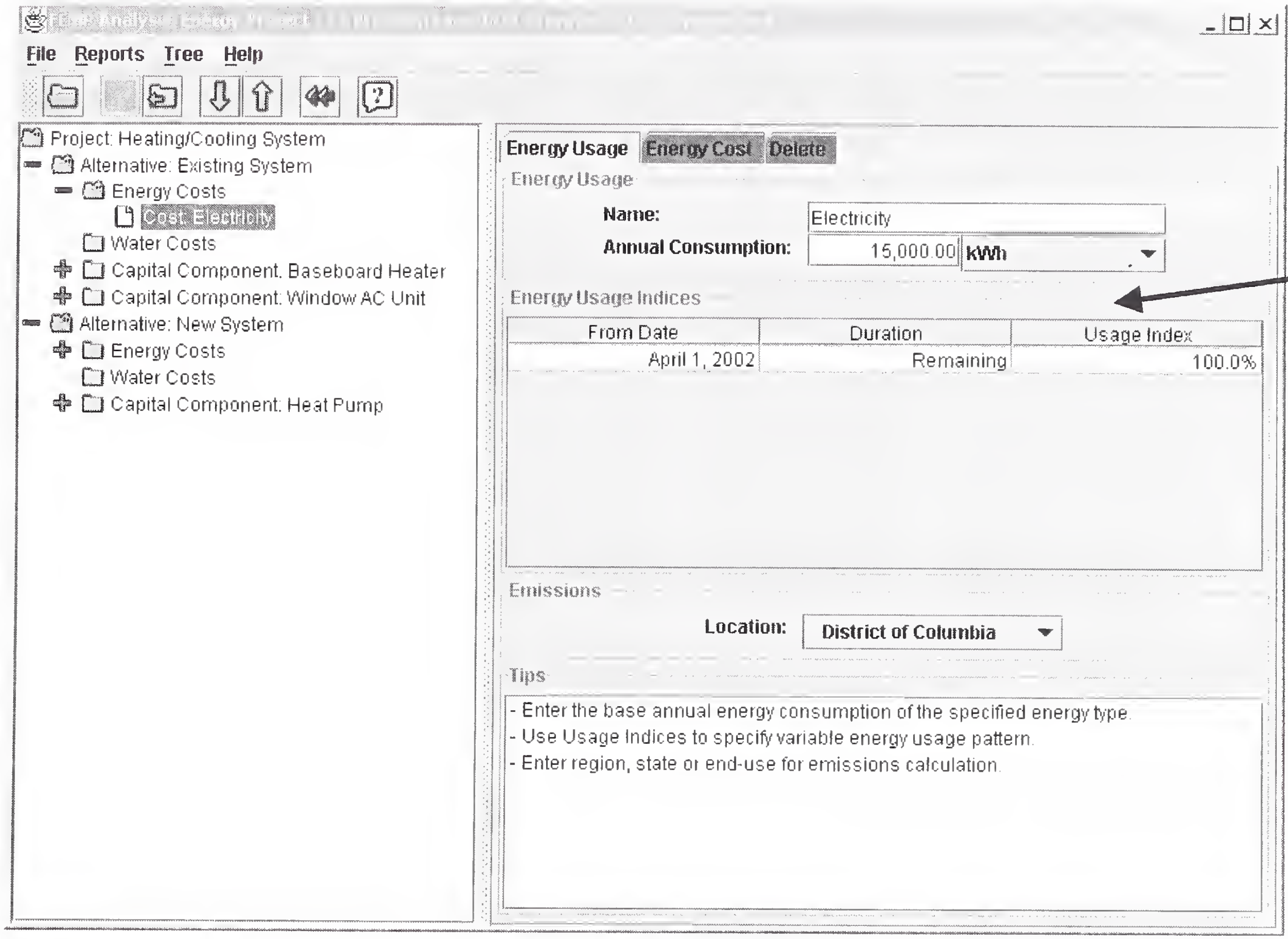
Delete Feature



You can delete:

- **Alternatives**
- **Capital Components**
- **All cost items**

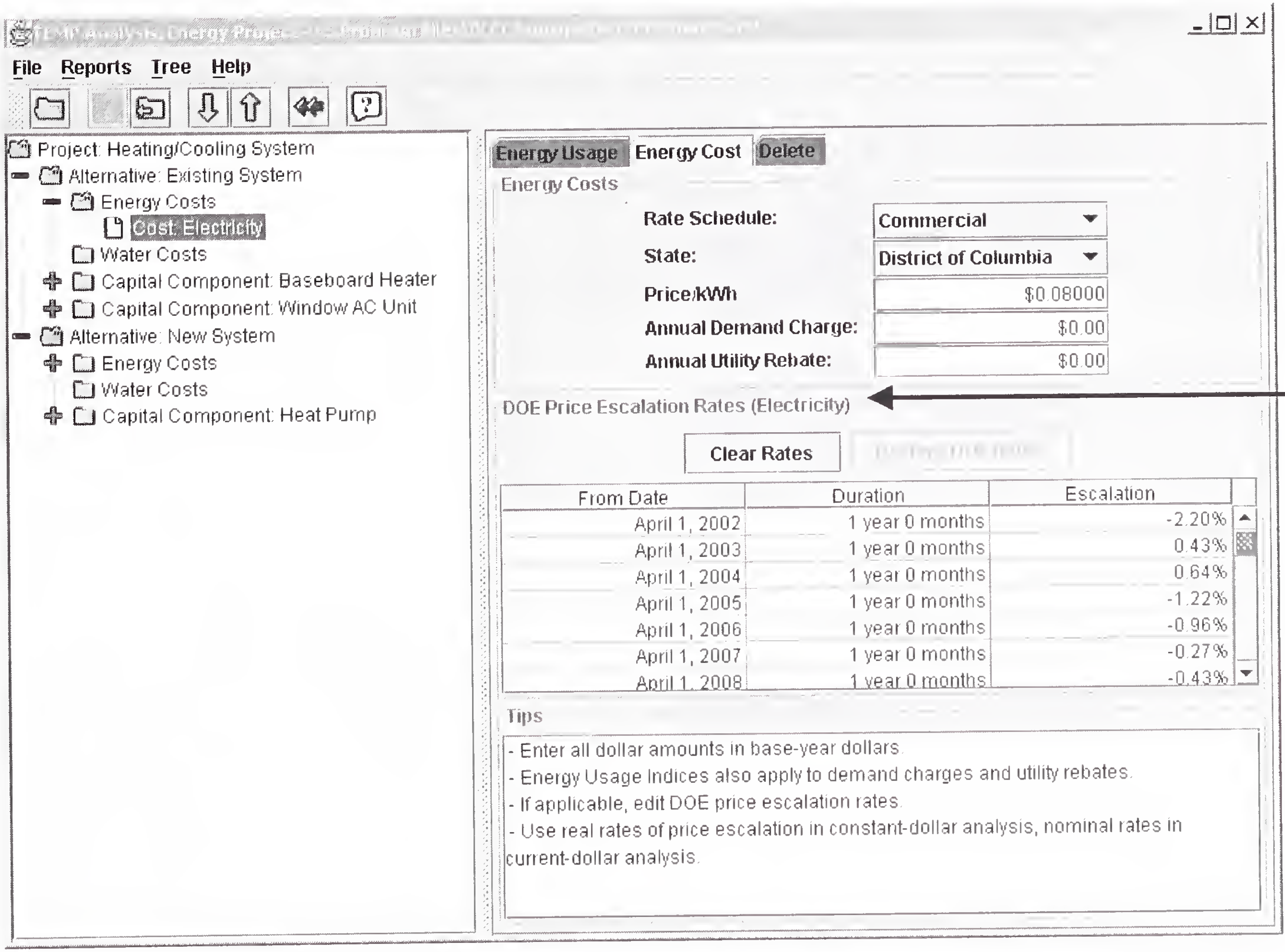
Energy Usage



You can have usage indices for:

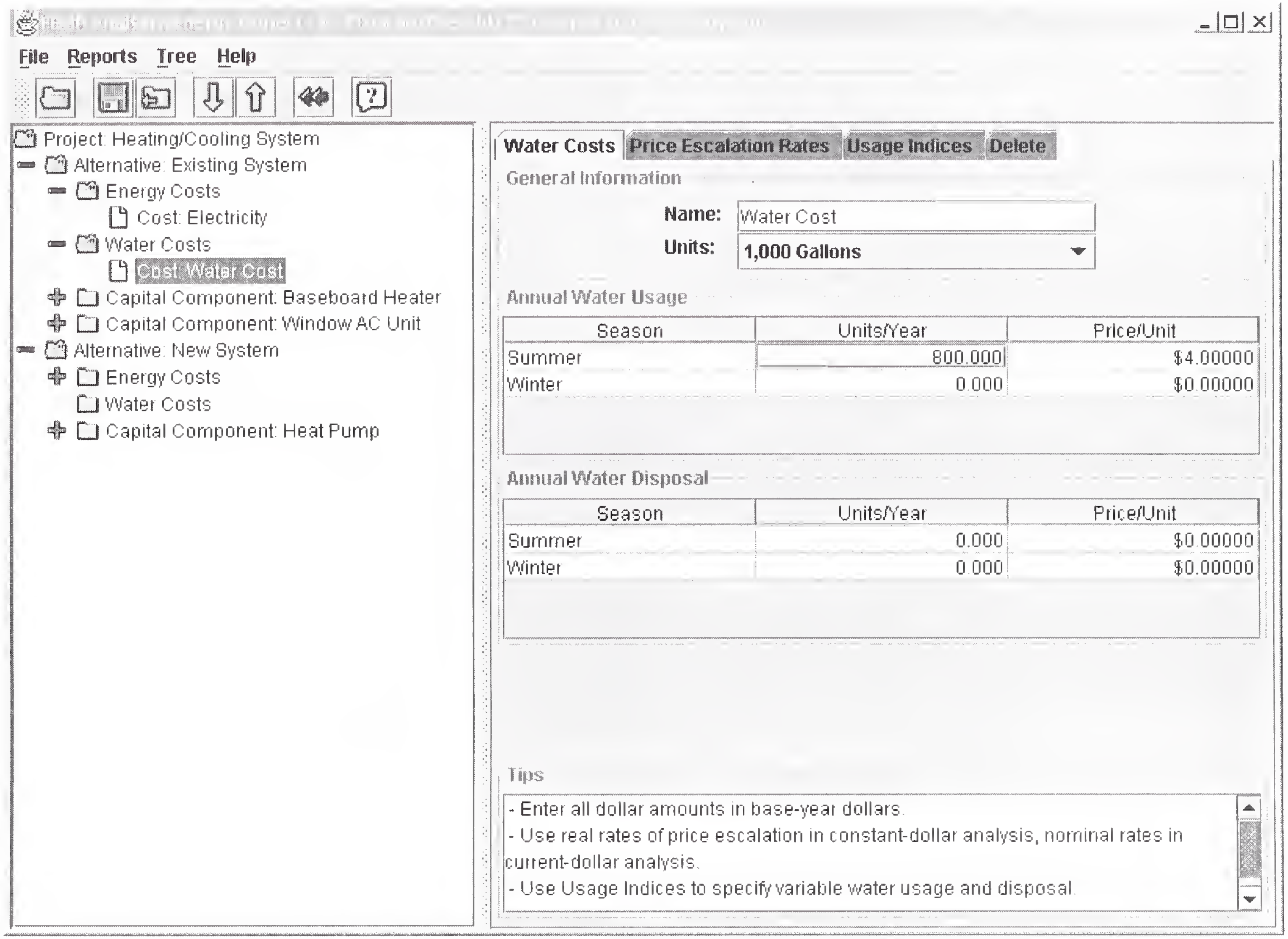
- Energy Costs
- Water Costs
- Annually Recurring Costs
- Annually Recurring Contract Costs

Energy Costs



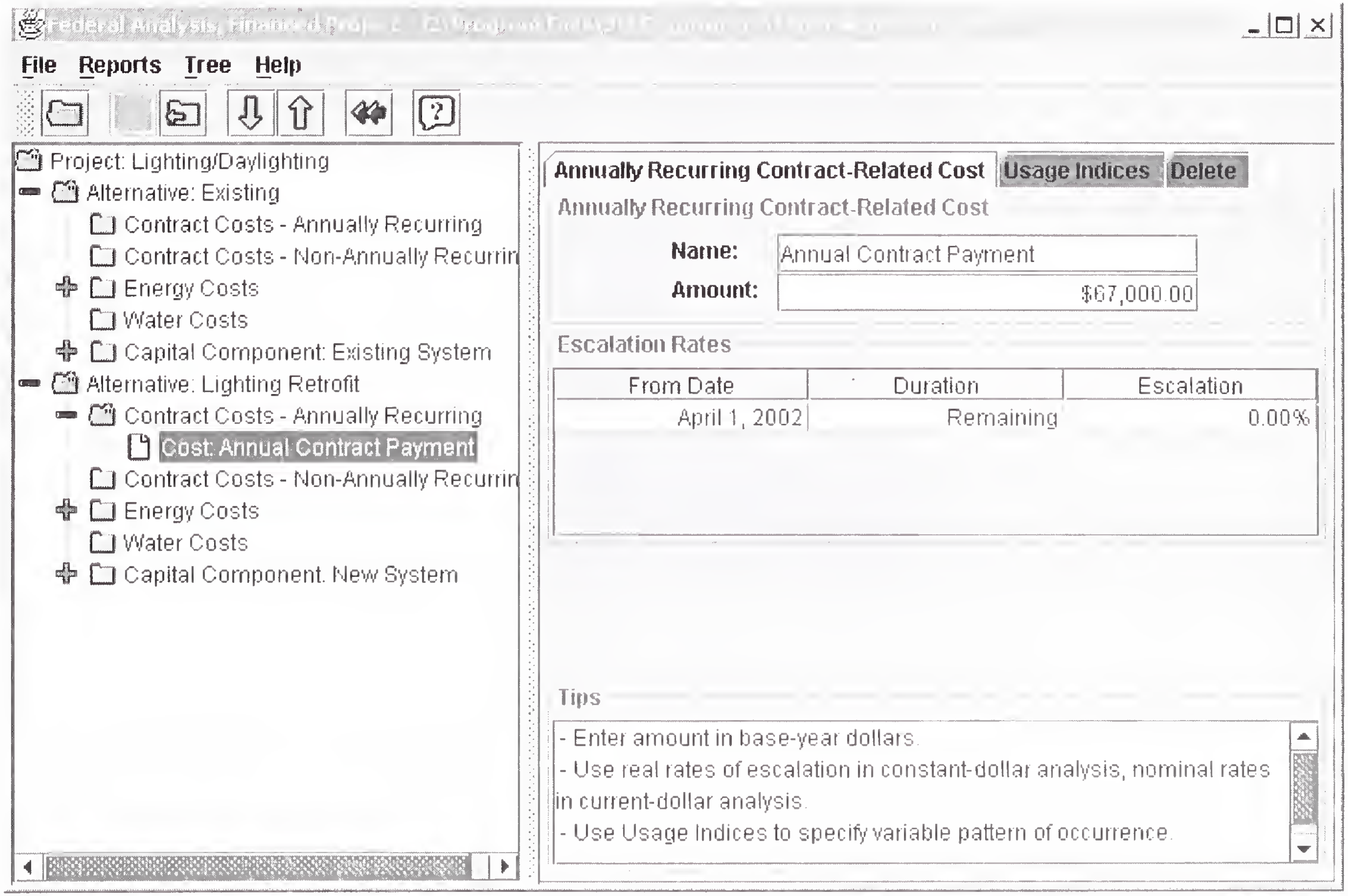
- **Default price escalation rates based on:**
  - **rate type**
  - **region**
  - **fuel type specified**
- **Rates can be edited**

Water Costs

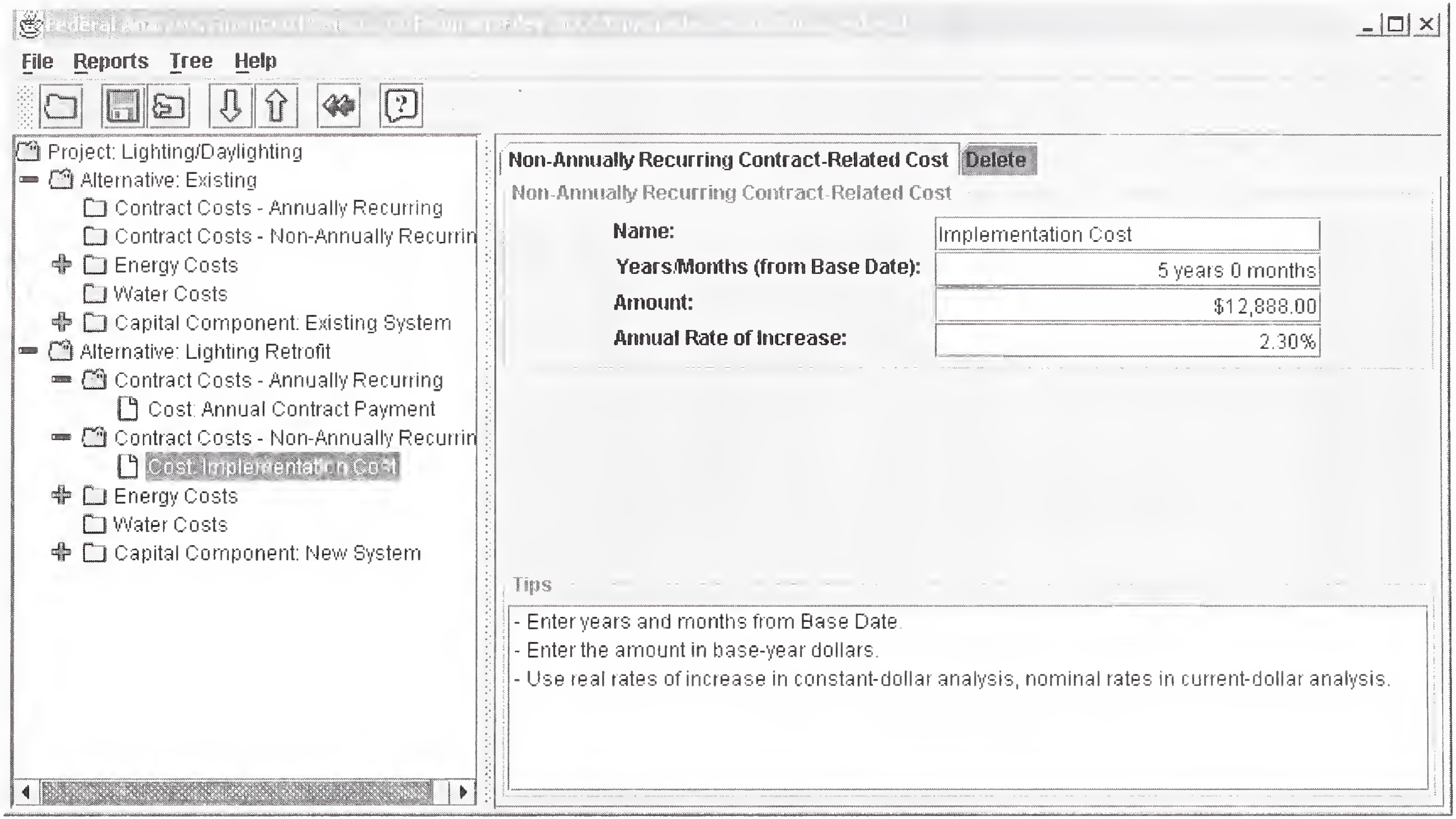


File Reports Tree Help
Project: Heating/Cooling System
Alternative: Existing System
Energy Costs
Cost: Electricity
Water Costs
Cost: Water Cost
Capital Component: Baseboard Heater
Capital Component: Window AC Unit
Alternative: New System
Energy Costs
Water Costs
Capital Component: Heat Pump
Water Costs
Price Escalation Rates
Usage Indices
Delete
General Information
Name: Water Cost
Units: 1,000 Gallons
Annual Water Usage
Season Units/Year Price/Unit
Summer 800.000 $4.00000
Winter 0.000 $0.00000
Annual Water Disposal
Season Units/Year Price/Unit
Summer 0.000 $0.00000
Winter 0.000 $0.00000
Tips
- Enter all dollar amounts in base-year dollars.
- Use real rates of price escalation in constant-dollar analysis, nominal rates in current-dollar analysis.
- Use Usage Indices to specify variable water usage and disposal.

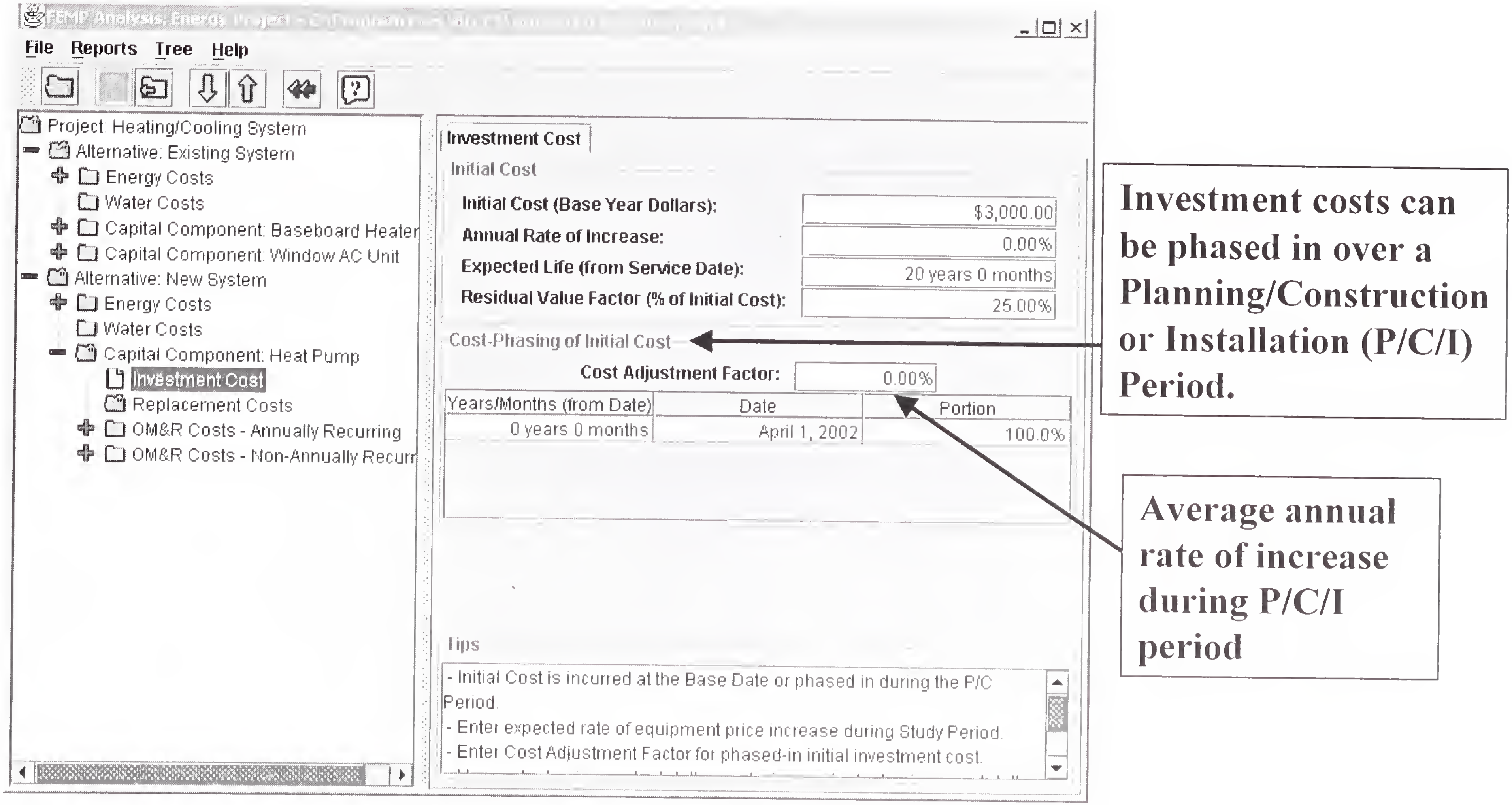
Contract Costs - Annually Recurring



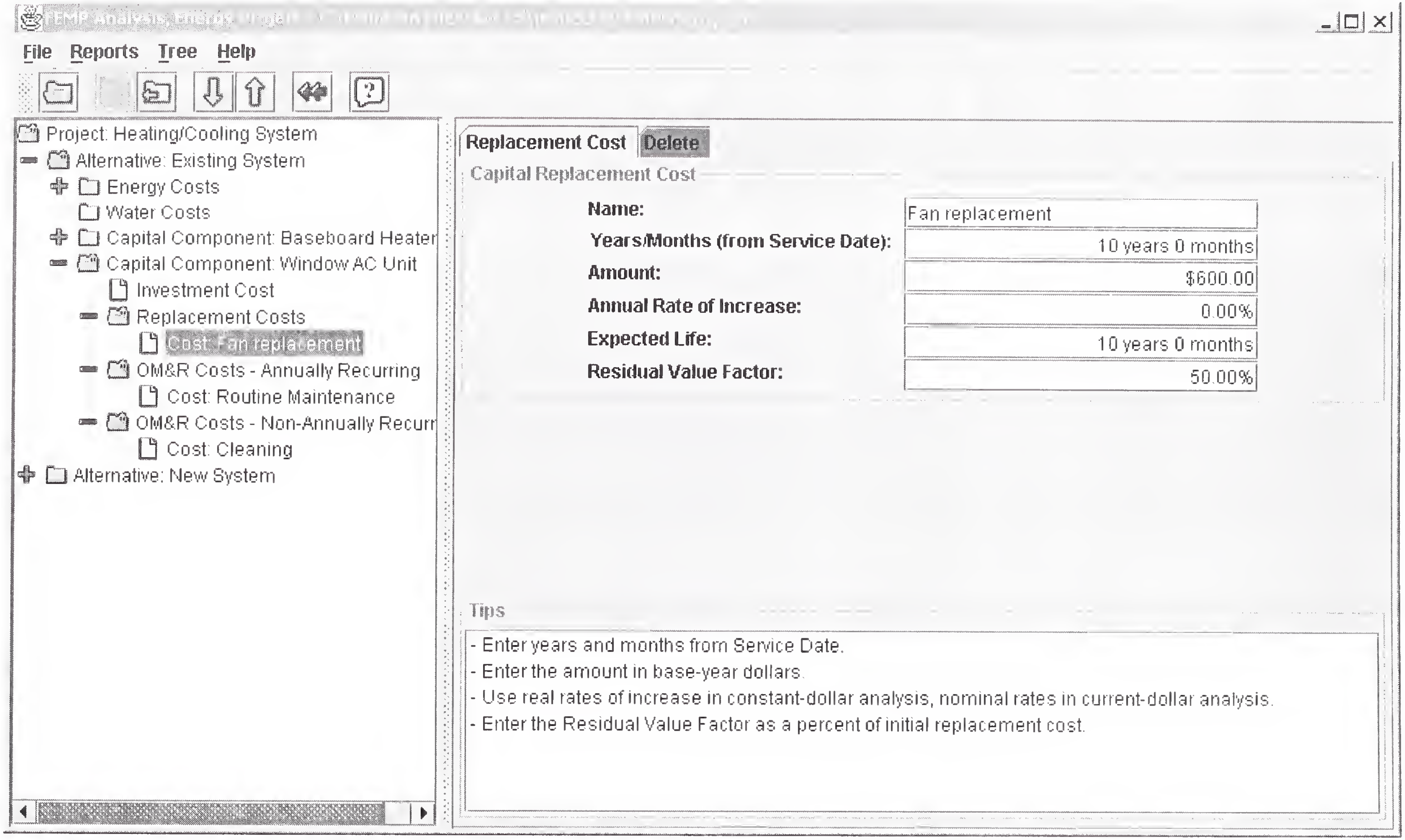
Contract Costs - Non-Annually Recurring



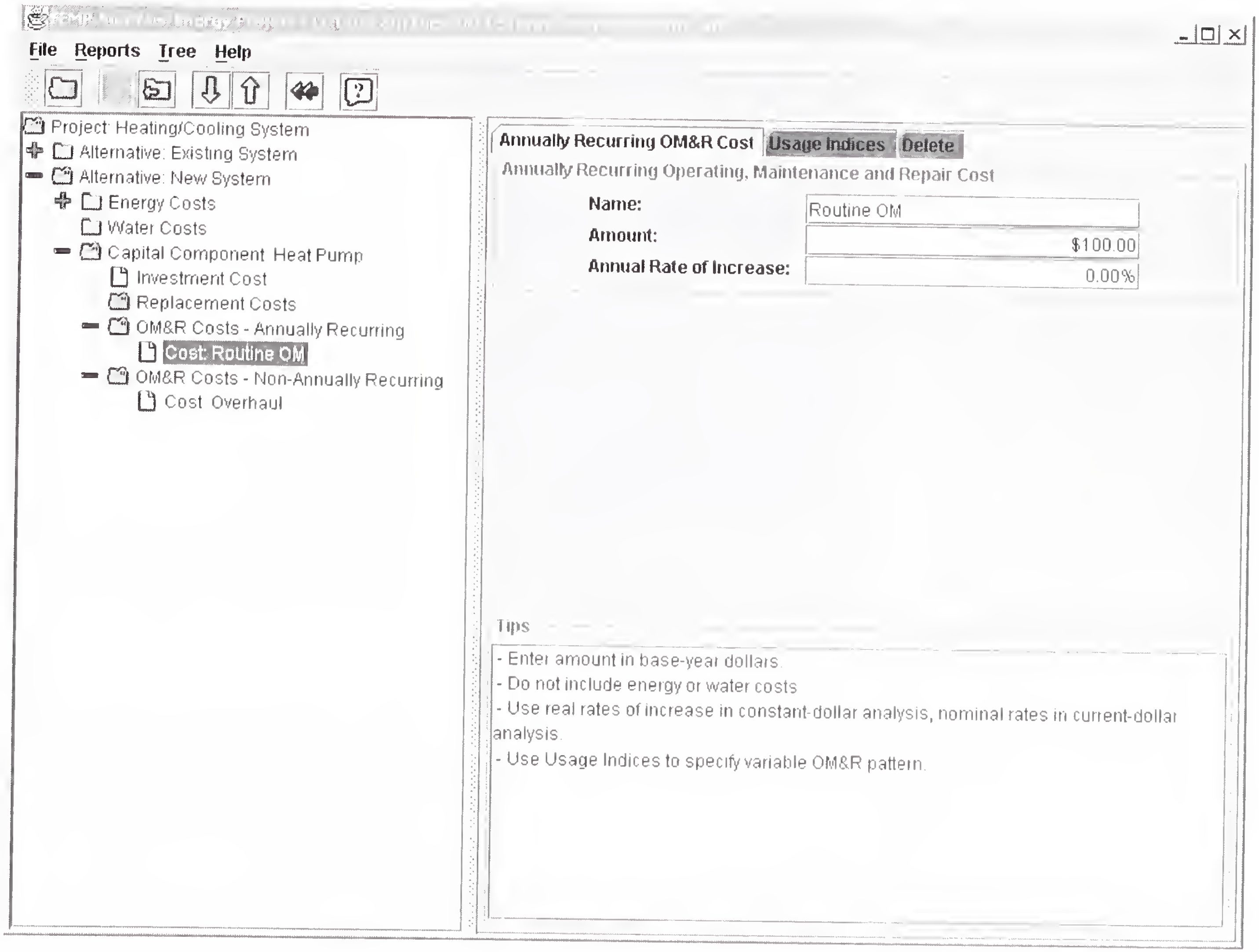
Investment Costs



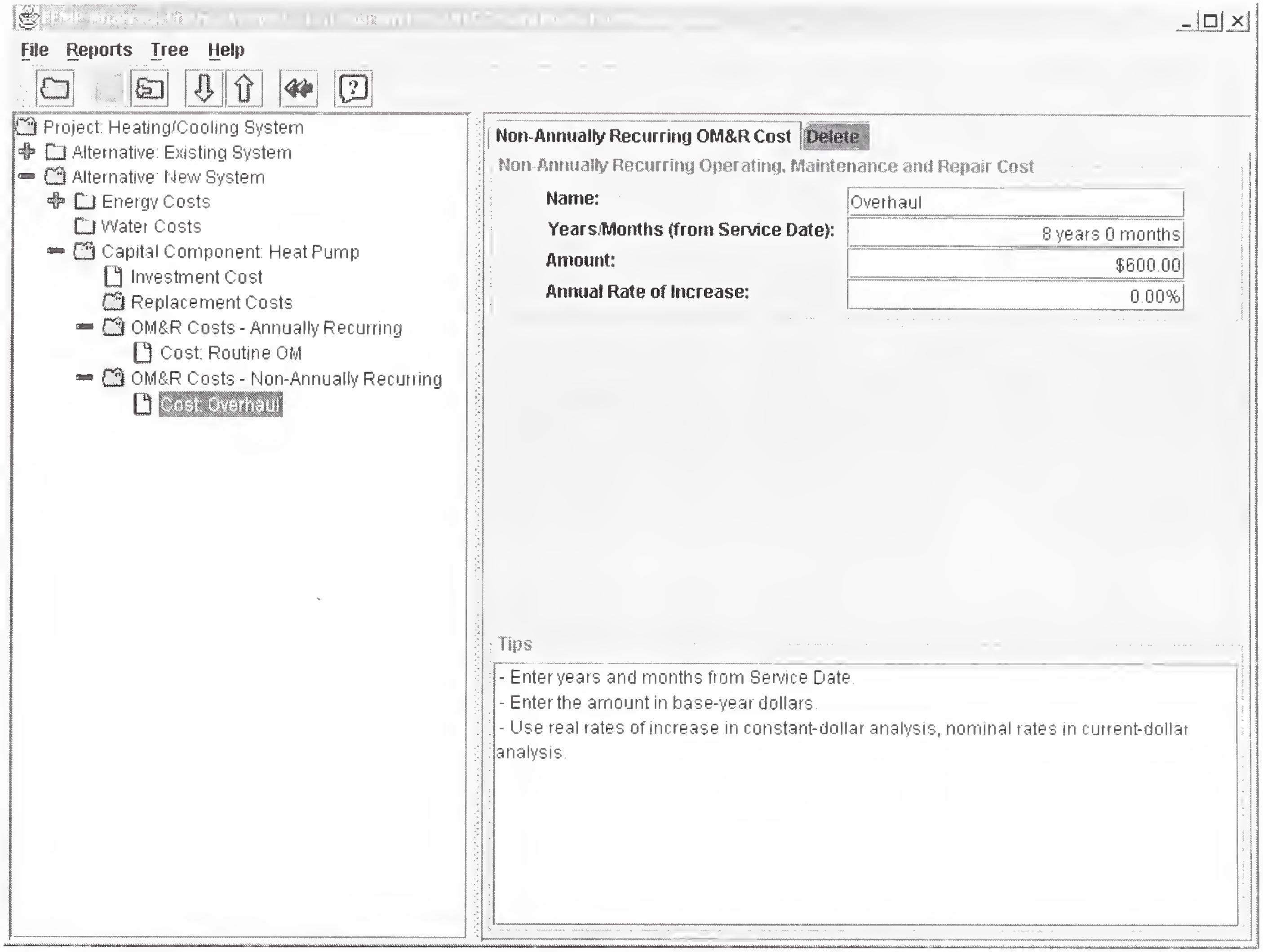
Capital Replacement Costs



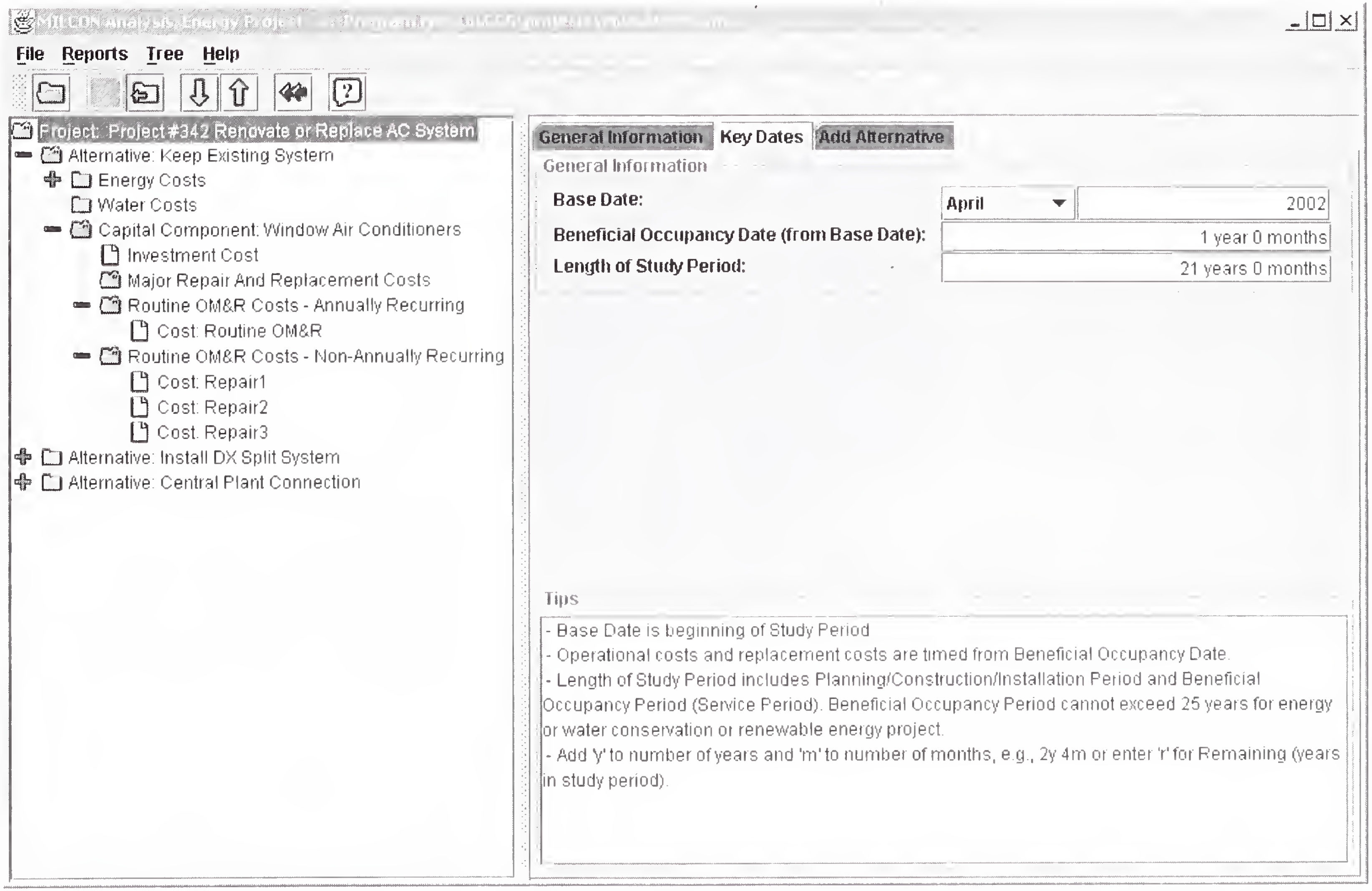
OM&R Costs - Annually Recurring



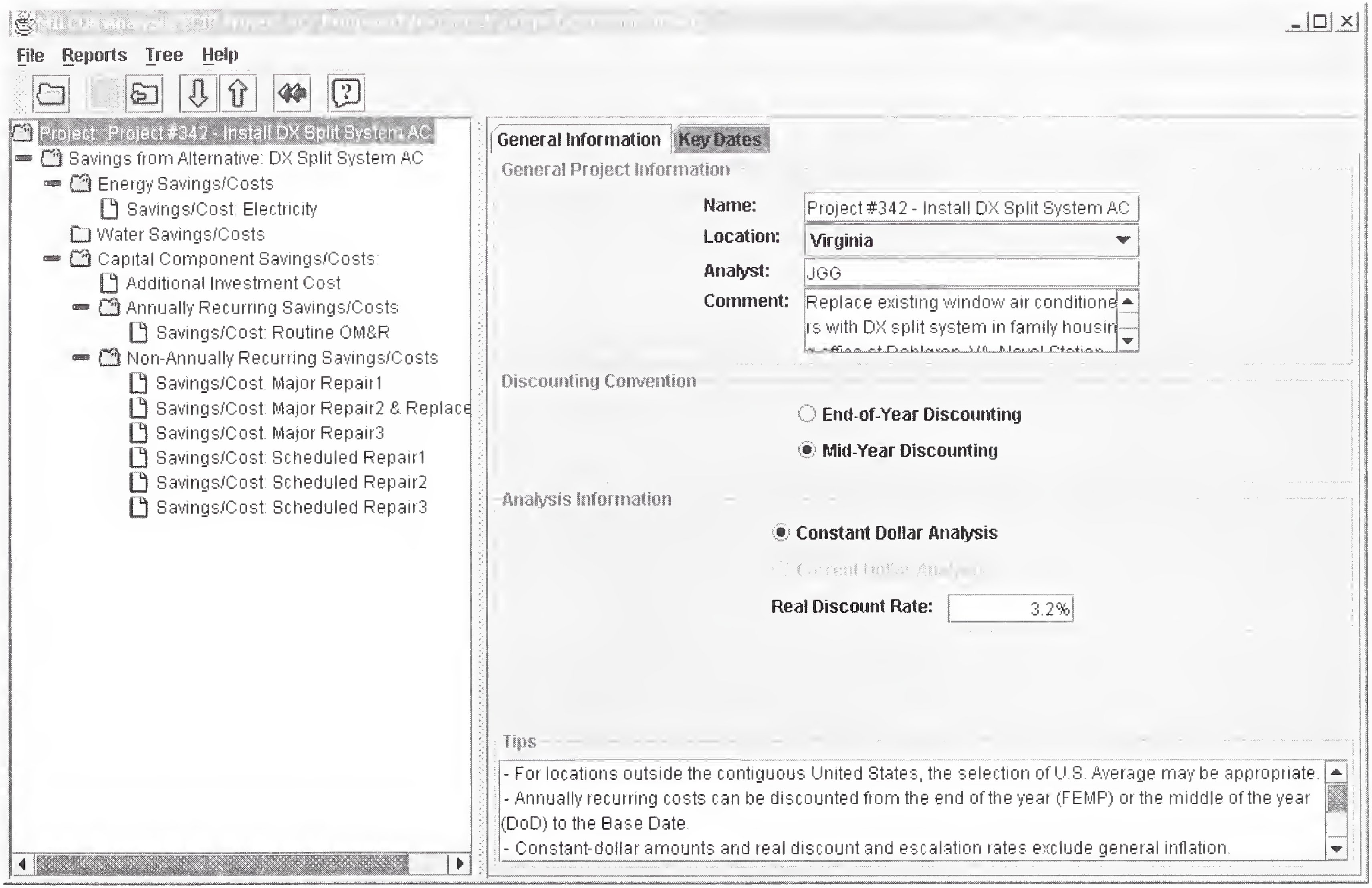
OM&R Costs - Non-Annually Recurring



MILCON - Energy Project

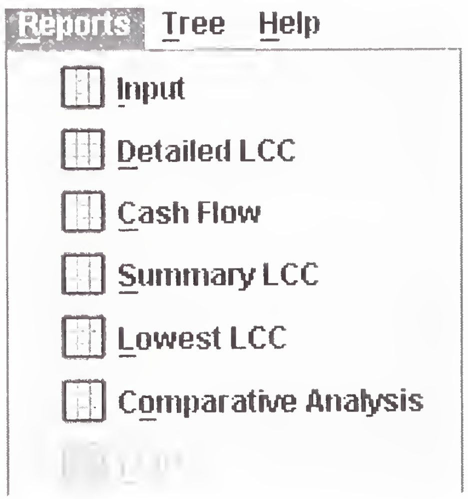


MILCON - ECIP Project



BLCC5 Reports

- For all alternatives in project
  - input data listing
  - life-cycle cost analysis (detailed and summary)
  - yearly cash flow analysis
- Comparative analysis
  - listing of LCCs for all project alternatives, with lowest LCC flagged
  - comparative economic measures (alternative versus base case)
  - side-by-side comparison of present values
  - net savings
  - savings-to-investment ratio
  - adjusted internal rate of return
  - payback
  - energy savings
  - emission reductions



BLCC5 Reports (cont.)

- Energy Conservation Investment Program (ECIP) Report
  - no capital replacement costs
  - component replacements should be entered as non-annually recurring savings/costs
    - will appear in the numerator of the SIR rather than in the denominator
  - residual values are not included
  - SIOH (supervision, inspection and overhead), design cost, salvage value of existing equipment, and public utility company rebates, if any, are specifically identified

Lowest Report

File

NIST BLCC 5.1-02: Lowest LCC

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\FederalFinanced.xml
Date of Study:	Thu May 30 16:15:15 EDT 2002
Analysis Type:	Federal Analysis, Financed Project
Project Name:	Lighting/Daylighting
Project Location:	Arizona
Analyst:	Derek Filben
Comment:	Replace existing lighting system with new system financed through a utility contract.
Base Date:	April 1, 2002
Study Period:	15 years 0 months (April 1, 2002 through March 31, 2017)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Lowest LCC

Comparative Present-Value Costs of Alternatives
(Shown in Ascending Order of Initial Cost, * = Lowest LCC)

Alternative	Initial Cost (PV)	Life Cycle Cost (PV)
Existing	$0	$848,189
Lighting Retrofit	$0	$578,010 *

File

NIST BLCC 5.1-02: ECIP Report

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A
The LCC calculations are based on the FEMP discount rates and energy price escalation rates updated on April 1, 2002.

Location:	Virginia	Discount Rate:	3.2%
Project Title:	Project #342 - Install DX Split System AC	Analyst:	JGG
Base Date:	April 1, 2002	Preparation Date:	Thu May 30 16:16:08 EDT 2002
BOD:	April 1, 2003	Economic Life:	21 years 0 months

File Name: C:\Program Files\BLCC5\projects\MilconECIP.xml

1. Investment

Construction Cost	$142,800
SIOH	$10,200
Design Cost	$17,000
Total Cost	$170,000
Salvage Value of Existing Equipment	$0
Public Utility Company Rebate	$0
Total Investment	$170,000

2. Energy and Water Savings (+) or Cost (-)
Base Date Savings, unit costs, & discounted savings

Item	Unit Cost	Usage Savings	Annual Savings	Discount Factor	Discounted Savings
Electricity	$25.52943	734.6 MBtu	$18,755	14.353	$269,185
Energy Subtotal		734.6 MBtu	$18,755		$269,185
Water Subtotal		0.0 Mgal	$0		$0
Total			$18,755		$269,185

NIST DOS-Based LCC Support Software

- **BLCC4**
- **ERATES: complex electricity rate schedules**
- **EMISS: air pollution emission factors**
- **DISCOUNT: present value factors and calculations**

NIST LCC Programs

- Programs updated every April 1 with new energy price escalation and discount rates

- Downloadable from DOE/FEMP Web site:
  - www.eren.doe.gov/femp -- Technical Assistance – Life-Cycle Cost Analysis

Exercise B

Exercise A2 is restated below. Try the exercise using BLCC5.

BLCC5 module:	**FEMP Analysis, Energy Project**
Location:	**Kansas**
Discounting Convention:	**End-of-Year**
Discount rate:	**3.2%**
Base date/service date:	**April 2002**
Study Period:	**15 years**
Annual space heating load:	**50 MBtu**
Fuel oil price:	**$1.12/gallon ($8.00/MBtu)**
Natural gas price:	**$0.80/therm ($8.00/MBtu)**
Rate type:	**Residential**

	Oil Furnace	**Gas Furnace**
Annual efficiency (average)	**82%**	**83%**
Initial cost:	**$4,500**	**$5,000**
Expected life (years)	**15**	**15**
Residual value	**$500**	**$1,000**
Annual maintenance cost	**$125**	**$75**

Use the Detailed LCC, Summary LCC, or Lowest LCC Report to determine which residential heating system has the lowest life-cycle cost. Use the Comparative Analysis Report to find its Net Savings and Savings-to-Investment Ratio. How do these values compare with the ones calculated in Exercise A2?

Solution to Exercise B

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise B.xml
Date of Study:	Mon Dec 23 12:12:16 EST 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Exercise B
Project Location:	Kansas
Analyst:	asr
Base Date:	April 1, 2002
Service Date:	April 1, 2002
Study Period:	15 years 0 months (April 1, 2002 through March 31, 2017)
Discount Rate:	3.2%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

Alternative: Oil Furnace

Energy: Distillate Fuel Oil (#1, #2)

Annual Consumption:	61.0 MBtu
Price per Unit:	$8.00000
Demand Charge:	$0
Utility Rebate:	$0
End-Use:	Residential Furnace
Rate Schedule:	Residential
State:	Kansas

Usage Indices

From Date	Duration	Usage Index
April 1, 2002	Remaining	100%

Component:

Initial Investment

Initial Cost (base-year $):	$4,500
Annual Rate of Increase:	0%
Expected Asset Life:	15 years 0 months
Residual Value Factor:	11.1%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	April 1, 2002	100%

Routine Recurring OM&R: Annual Maintenance

Amount:	$125
Annual Rate of Increase:	0%

Usage Indices

From Date	Duration	Factor
April 1, 2002	Remaining	100%

Alternative: Gas Furnace

Energy: Natural Gas

Annual Consumption:	60.2 MBtu
Price per Unit:	$8.00000
Demand Charge:	$0
Utility Rebate:	$0
End-Use:	Residential Furnace
Rate Schedule:	Residential
State:	Kansas

Usage Indices

From Date	Duration	Usage Index
April 1, 2002	Remaining	100%

Component:

Initial Investment

Initial Cost (base-year $):	$5,000
Annual Rate of Increase:	0%
Expected Asset Life:	15 years 0 months
Residual Value Factor:	20%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	April 1, 2002	100%

Routine Recurring OM&R: Annual Maintenance

Amount:	$75
Annual Rate of Increase:	0%

Usage Indices

From Date	Duration	Factor
April 1, 2002	Remaining	100%

NIST BLCC 5.1-02: Summary LCC

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise B.xml
Date of Study:	Mon Dec 23 12:20:07 EST 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Exercise B
Project Location:	Kansas
Analyst:	asr
Base Date:	April 1, 2002
Service Date:	April 1, 2002
Study Period:	15 years 0 months (April 1, 2002 through March 31, 2017)
Discount Rate:	3.2%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

Alternative: Oil Furnace

LCC Summary

	Present Value	Annual Value
Initial Cost	$4,500	$382
Energy Consumption Costs	$5,408	$460
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$1,471	$125
Non-Annually Recurring OM&R Costs	$0	$0
Replacement Costs	$0	$0
Less Remaining Value	-$312	-$26
	------------	------------
Total Life-Cycle Cost	$11,067	$941

Alternative: Gas Furnace
LCC Summary

	Present Value	Annual Value
Initial Cost	$5,000	$425
Energy Consumption Costs	$5,606	$477
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$883	$75
Non-Annually Recurring OM&R Costs	$0	$0
Replacement Costs	$0	$0
Less Remaining Value	-$623	-$53
	------------	------------
Total Life-Cycle Cost	$10,866	$923

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Oil Furnace
Alternative: Gas Furnace

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise B.xml
Date of Study:	Mon Dec 23 12:12:41 EST 2002
Project Name:	Exercise B
Project Location:	Kansas
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	asr
Base Date:	April 1, 2002
Service Date:	April 1, 2002
Study Period:	15 years 0 months(April 1, 2002 through March 31, 2017)
Discount Rate:	3.2%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs
PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$4,500	$5,000	-$500
Future Costs:			
Energy Consumption Costs	$5,408	$5,606	-$199
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$1,471	$883	$588
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	-$312	-$623	$312
	------------	------------	------------
Subtotal (for Future Cost Items)	$6,567	$5,866	$701
	------------	------------	------------
Total PV Life-Cycle Cost	$11,067	$10,866	$201

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$390
- Increased Total Investment	$188

Net Savings	$201

Savings-to-Investment Ratio (SIR)

SIR = 2.07

Adjusted Internal Rate of Return

AIRR = 8.33%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year	15
Discounted Payback occurs in year	15

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	**-----Average Base Case**	**Annual Alternative**	**Consumption----- Savings**	**Life-Cycle Savings**
Distillate Fuel Oil (#1, #2)	61.0 MBtu	0.0 MBtu	61.0 MBtu	914.6 MBtu
Natural Gas	0.0 MBtu	60.2 MBtu	-60.2 MBtu	-903.5 MBtu

Energy Savings Summary (in MBtu)

Energy Type	**-----Average Base Case**	**Annual Alternative**	**Consumption----- Savings**	**Life-Cycle Savings**
Distillate Fuel Oil (#1, #2)	61.0 MBtu	0.0 MBtu	61.0 MBtu	914.6 MBtu
Natural Gas	0.0 MBtu	60.2 MBtu	-60.2 MBtu	-903.5 MBtu

Emissions Reduction Summary

Energy Type	**-----Average Base Case**	**Annual Alternative**	**Emissions----- Reduction**	**Life-Cycle Reduction**
Distillate Fuel Oil (#1, #2)				
CO2	4,425.73 kg	0.00 kg	4,425.73 kg	66,376.81 kg
SO2	31.66 kg	0.00 kg	31.66 kg	474.81 kg
NOx	3.86 kg	0.00 kg	3.86 kg	57.90 kg
Natural Gas				
CO2	0.00 kg	3,182.08 kg	-3,182.08 kg	-47,724.64 kg
SO2	0.00 kg	25.68 kg	-25.68 kg	-385.15 kg
NOx	0.00 kg	2.48 kg	-2.48 kg	-37.18 kg

Total:

CO2	4,425.73 kg	3,182.08 kg	1,243.65 kg	18,652.18 kg
SO2	31.66 kg	25.68 kg	5.98 kg	89.66 kg
NOx	3.86 kg	2.48 kg	1.38 kg	20.72 kg

Module C

Fuel Switching and Phased-In Capital Replacements

Objective: Upon completion of this module, you will be able to

- **evaluate capital replacements affecting energy types and energy usage amounts after occupancy.**

Boiler Replacement Problem

Location:	**Office building in Maryland**
Existing:	**3 -700 kBtu oil-fired boilers**
	60% efficient, 15-year remaining life
	oil price $1.20/gallon ($8.57 MBtu)
Proposal:	**3 -700 kBtu gas/oil-fired boilers, 80/83% efficient**
	$15,000 each (installed)
	30-year expected life
	gas price $1.00/therm ($10.00 MBtu)

Maintenance similar for both systems

Annual heat load	**= 2,065 MBtu**
Study period	**= 15 years**
FEMP LCC discount rate	**= 3.2%**

Preliminary Analysis: Replace All Three Boilers Immediately

Calculate LCC of existing system.

$$LCC_{existing} = AL/Eff_{existing} \times P_{oil} \times UPV^*$$

$$LCC_{existing} = 2{,}065/.60 \times \$8.57 \times 11.82$$

$$= \underline{\$348{,}632}$$

IC = initial cost
AL = annual load
Eff = seasonal efficiency
P = energy price ($/MBtu)
UPV* = modified uniform present value (commercial, region 3, oil or gas)
RF = residual value factor
SPV = single present value factor
SP = study period

Preliminary Analysis (cont.): Replace All Three Boilers Immediately

Calculate LCC of new boilers using both gas and oil.

$$LCC_{new} = IC + AL/Eff_{new} \times P_{gas/oil} \times UPV^* - IC \times RF \times SPV_{sp}$$

$$LCC_{new(gas)} = \$45,000 + 2,065/0.80 \times \$10.00 \times 11.73 - \$45,000 \times 0.5 \times 0.623 = \underline{\$333,763}$$

$$LCC_{new(oil)} = \$45,000 + 2,065/0.83 \times \$8.57 \times 11.82 - \$45,000 \times 0.5 \times 0.623 = \underline{\$283,006}$$

Phased-In Boiler Replacement

Replace boiler #1 immediately, #2 at end of year 2,
#3 at end of year 4.

$$
\begin{aligned}
LCC_{new} = {} & IC_1 \text{ x } SPV_0 + IC_2 \text{ x } SPV_2 + IC_3 \text{ x } SPV_4 + \\
& + AL_1/Eff_{new} \text{ x } P_{oil} \text{ x } UPV^*_{(15,oil,S,com)} \\
& + AL_2/Eff_{existing} \text{ x } P_{oil} \text{ x } UPV^*_{(2,oil,S,com)} \\
& + AL_2/Eff_{new} \text{ x } P_{oil} \text{ x } [UPV^*_{(15,oil,S,com)} - UPV^*_{(2,oil,S,com)}] \\
& + AL_3/Eff_{existing} \text{ x } P_{oil} \text{ x } UPV^*_{(4,oil,S,com)} \\
& + AL_3/Eff_{new} \text{ x } P_{oil} \text{ x } [UPV^*_{(15,oil,S,com)} - UPV^*_{(4,oil,S,com)}] \\
& - IC_1 \text{ x } RF_1 \text{ x } SPV_{15} - IC_2 \text{ x } RF_2 \text{ x } SPV_{15} \\
& - IC_3 \text{ x } RF_3 \text{ x } SPV_{15}
\end{aligned}
$$

Boiler Load Profile

The annual load on each boiler (AL_1, AL_2, AL_3) is needed to identify energy use as boilers are phased in.

bin	outdoor temp	load (kBtu)	load distribution (kBtu)			hrs/ year
			boiler 1	boiler 2	boiler 3	
1	47	222	222	0	0	684
2	42	444	444	0	0	790
3	37	668	666	0	0	744
4	32	889	700	189	0	542
5	27	1111	700	411	0	254
6	22	1333	700	633	0	138
7	17	1556	700	700	156	54
8	12	1778	700	700	378	17
9	7	2000	700	700	600	2

Annual Energy Use by Individual Boiler

bin	annual load (MBtu)			total load
	boiler 1	boiler 2	boiler 3	
1	152	0	0	152
2	351	0	0	351
3	496	0	0	496
4	379	102	0	481
5	178	104	0	282
6	97	87	0	184
7	38	38	8	84
8	12	12	6	30
9	1	2	1	4
Total	1,704	345	15	2,064

LCC for Existing Boilers

$$LCC_{existing(i)} = AL_1/Eff_{existing} \times P_{oil} \times UPV^*_{15}$$

$$LCC_{existing(1)} = 1{,}704/0.60 \times \$8.57 \times 11.82 = \$287{,}685$$

$$LCC_{existing(2)} = 345/0.60 \times \$8.57 \times 11.82 = \$58{,}246$$

$$LCC_{existing(3)} = 15/0.60 \times \$8.57 \times 11.82 = \$2{,}532$$

LCC for New Boilers (individual)

$$LCC_{new(i)} = IC_{new} \times SPV_{y(i)}$$
$$+ AL_{(i)}/Eff_{existing} \times P_{oil} \times UPV^*_{y(i),oil,S,com}$$
$$+ AL_{(i)}/Eff_{new} \times P_{oil} \times [UPV^*_{15,oil,S,com} - UPV^*_{y(i),oil,S,com}]$$
$$- IC_{new(i)} \times RF_i \times SPV_{sp}$$

$$LCC_{new(1)} = \$15{,}000 \times 1.0$$
$$+ 1{,}704/0.60 \times \$8.57 \times 0.0$$
$$+ 1{,}704/0.83 \times \$8.57 \times (11.82 - 0.0)$$
$$- \$15{,}000 \times 0.50 \times 0.623 = \$218{,}292$$

$$LCC_{new(2)} = \$15{,}000 \times 0.939$$
$$+ 345/0.60 \times \$8.57 \times 1.79$$
$$+ 345/0.83 \times \$8.57 \times (11.82 - 1.79)$$
$$- \$15{,}000 \times 0.57 \times 0.623 = \$53{,}308$$

$$LCC_{new(3)} = \$15{,}000 \times 0.882$$
$$+ 15/0.60 \times \$8.57 \times 3.46$$
$$+ 15/0.83 \times \$8.57 \times (11.82 - 3.46)$$
$$- \$15{,}000 \times 0.63 \times 0.623 = \$9{,}379$$

Lowest LCC and Net Savings

Boiler #	Existing LCC	New LCC	Net Savings
1.	$287,685	$218,292	$69,393
2.	$58,246	$53,308	$4,938
3.	$2,532	$9,379	-$6,847

Oil Only Versus Gas/Oil Boiler

A single-fuel, oil-fired boiler costs $10,000; all other costs are the same. Is it more cost effective?

Calculate LCC of new oil-fired boilers.

$$LCC_{new} = IC + AL/Eff_{new} \times P_{oil} \times UPV^{*} - IC \times RF \times SPV_{sp}$$

$$LCC_{new(oil)} = \$30{,}000 + 2{,}065/0.83 \times \$8.57 \times 11.82 - \$30{,}000 \times 0.5 \times 0.623$$

$$= \underline{\$272{,}678}$$

Lowest Life-Cycle Cost

Option	LCC
Existing Oil-Fired Boiler	$348,632
New Gas/Oil-Fired Boiler	$283,006
New Oil-Fired Boiler	$272,678

What issues need enter into the decision other than lowest LCC?

Example C

Determine the LCC, using BLCC5, for the following three cases:

Location:	**Office building in Maryland**
Annual heat load:	**2,065 MBtu**
Study period:	**15 years**
FEMP discount rate:	**3.2%**
Oil price:	**$1.20/gallon, 140,000 Btu/gallon**
Gas price:	**$1.00/therm, 100,000 Btu/therm**

Maintenance similar for all options.

Example C (cont.)

Case 1: Existing 3 - 700 kBtu oil-fired boilers
60% efficient, 15-year remaining life

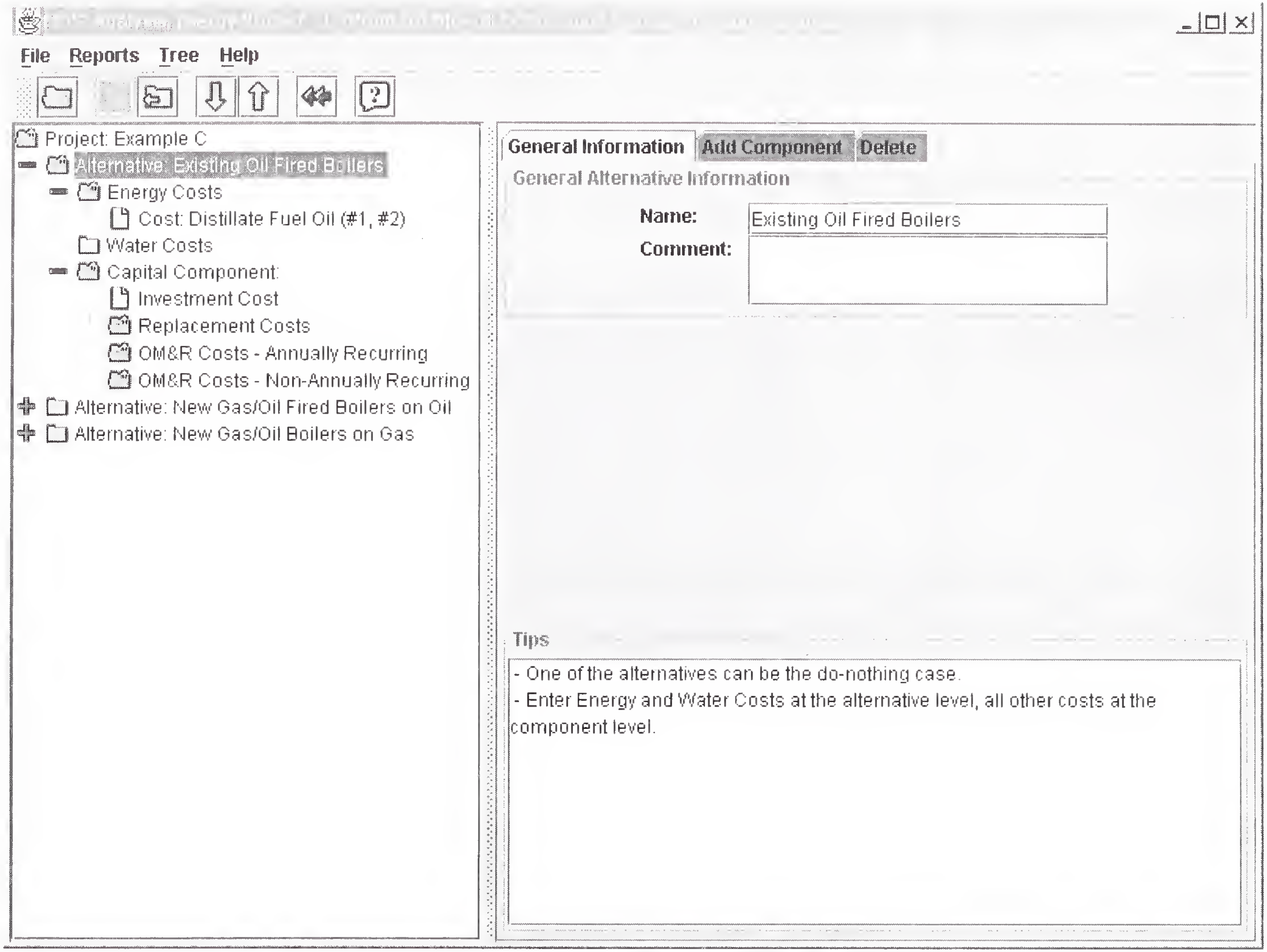
Case 2: New 3 - 700 kBtu gas/oil-fired boilers
$15,000 each, 80/83% (gas/oil) efficient
30-year expected life, fired-on oil

Case 3: New 3 - 700 kBtu gas/oil-fired boilers
$15,000 each, 80/83% (gas/oil) efficient
30-year expected life, fired-on gas

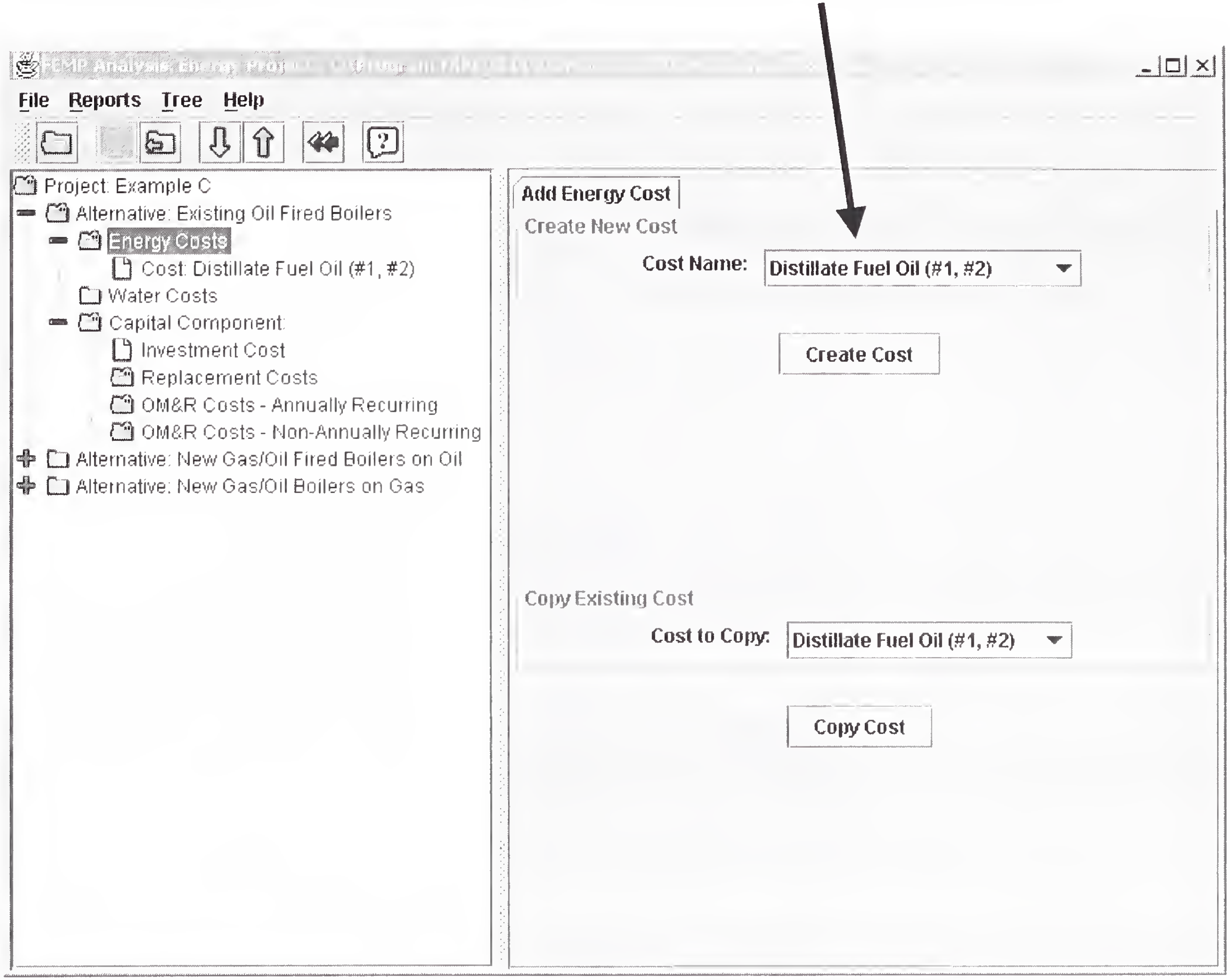
Annual Energy Use

Case #		Energy Use
1	$2{,}065 \times 10^6 / (140{,}000 \times .60)$	24,583 gallons
2	$2{,}065 \times 10^6 / (140{,}000 \times .83)$	17,771 gallons
3	$2{,}065 \times 10^6 / (100{,}000 \times .80)$	25,813 therms

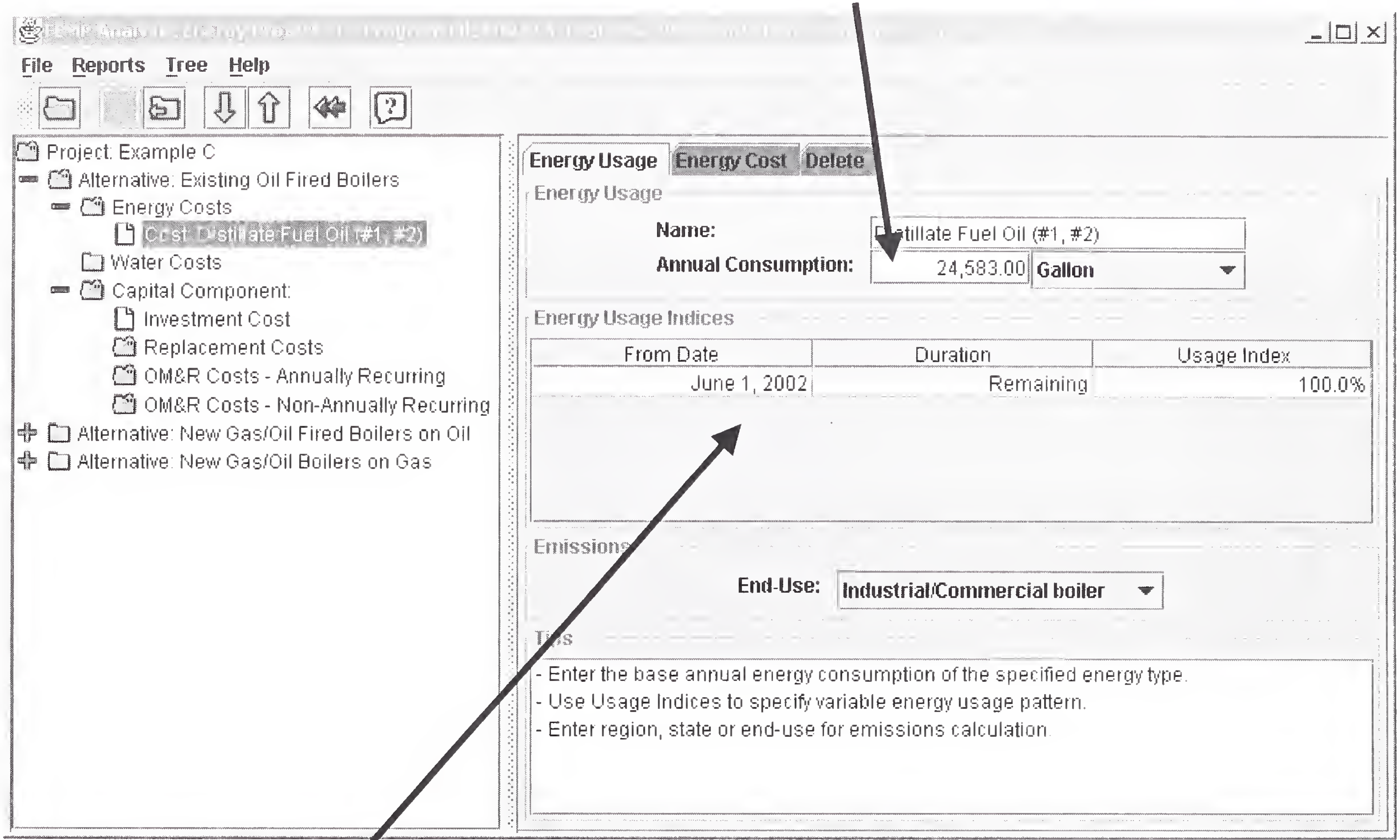
Alternative 1 – Existing Oil-Fired Boilers



Choose the Fuel Type

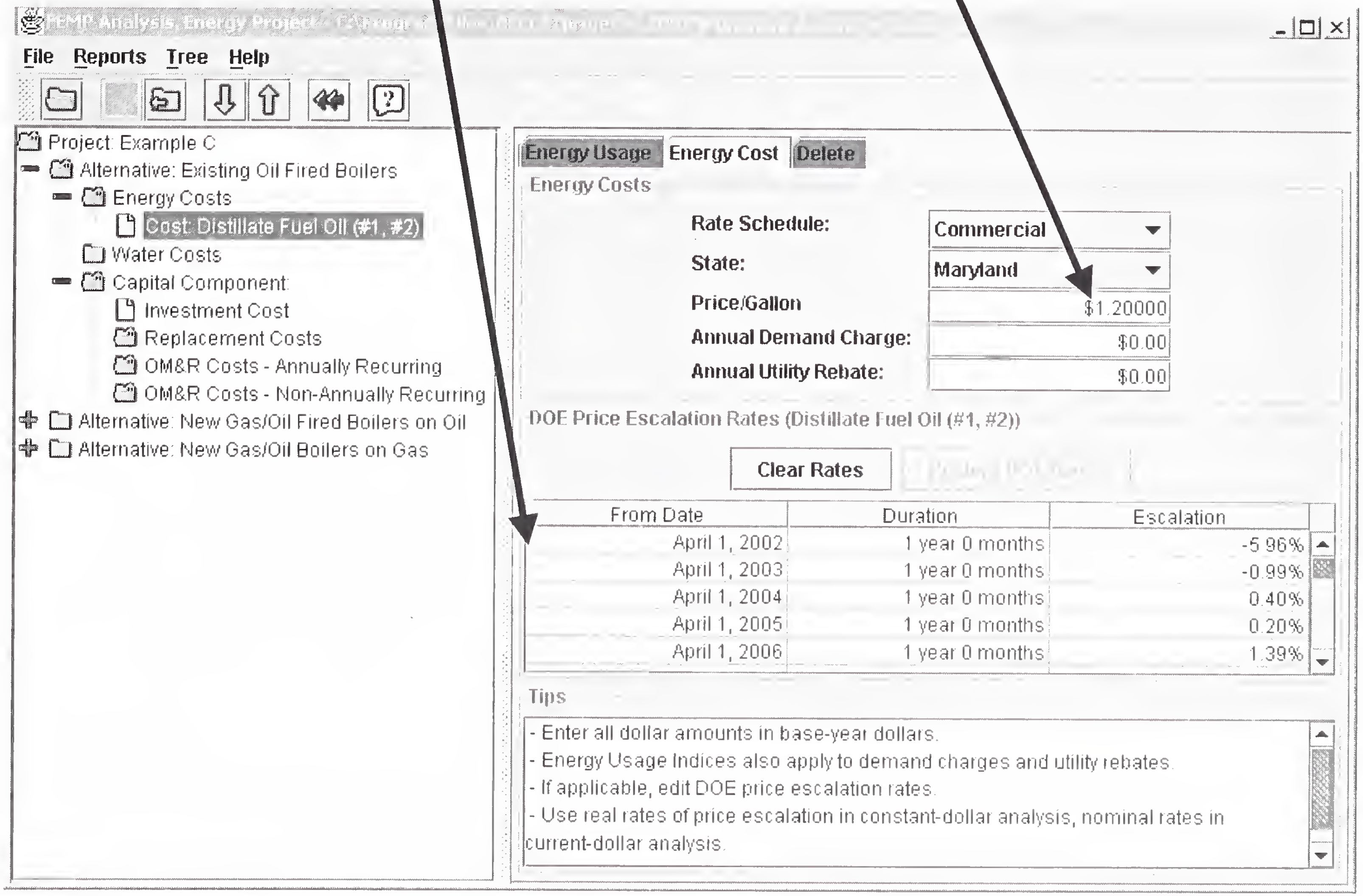


Enter the Annual Consumption



You can index the use here if needed.

Enter the Fuel Price and Escalation Information



Review the Summary LCC Report

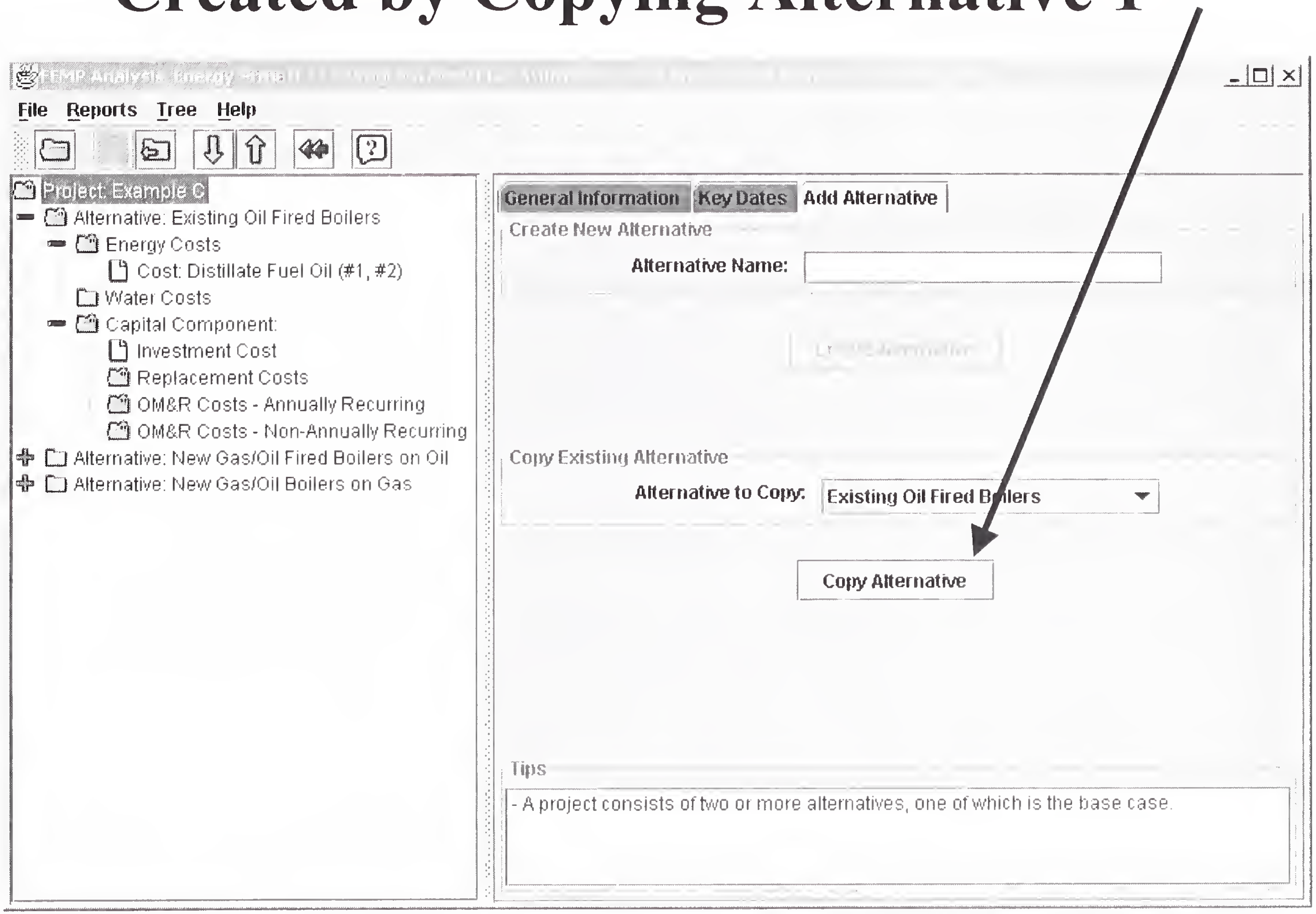
File

Alternative: Existing Oil Fired Boilers

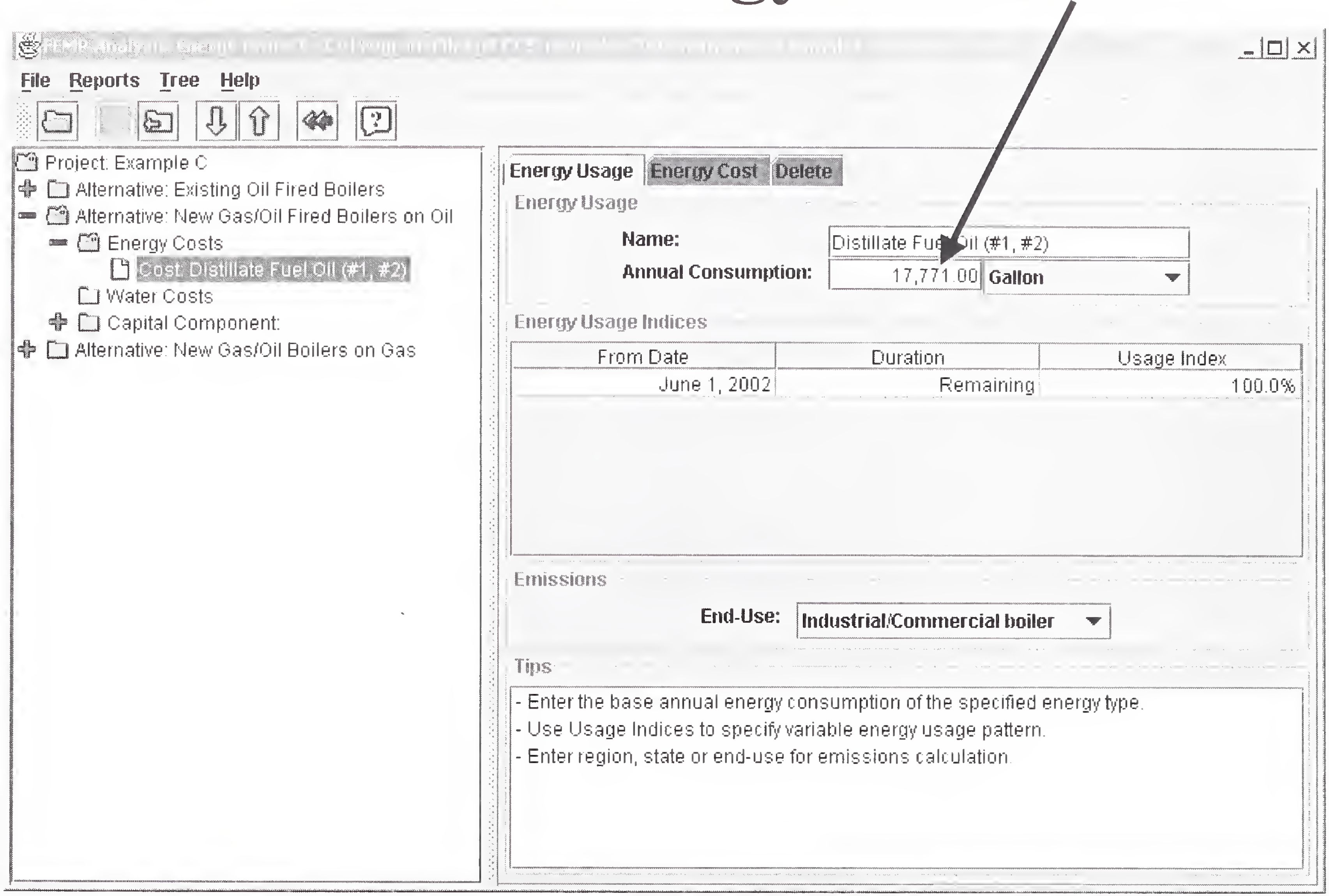
LCC Summary

	Present Value	Annual Value
Initial Cost	$0	$0
Energy Consumption Costs	$353,186	$30,018
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$0	$0
Non-Annually Recurring OM&R Costs	$0	$0
Replacement Costs	$0	$0
Less Remaining Value	$0	$0
Total Life-Cycle Cost	$353,186	$30,018

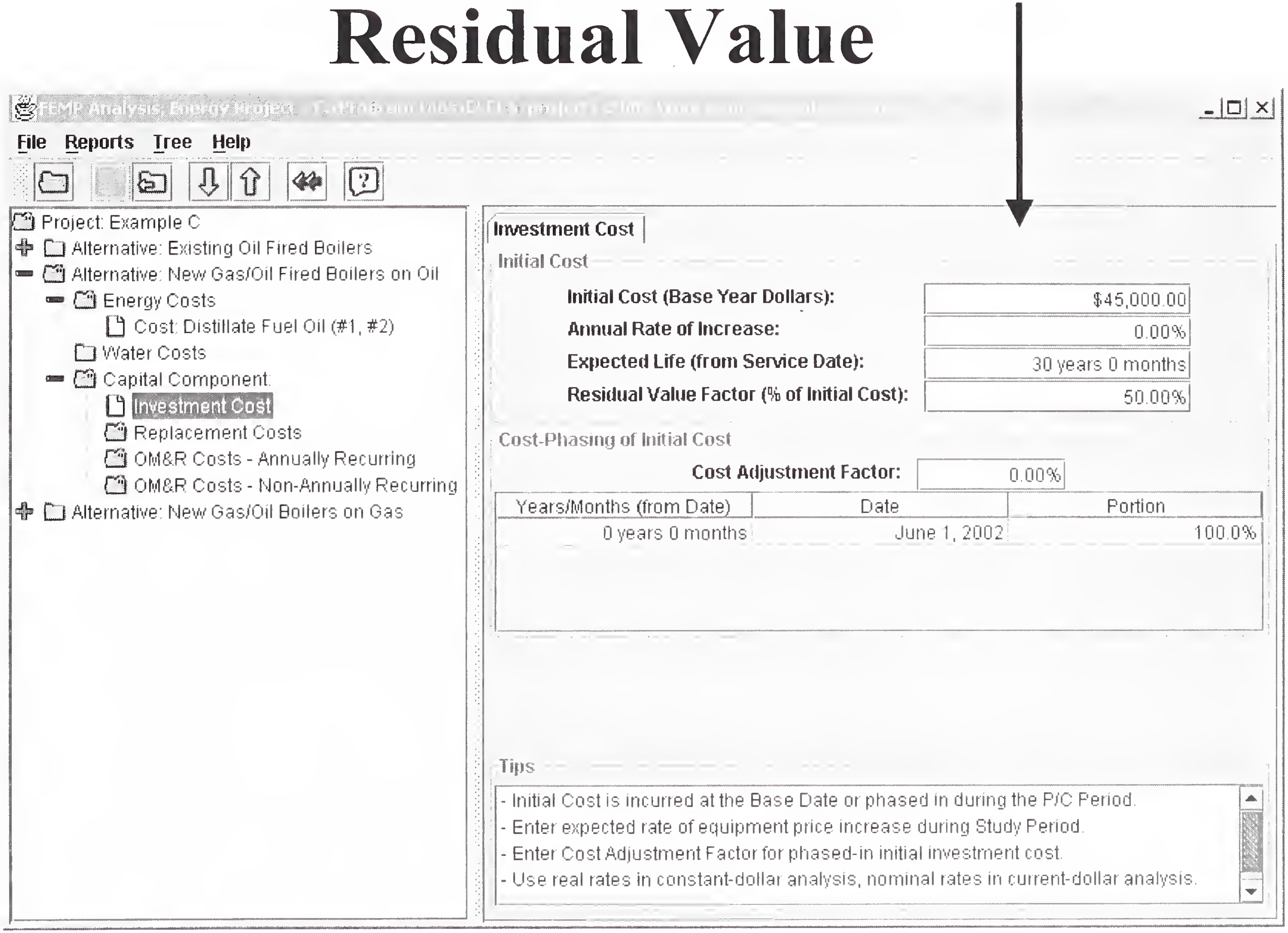
Alternative 2 – Gas/Oil Boilers Burning Oil, Created by Copying Alternative 1



Enter New Energy Use Data



Enter Initial Cost, Life, and Residual Value



Review the Summary LCC Report

File

Alternative: New Gas/Oil Fired Boilers on Oil

LCC Summary

	Present Value	Annual Value
Initial Cost	$45,000	$3,825
Energy Consumption Costs	$255,318	$21,700
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$0	$0
Non-Annually Recurring OM&R Costs	$0	$0
Replacement Costs	$0	$0
Less Remaining Value	-$14,029	-$1,192
Total Life-Cycle Cost	$286,289	$24,332

Analyze Alternative 3 and Review Results

Lowest Report

File

NIST BLCC 5.1-02: Lowest LCC

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Examples\Example C.xml
Date of Study:	Thu May 30 11:49:17 EDT 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Example C
Project Location:	Maryland
Analyst:	GMM
Base Date:	June 1, 2002
Service Date:	June 1, 2002
Study Period:	15 years 0 months (June 1, 2002 through May 31, 2017)
Discount Rate:	3.2%
Discounting Convention:	End-of-Year

Lowest LCC

Comparative Present-Value Costs of Alternatives
(Shown in Ascending Order of Initial Cost, * = Lowest LCC)

Alternative	Initial Cost (PV)	Life Cycle Cost (PV)	
Existing Oil Fired Boilers	$0	$353,186	
New Gas/Oil Fired Boilers on Oil	$45,000	$286,289	*
New Gas/Oil Boilers on Gas	$45,000	$336,557	

Exercise C

The owner of a commercial building in Maryland is considering the replacement of three, older inefficient (60%) distillate fuel oil-fired boilers with newer, more efficient (83%) boilers. The annual heat load on the building is 2,065 MBtu distributed over the three boilers. #2 oil has a heating value of 140,000 Btu/gal and presently costs $1.20 per gallon.

Because of cash flow, the owner has decided she cannot afford to replace all three at the same time. Her schedule is to replace one boiler now, another at the end of year two, and a third at the end of year four.

The boiler control system presently stages one boiler on until it can no longer meet the load and then adds another boiler. Using this strategy, the lead boiler meets 1,704 MBtu of the load, the second boiler meets 345 MBtu, and the last boiler only comes on to meet 15 MBtu of the load.

She plans to use the first new boiler installed as the lead boiler.

Compare the life-cycle cost of this approach against the status quo. Use a 15-year study period and assume a 30-year life for the new boilers. The base date is specified as June 2002. Use the end-of-year discounting convention.

Hint: You will need to determine the oil use of each boiler during the construction period and use the energy-indexing feature of BLCC5. You will also need to determine the remaining life of each new boiler for residual value calculation.

Exercise C (cont.)

Boiler #	Annual Load MBtu	Fuel Used Gallons	Year 1	Year 2	Year 3	Year 4	Year 5 through 15
1 old	1,704	20,286					
2 old	345	4,107	4,107	4,107			
3 old	15	179	179	179	179	179	
	Total =	24,571					
1 new	1,704	14,664	14,664	14,664	14,664	14,664	14,664
2 new	345	2,969			2,969	2,969	2,969
3 new	15	129					129
	Total =	17,762	18,950	18,950	17,812	17,812	17,762
		Fraction	1	1	0.940	0.940	0.937

Boiler	Life Used	Life Left	Residual Value Factor
1	15	15	0.50
2	13	17	0.57
3	11	19	0.63

Solution to Exercise C

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise C.xml
Date of Study:	Mon Dec 23 12:35:17 EST 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Exercise C
Project Location:	Maryland
Analyst:	Gene Meyer
Comment:	Phased Boiler Replacement Versus Base Case of Do Nothing
Base Date:	June 1, 2002
Service Date:	June 1, 2002
Study Period:	15 years 0 months (June 1, 2002 through May 31, 2017)
Discount Rate:	3.2%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

Alternative: Existing 60% Boilers

Energy: Distillate Fuel Oil (#1, #2)

Annual Consumption:	24,571.0 Gal
Price per Unit:	$1.20000
Demand Charge:	$0
Utility Rebate:	$0
End-Use:	Industrial/Commercial boiler
Rate Schedule:	Commercial
State:	Maryland

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	Remaining	100%

Component:

Initial Investment

Initial Cost (base-year $):	$0
Annual Rate of Increase:	0%
Expected Asset Life:	0 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Alternative: Phased Boiler Replacement

Energy: Distillate Fuel Oil (#1, #2)

Annual Consumption:	18,950.0 Gal
Price per Unit:	$1.20000
Demand Charge:	$0
Utility Rebate:	$0
End-Use:	Industrial/Commercial boiler
Rate Schedule:	Commercial
State:	Maryland

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	2 years 0 months	100%
June 1, 2004	2 years 0 months	94%
June 1, 2006	Remaining	93.7%

Component: Boiler #1

Comment: Installed in year 1

Initial Investment

Initial Cost (base-year $):	$15,000
Annual Rate of Increase:	0%
Expected Asset Life:	30 years 0 months
Residual Value Factor:	50%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Component: Boiler #2

Comment: Installed at end of year two.

Initial Investment

Initial Cost (base-year $):	$15,000
Annual Rate of Increase:	0%
Expected Asset Life:	32 years 0 months
Residual Value Factor:	57%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
2 years 0 months	June 1, 2004	100%

Component: Boiler #3

Comment: Installed at end of year 4

Initial Investment

Initial Cost (base-year $):	$15,000
Annual Rate of Increase:	0%
Expected Asset Life:	34 years 0 months
Residual Value Factor:	63%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
4 years 0 months	June 1, 2006	100%

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Existing 60% Boilers
Alternative: Phased Boiler Replacement

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise C.xml
Date of Study:	Mon Dec 23 12:37:35 EST 2002
Project Name:	Exercise C
Project Location:	Maryland
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	Gene Meyer
Comment	Phased Boiler Replacement Versus Base Case of Do Nothing
Base Date:	June 1, 2002
Service Date:	June 1, 2002
Study Period:	15 years 0 months(June 1, 2002 through May 31, 2017)
Discount Rate:	3.2%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$0	$42,308	-$42,308
Future Costs:			
Energy Consumption Costs	$353,014	$257,803	$95,211
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$0	$0	$0
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	-$15,899	$15,899
	------------	------------	------------
Subtotal (for Future Cost Items)	$353,014	$241,904	$111,110
	------------	------------	------------
Total PV Life-Cycle Cost	$353,014	$284,212	$68,802

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$95,211
- Increased Total Investment	$26,409

Net Savings	$68,802

Savings-to-Investment Ratio (SIR)

SIR = 3.61

Adjusted Internal Rate of Return

AIRR = 12.41%

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback occurs in year 7

Discounted Payback occurs in year 7

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Distillate Fuel Oil (#1, #2)	24,571.0 Gal	17,923.0 Gal	6,648.0 Gal	99,705.8 Gal

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Distillate Fuel Oil (#1, #2)	3,729.1 MBtu	2,720.1 MBtu	1,008.9 MBtu	15,132.1 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Distillate Fuel Oil (#1, #2)				
CO2	270,643.67 kg	197,416.56 kg	73,227.12 kg	1,098,256.39 kg
SO2	1,935.98 kg	1,412.17 kg	523.81 kg	7,856.09 kg
NOx	243.96 kg	177.96 kg	66.01 kg	990.00 kg
Total:				
CO2	270,643.67 kg	197,416.56 kg	73,227.12 kg	1,098,256.39 kg
SO2	1,935.98 kg	1,412.17 kg	523.81 kg	7,856.09 kg
NOx	243.96 kg	177.96 kg	66.01 kg	990.00 kg

Module D

Replacement of Functional Systems to Improve Energy Efficiency

Objectives: Upon completion of this module, you will understand

- cost-effectiveness requirements for
  - new systems or mandatory replacement of functional systems
  - optional replacement of functional systems.
- timing of optional system replacement.
- sensitivity analysis.

Optional Replacement to Increase Energy Efficiency

- Entire investment cost must be justified, not just incremental cost.
- Timing of optional replacement is independent of remaining system life.
- Optimal timing is affected by changes in energy prices, technology, and other factors.

Example D

Economic Evaluation of Air Conditioning System – Source: Joe Graf, NAVFAC

PROBLEM STATEMENT

The existing facility, an 8100 sq. ft. government office building in Virginia, provides administrative space, counseling rooms, and records and research areas. Over time, the increased use of devices such as individual work stations and printers has increased the cooling requirements at the building. The building is currently cooled by several window air conditioners, which require frequent maintenance and consume excessive amounts of energy. On very hot days there are complaints about uncomfortably high temperatures in the building. The building is heated by electric baseboard heating.

Options

Maintain Existing System

With the current maintenance schedule, the present heating and cooling system could be kept functional for another 20 years.

Install DX Split System

Install new "split-system" air-conditioning unit and associated elements required to provide adequate space conditioning. The installation will provide a new air distribution system for the building, with central air conditioning throughout.

Connect to Central Chilled Water Plant

Install piping network to connect the office building to the central chilled water plant on the site. The installation will provide a new air distribution system for the building, with air conditioning throughout. This option, if cost effective, would be preferred to the DX Split System because it would allow centralized maintenance. A general overhaul of the Central Plant is scheduled for 2005. If the piping connection to the office building were done then, the initial investment cost would be reduced by about 20%.

Electric baseboard heating will continue to be used for the facility. The removed air conditioning units will not have any appreciable salvage value. Either upgrade will require a planning and installation period of one year. The equipment installation will inconvenience personnel in the office building but should not shut the office down

Example D (cont.)

Economic Evaluation of Air Conditioning System

ANALYSIS

Perform an LCC analysis to determine which of the available options results in the lowest life-cycle cost. Perform sensitivity analysis for those of the uncertain variables that have the greatest impact on LCC.

Scenarios

1. Analyze the outcomes, assuming that
   a) you will keep the existing system if its LCC is lower than the LCCs of the alternatives, or
   b) you have already decided to replace the existing system with one of the possible two alternatives.
2. Perform sensitivity analysis by varying initial investment costs and electricity prices.
   a) Determine critical inputs by changing all input values by 10% and calculating the percentage effect on LCC.
   b) Calculate NS for all alternatives by changing energy prices and investment costs by ±10%, ±25%, and ±50%.

General Project Information

- AC system in NAVFAC office building in Virginia
- Discount rate: 3.2%
- Mid-year discounting
- Constant-dollar analysis
- Agency-funded project

Key dates

- **Base Date:** June 2002
- **Study period:** 21 years
- **Implementation Period:** 1 year
- **Service Date:** June 2003

Note: operational costs begin at service date

Alt. 1: Base Case:
Keep Existing System

Initial cost:	**$0**
Energy consumption:	**285,000 kWh/yr**
Energy price:	**$0.08711/kWh, industrial**
Ann.-recurr. OM&R costs:	**$1,050, increasing at 2%/yr**
Non-ann.rec. OM&R costs:	**$5,000 in years 5, 10 & 15 after service date**
Expected system life:	**20 years**

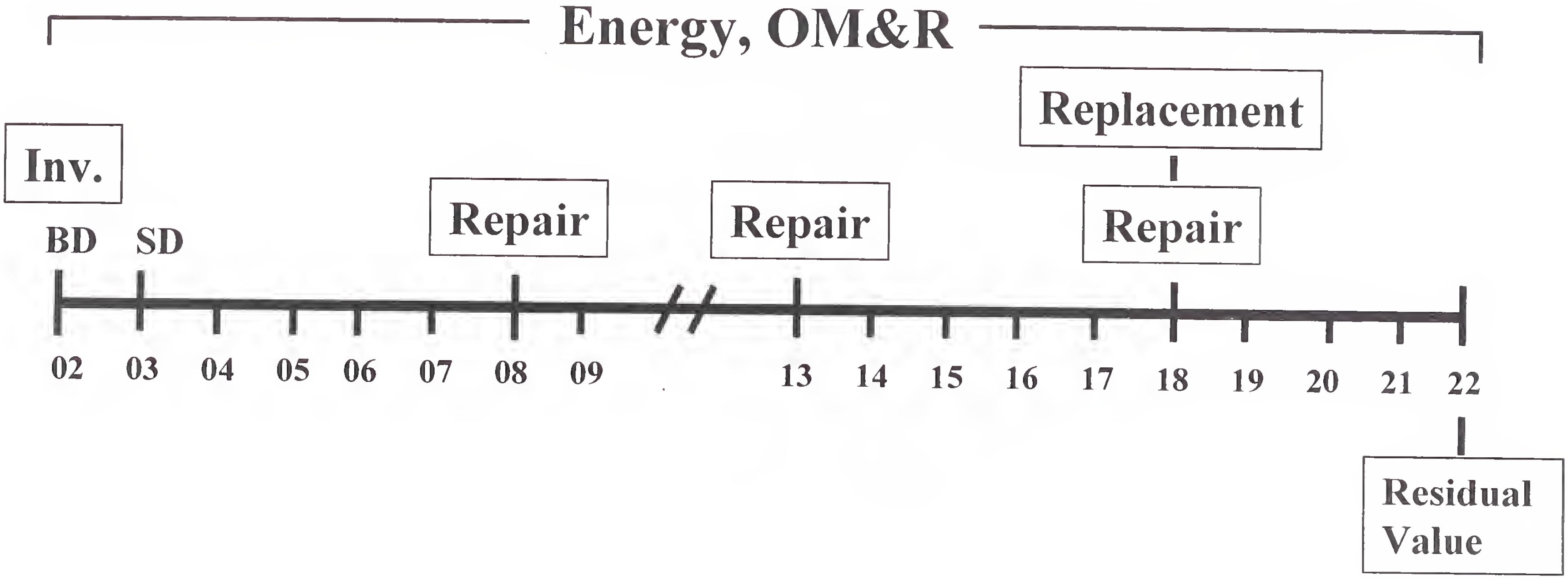
Alt. 2:
DX Split System AC

Initial cost:	$210,000
Energy consumption:	120,330 kWh/yr
Energy price:	$0.08711/kWh, industrial
Ann.-recurr. OM&R costs:	$530
Non-ann.rec. OM&R costs:	$6,300 in yrs. 5, 10, 15 after service date
Capital replacement cost:	$31,130 in year 15 after service date Useful Life: 15 years Residual Value Factor: 67%
Expected system life:	20 years

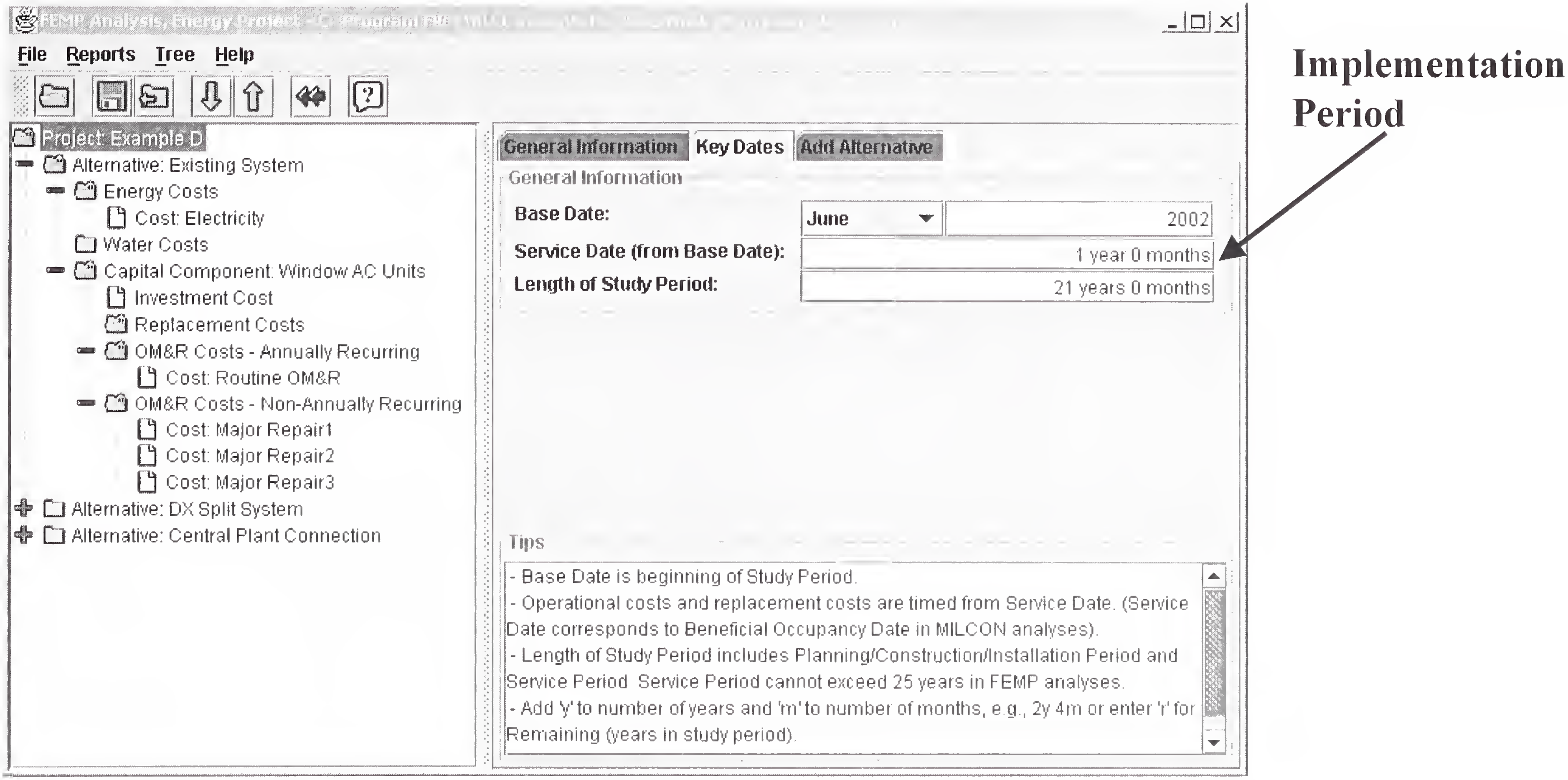
Alt. 3: Central Plant Connection

Initial cost:	$275,000
Energy consumption:	112,000 kWh/yr
Energy price:	$0.08711/kWh, industrial
Ann.-recurr. OM&R costs:	$126
Non-ann.rec. OM&R costs:	$950 in yrs 6, 12, 18 after service date
Expected system life:	20 years

Alt. 2: DX Split System Cash Flow Diagram

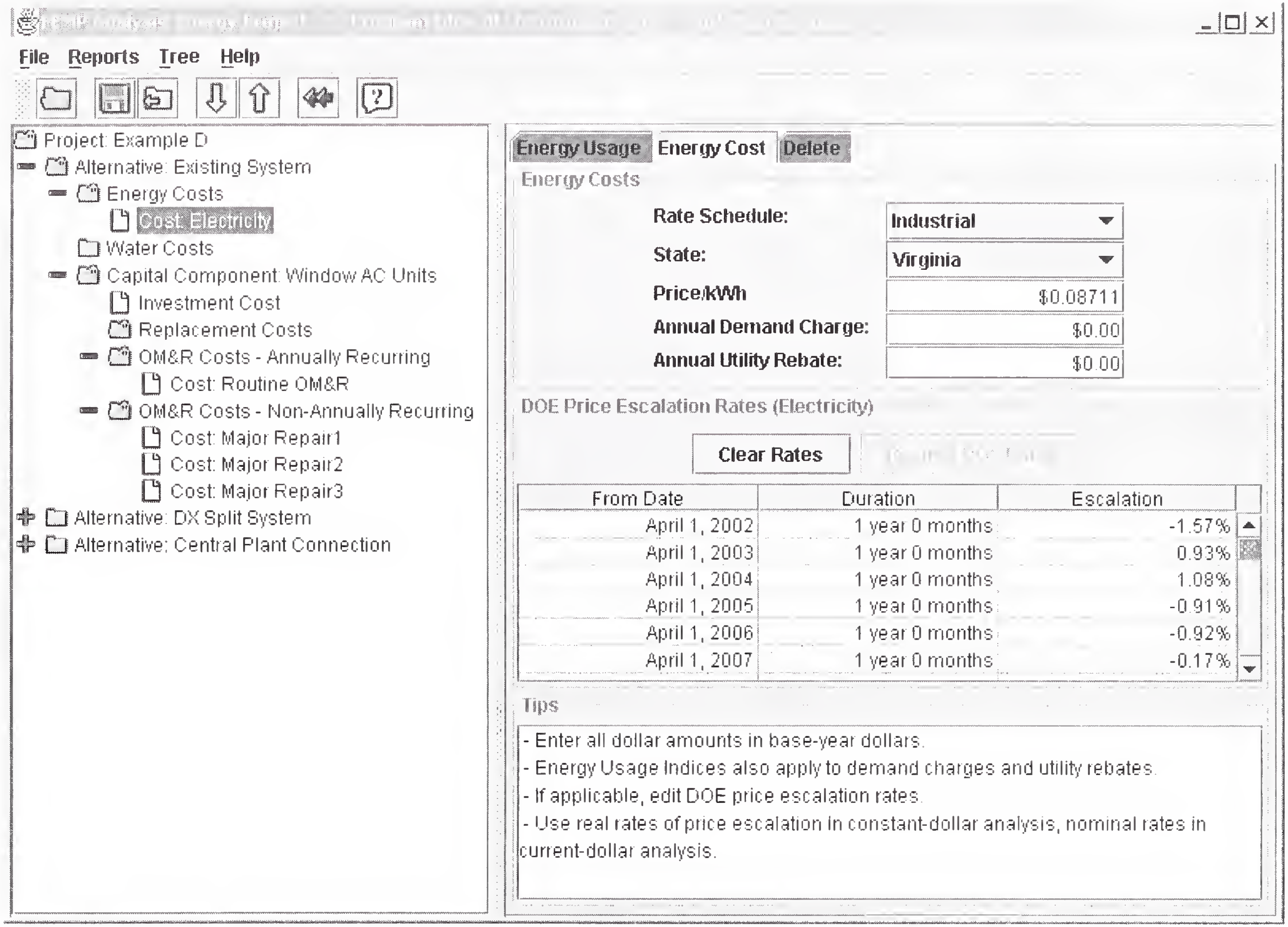


Key Dates

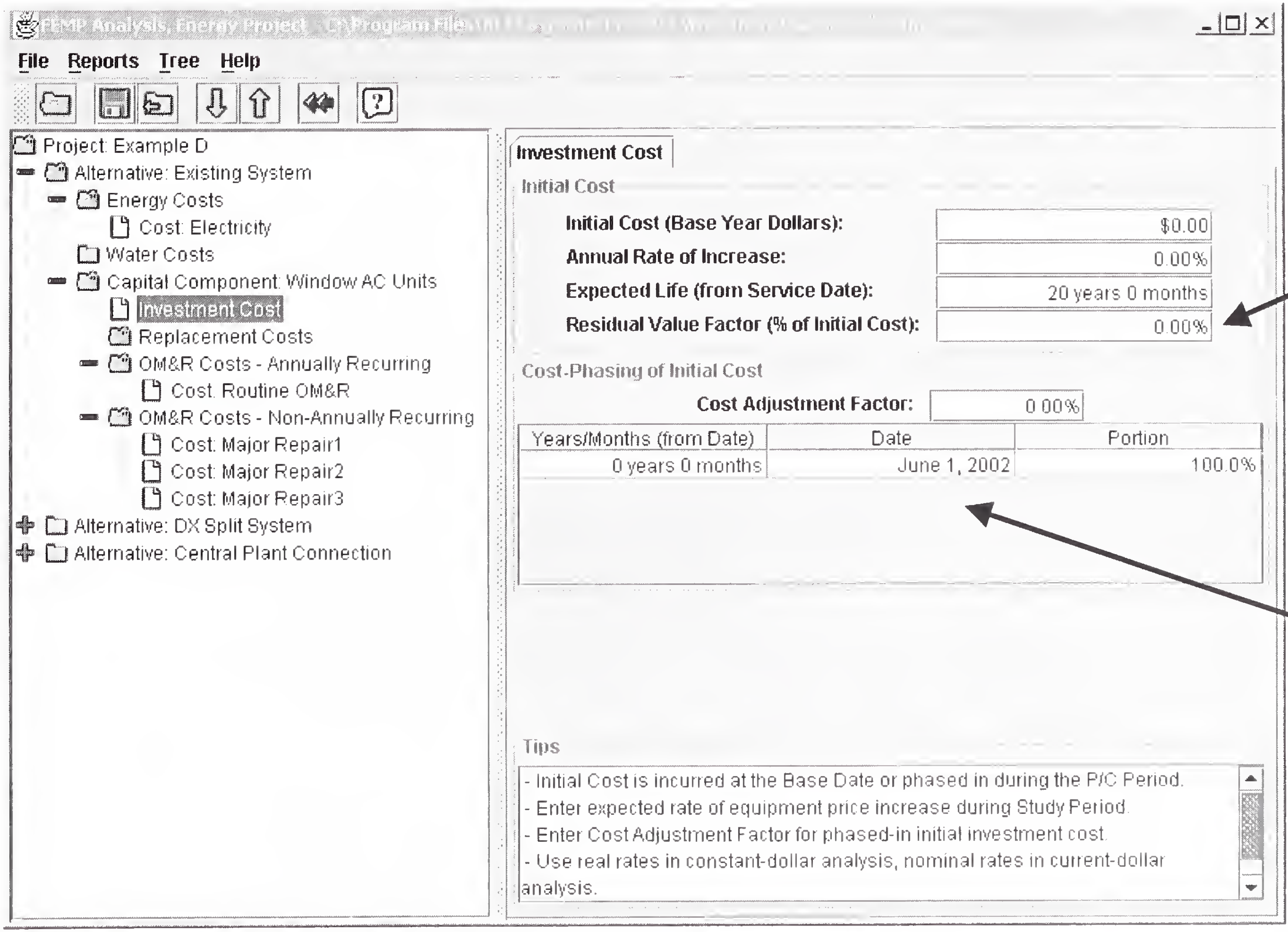


File Reports Tree Help
Project: Example D
Alternative: Existing System
Energy Costs
Cost: Electricity
Water Costs
Capital Component: Window AC Units
Investment Cost
Replacement Costs
OM&R Costs - Annually Recurring
Cost: Routine OM&R
OM&R Costs - Non-Annually Recurring
Cost: Major Repair1
Cost: Major Repair2
Cost: Major Repair3
Alternative: DX Split System
Alternative: Central Plant Connection
General Information
Key Dates
Add Alternative
General Information
Base Date:
June
2002
Service Date (from Base Date):
1 year 0 months
Length of Study Period:
21 years 0 months
Tips
- Base Date is beginning of Study Period.
- Operational costs and replacement costs are timed from Service Date. (Service Date corresponds to Beneficial Occupancy Date in MILCON analyses).
- Length of Study Period includes Planning/Construction/Installation Period and Service Period. Service Period cannot exceed 25 years in FEMP analyses.
- Add 'y' to number of years and 'm' to number of months, e.g., 2y 4m or enter 'r' for Remaining (years in study period).
Implementation Period

Energy Costs



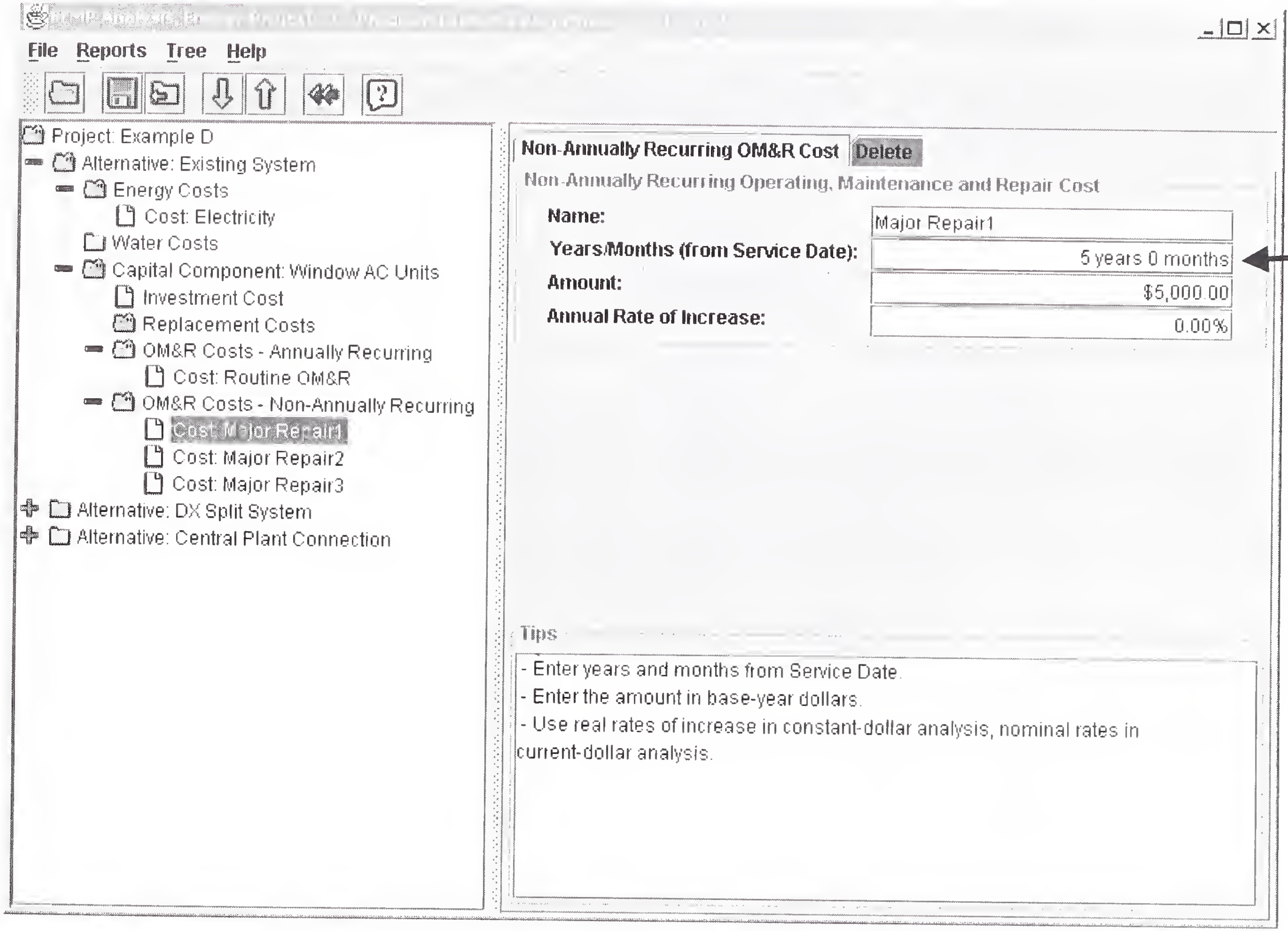
Investment Costs



No residual value

Investment cost incurred at Base Date

OM&R Costs



NAR repairs in yrs. 5,10,15

Lowest Report

File

NIST BLCC 5.1-02: Lowest LCC

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Examples\Example D.xml
Date of Study:	Fri May 24 14:43:53 EDT 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Example D
Project Location:	Virginia
Analyst:	SKF
Comment:	Provide economical and effective air conditioning for the family housing office at the Dahlgren, VA Naval Station.
Base Date:	June 1, 2002
Service Date:	June 1, 2003
Study Period:	21 years 0 months (June 1, 2002 through May 31, 2023)
Discount Rate:	3.2%
Discounting Convention:	Mid-Year

Lowest LCC

Comparative Present-Value Costs of Alternatives
(Shown in Ascending Order of Initial Cost, * = Lowest LCC)

Alternative	Initial Cost (PV)	Life Cycle Cost (PV)
Existing System	$0	$386,616 *
DX Split System	$210,000	$390,041
Central Plant Connection	$275,000	$419,184

Lowest LCC
Existing System

Existing System and DX SS

File

Comparison of Present-Value Costs

PV Life-Cycle Cost	EX S Base Case	DX SS Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$0	$210,000	-$210,000
Future Costs:			
Energy Consumption Costs	$357,414	$150,904	$206,510
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$29,202	$21,096	$8,106
Capital Replacements	$0	$18,806	-$18,806
Residual Value at End of Study Period	$0	-$10,765	$10,765
Subtotal (for Future Cost Items)	$386,616	$180,041	$206,575
Total PV Life-Cycle Cost	$386,616	$390,041	-$3,425

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$214,616
- Increased Total Investment	$218,041
Net Savings	-$3,425

Total investment > savings

Existing System and CP Conn.

Comparative Analysis Report

File

Comparison of Present-Value Costs

PV Life-Cycle Cost	EX S Base Case	CPC Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$0	$275,000	-$275,000
Future Costs:			
Energy Consumption Costs	$357,414	$140,457	$216,957
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$29,202	$3,727	$25,475
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	$0	$0
Subtotal (for Future Cost Items)	$386,616	$144,184	$242,432
Total PV Life-Cycle Cost	$386,616	$419,184	-$32,568

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$242,432
- Increased Total Investment	$275,000
Net Savings	-$32,568

Total investment > savings

LCCs - Optional Replacement

For *optional* replacement of a functional system, *entire* investment cost must be supported by savings.

	Base Case Costs	Savings from Upgrades	
	Ex. System	DX SS	CPC
Investment	0	- $210,000	- $275,000
Replacement costs	-	- 18,806	-
Residual Value	-	10,765	-
Total Inv. Costs		-$218,041	-$275,000
PV energy costs	$357,414	206,510	216,957
PV OM&R costs	29,202	8,106	25,475
Total Operat'l Costs	$386,616	$214,616	$242,432
Net Savings	-	-$ 3,452	-$ 32,568

DX Split System and Central Plant Conn.

Comparative Analysis Report

File

Comparison of Present-Value Costs

PV Life-Cycle Cost	DX SS Base Case	CPC Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$210,000	$275,000	-$65,000
Future Costs:			
Energy Consumption Costs	$150,904	$140,457	$10,447
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$21,096	$3,727	$17,370
Capital Replacements	$18,806	$0	$18,806
Residual Value at End of Study Period	-$10,765	$0	-$10,765
Subtotal (for Future Cost Items)	$180,041	$144,184	$35,857
Total PV Life-Cycle Cost	$390,041	$419,184	-$29,143

Incremental investment costs

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$27,816
- Increased Total Investment	$56,959
Net Savings	-$29,143

LCCs - Mandatory Replacement

For *new* system or *mandatory* replacement of an existing system, *incremental* investment cost must be supported by savings.

	Costs		Savings
	DX SS	CPC	from alternative
Investment	$210,000	$275,000	-$ 65,000
Replacement costs	18,806	-	18,806
Residual Value	-10,765	-	- 10,765
Total Inv. Costs	$218,041	$275,000	- $56,959
PV energy costs	150,904	140,457	10,447
PV OM&R costs	21,096	3,727	17,370
Total Operat'l Costs	$172,000	$144,184	$ 27,817
Net Savings	-		-$ 29,142

LCCs of AC Systems (cont.)

Analysis results:

- **If replacement is optional, Existing System has lowest LCC.**
- **If replacement is mandatory, DX Split System has lowest LCC.**
- **Central Plant Connection is not cost effective in either case.**

Other considerations:

- **Outcome may be changed by**
  - **Change in energy prices, investment or OM&R costs.**
  - **Change in heating and cooling requirements, timing, and other factors.**

Evaluate other option:

- **Postpone Central Plant Connection.**

Sensitivity Analysis

Repeat economic evaluation with one or more input values changed.

- **Determine**
  - **which input values are uncertain.**
  - **which input values are critical.**
- **Evaluate**
  - **effect of changes on LCC, NS, or any other measure of economic evaluation.**

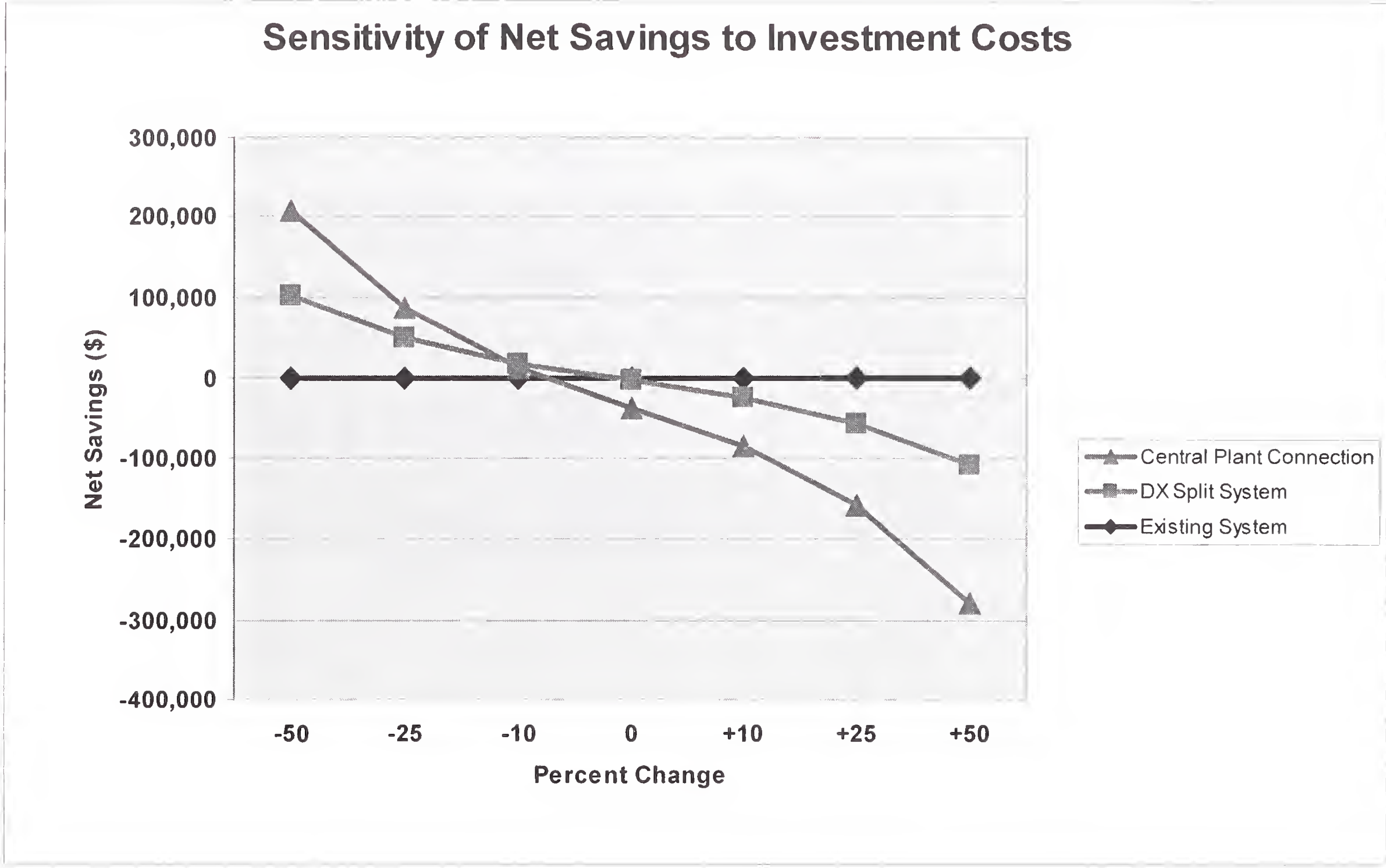
Sensitivity Analysis (cont.)

Identify critical inputs for DX Split System

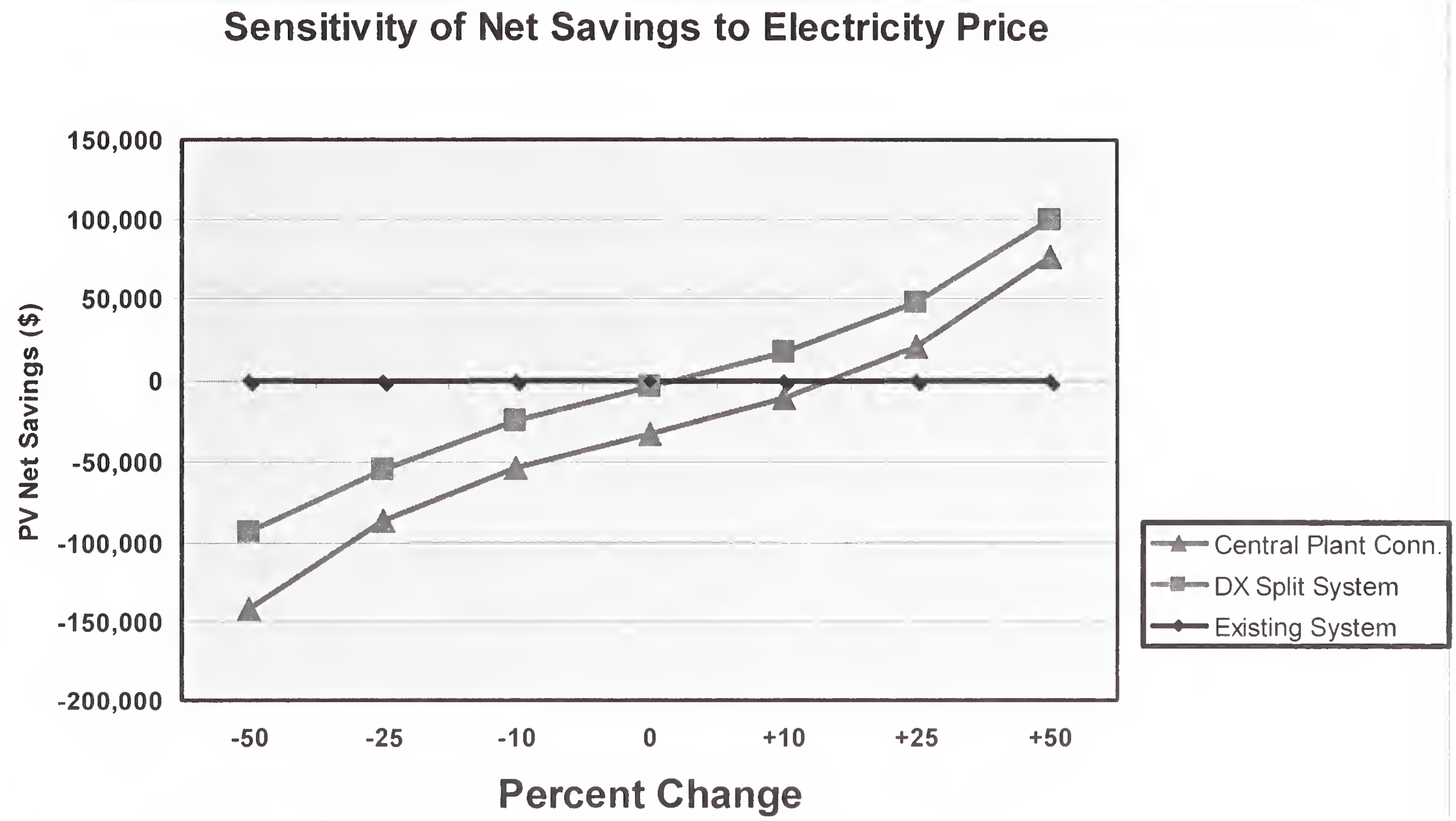
Uncertain Input	10% Increase	Change in LCC in $	Change in LCC in %	
Energy price/kWh	$0.0958	$15,089	3.9%	*
Investment cost	231,000	21,000	5.4%	*
AR OM&R cost	583	762	0.2%	
NAR OM&R cost	6,930	1,348	0.3%	

**Input values with highest impact on LCC.*

Sensitivity Analysis (cont.)



Sensitivity Analysis (cont.)



Exercise D

Economic Evaluation of Air Conditioning System

Refer to the problem statement at the beginning of Module D. Add Alternative 4 to BLCC5 project file Example D.xml.

Alternative 4: Postponed Central Plant Connection

Determine whether it would be cost effective to postpone the Central Plant Connection by three years rather than to install the DX Split System now.

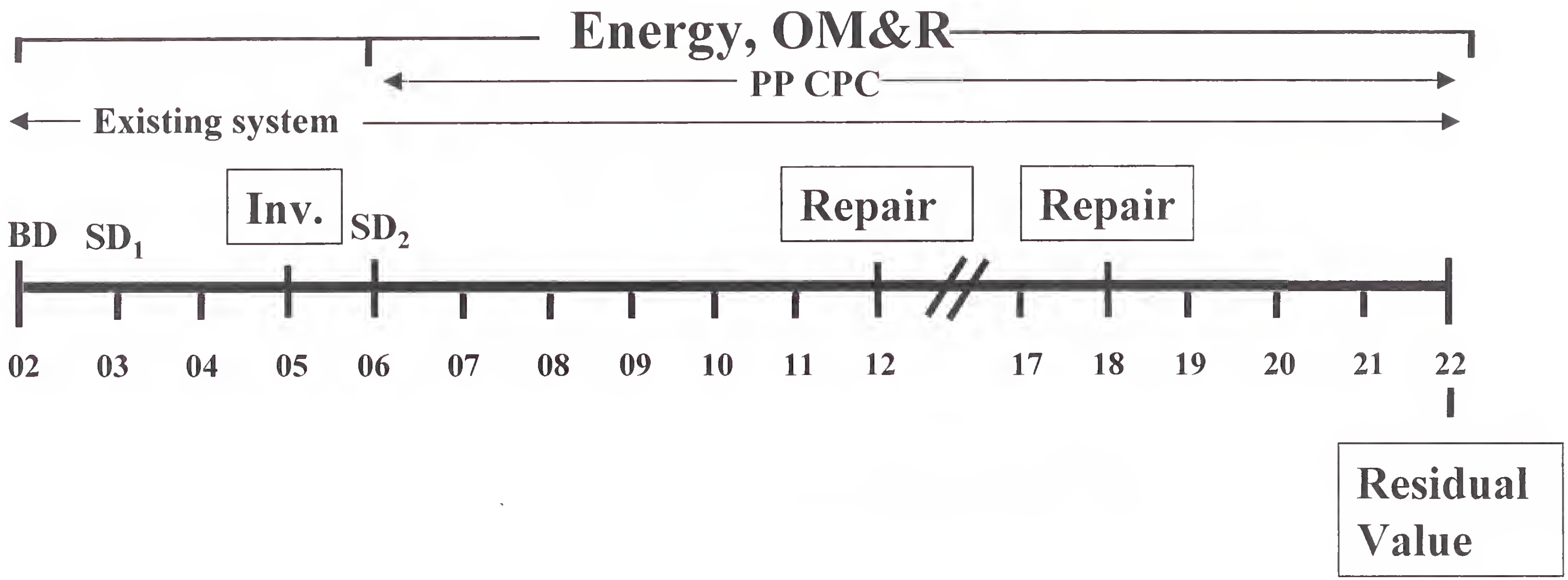
- Use the same inputs as above for Central Plant Connection, except for investment costs, which would be lower by 20%.
- Postpone Service Date by three years.
- Use cost phasing feature in BLCC5 to enter initial investment cost with a 0% rate of increase.
- Enter residual value factor for a period of three years (3/20 years = 15%).
- Use indexing feature to postpone occurrence of energy and OM&R costs.
- Include in analysis the energy costs and OM&R costs of the existing system for the three-year delay.

Exercise D: Postponed Central Plant Connection

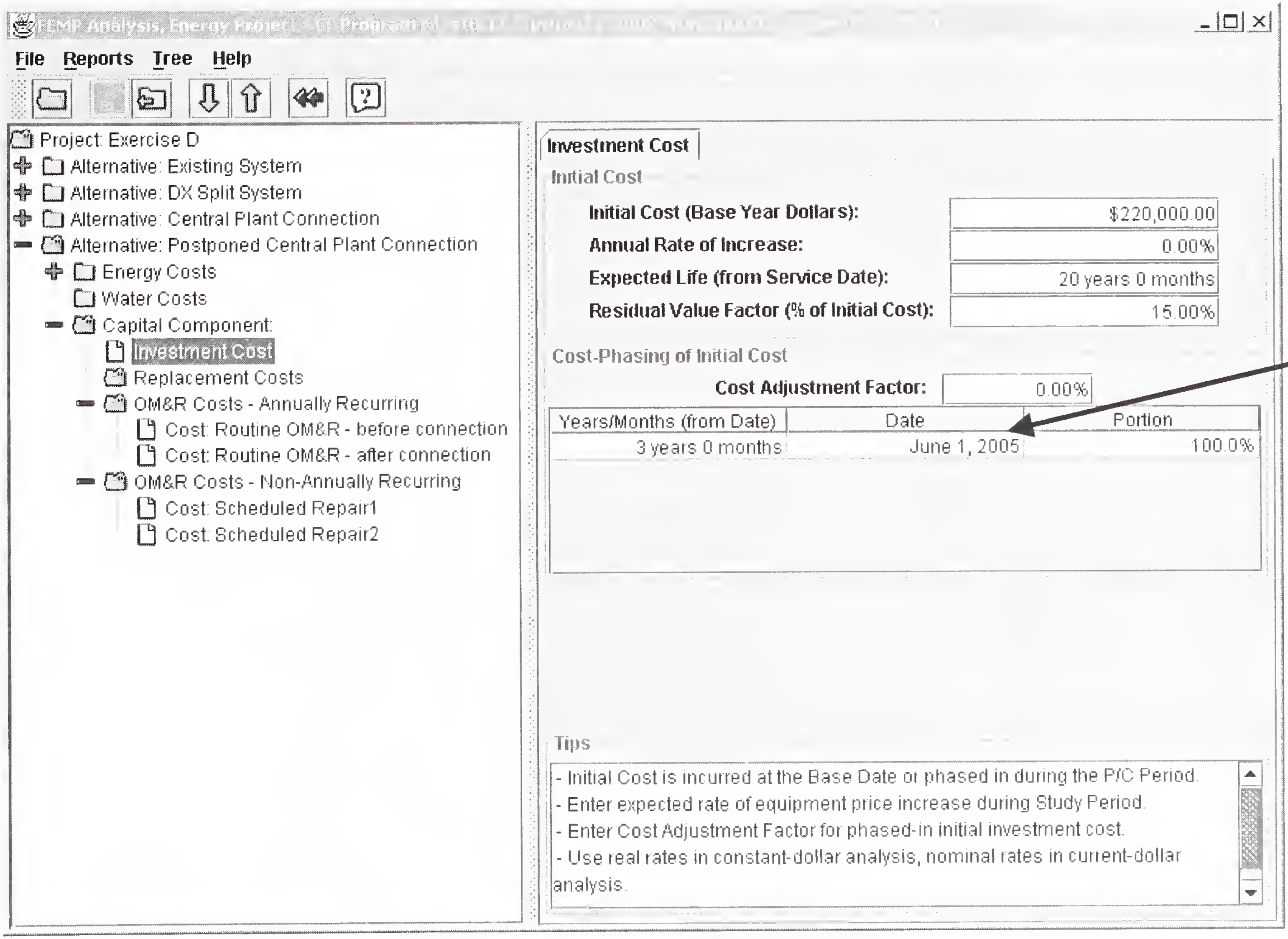
Postpone CP Connection by three years

- Reduce initial investment cost by 20%
- Use cost phasing of initial investment cost
- Use residual value factor of 15%
- Use indexing to postpone energy and OM&R costs
- Include energy costs and OM&R costs of the existing system for the three-year delay

PP CP Connection
Cash Flow Diagram

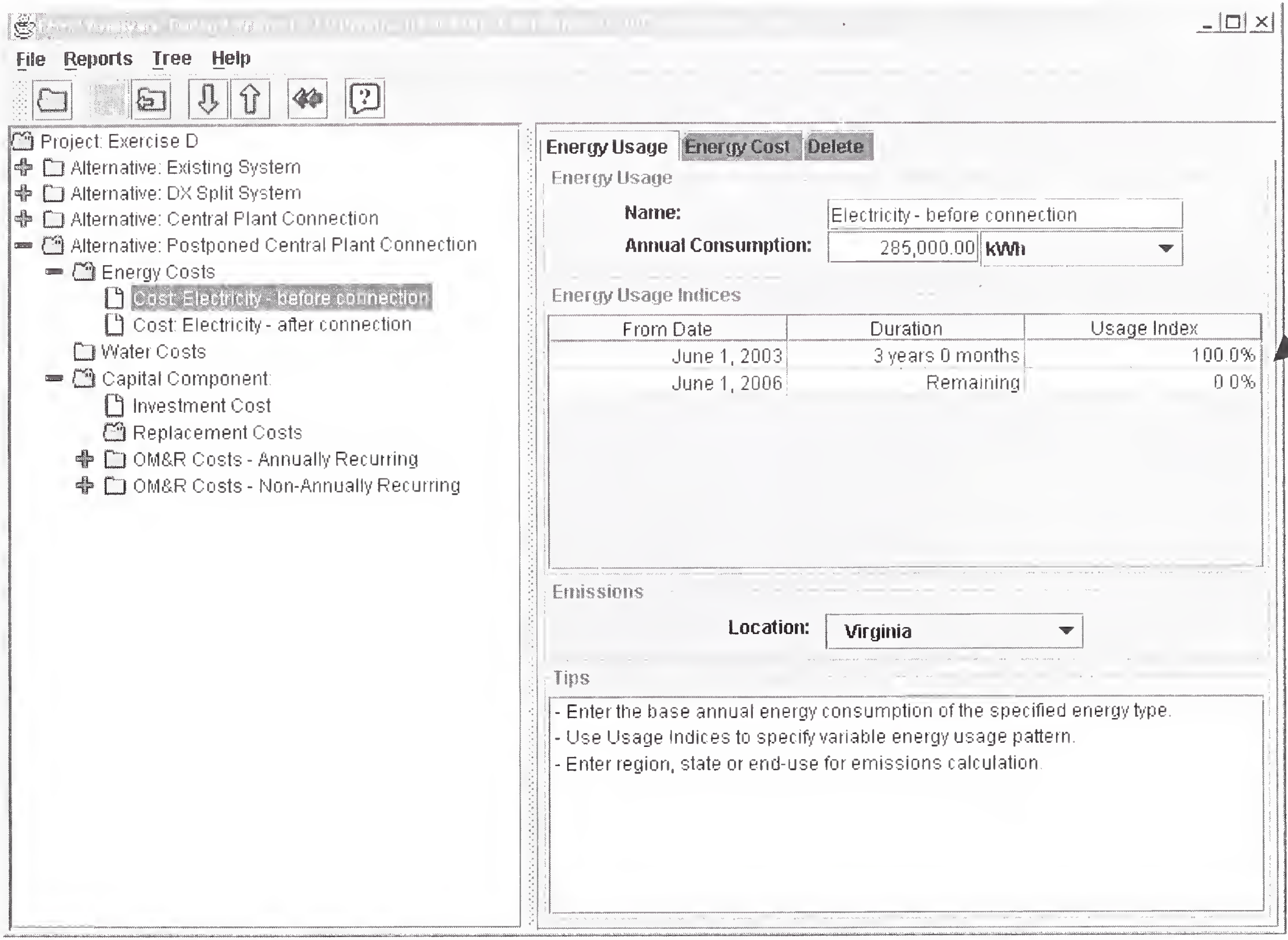


Cost Phasing of Initial Investment



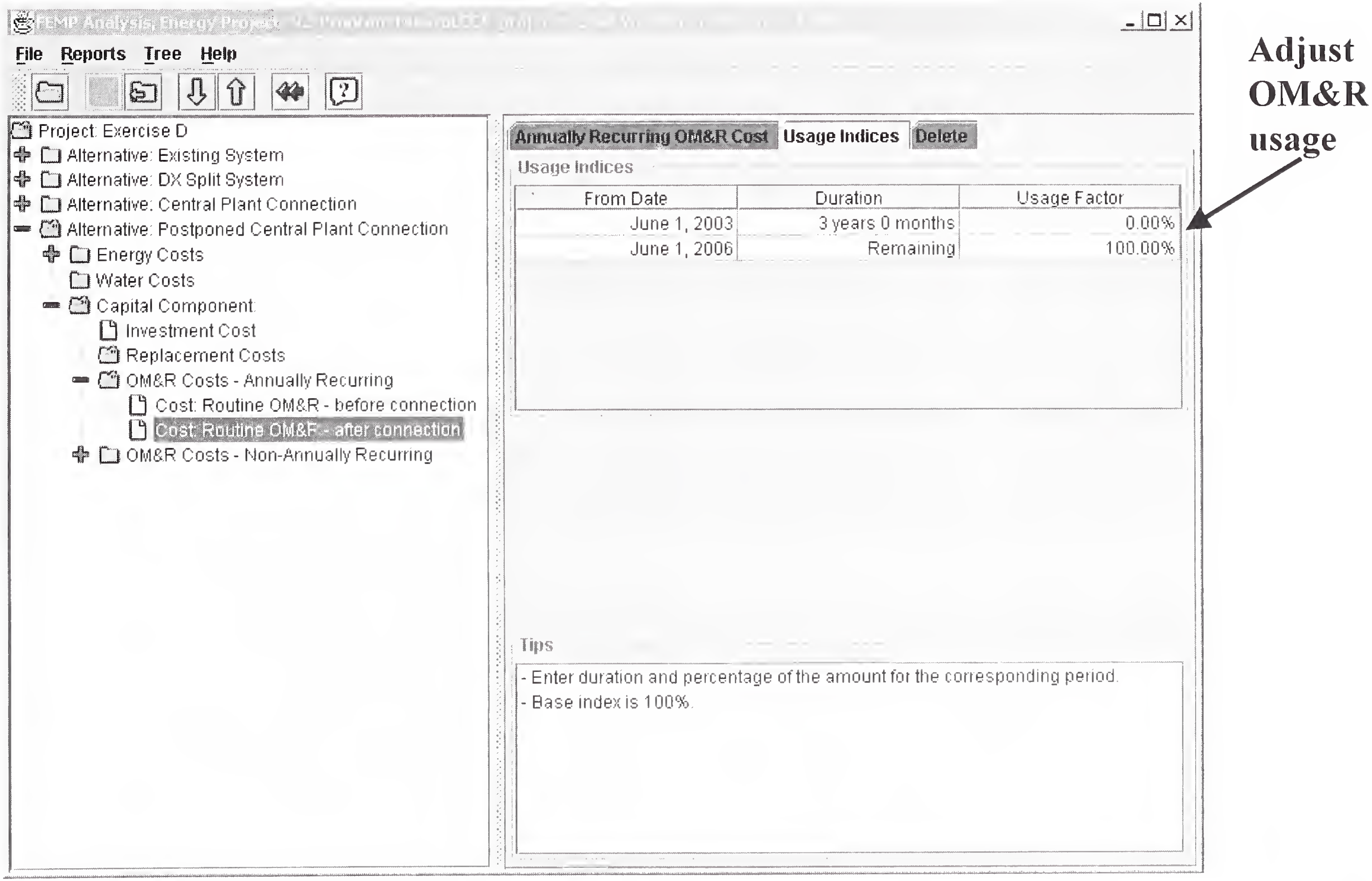
Postpone Initial Investment Cost by three years

Indexing of Energy Usage



Adjust energy usage

Indexing of OM&R Costs



File

NIST BLCC 5.1-02: Lowest LCC

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise D.xml
Date of Study:	Thu Jun 06 07:51:02 EDT 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Exercise D
Project Location:	Virginia
Analyst:	SKF
Comment:	Provide economical and effective air conditioning for the family housing office at the Dahlgren, VA Naval Station.
Base Date:	June 1, 2002
Service Date:	June 1, 2003
Study Period:	21 years 0 months (June 1, 2002 through May 31, 2023)
Discount Rate:	3.2%
Discounting Convention:	Mid-Year

Lowest LCC

Comparative Present-Value Costs of Alternatives

(Shown in Ascending Order of Initial Cost, * = Lowest LCC)

Alternative	Initial Cost (PV)	Life Cycle Cost (PV)
Existing System	$0	$386,616
Postponed Central Plant Connection	$200,159	$371,125*
DX Split System	$210,000	$390,041
Central Plant Connection	$275,000	$419,184

Lowest LCC:
Postp. Centr. Plant Conn.

DX SS and Postponed CPC

Comparative Analysis Report

File

Comparison of Present-Value Costs

PV Life-Cycle Cost

	DX SS Base Case	PP CPC Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$210,000	$200,159	$9,841
Future Costs:			
Energy Consumption Costs	$150,904	$182,211	-$31,307
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$21,096	$5,789	$15,307
Capital Replacements	$18,806	$0	$18,806
Residual Value at End of Study Period	-$10,765	-$17,033	$6,268
Subtotal (for Future Cost Items)	$180,041	$170,967	$9,075
Total PV Life-Cycle Cost	$390,041	$371,125	$18,916

Net Savings from Alternative Compared with Base Case

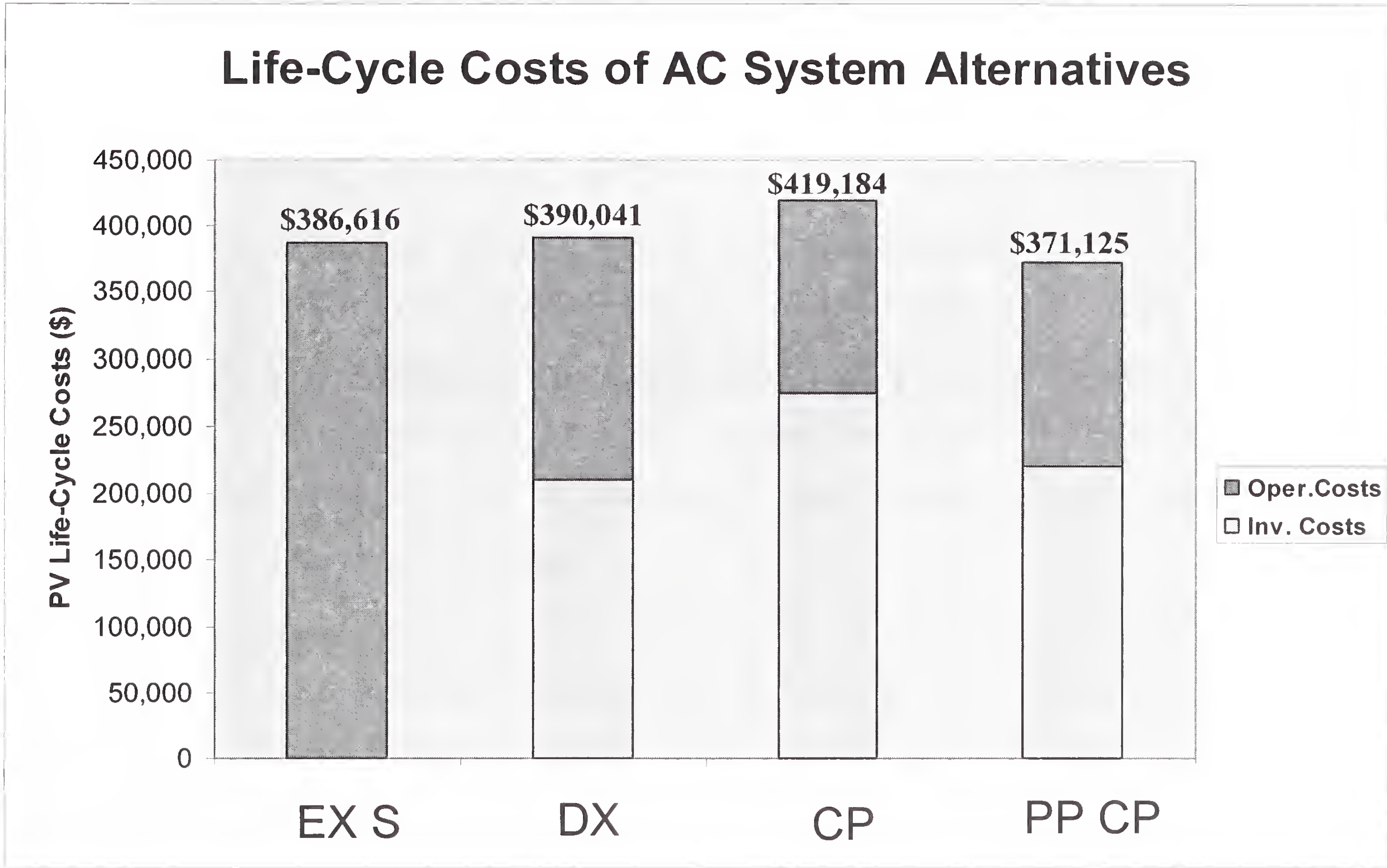
PV of Non-Investment Savings	-$15,999
- Increased Total Investment	-$34,915
Net Savings	$18,916

Positive Net Savings

Exercise D:
Summary of LCC Results

	EX S	DX SS	CP	PP CP
Investment cost	$ 0	$210,000	$275,000	$200,159
Replacement costs	0	18,806	0	0
Residual value	0	- 10,765	0	- 17,033
Energy costs	357,414	150,904	140,457	182,211
AR OM&R costs	18,507	7,620	1,812	4,521
NAR OM&R costs	10,695	13,476	1,915	1,267
Total PV LCC	$386,616	$390,041	$419,184	$371,125

Comparison of LCC Costs



Summary of Analysis Results

- Cost-effectiveness selection depends on circumstances and timing.
- Other considerations:
  - Postponed CP Connection has lower LCC but higher life-cycle energy consumption and emissions than immediate installation of DX Split System.
  - LCC for postponed CP Connection does not include productivity losses for period of delay.
- Conclusion:
  - Lowest LCC is one among many criteria that affect decision making.

Solution to Exercise D

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise D.xml
Date of Study:	Thu Jun 06 15:08:09 EDT 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Exercise D
Project Location:	Virginia
Analyst:	SKF
Comment:	Provide economical and effective air conditioning for the family housing office at the Dahlgren, VA Naval Station.
Base Date:	June 1, 2002
Service Date:	June 1, 2003
Study Period:	21 years 0 months (June 1, 2002 through May 31, 2023)
Discount Rate:	3.2%
Discounting Convention:	Mid-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

Alternative: Existing System

Comment: Functional for 20 years with current maintenance and repair schedule

Energy: Electricity

Annual Consumption:	285,000.0 kWh
Price per Unit:	$0.08711
Demand Charge:	$0
Utility Rebate:	$0
Location:	Virginia
Rate Schedule:	Industrial
State:	Virginia

Usage Indices

From Date	Duration	Usage Index
June 1, 2003	**Remaining**	100%

Component: Window AC Units

Initial Investment

Initial Cost (base-year $):	$0
Annual Rate of Increase:	0%
Expected Asset Life:	20 years 0 months

Residual Value Factor: 0%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Routine Recurring OM&R: Routine OM&R

Amount: $1,050
Annual Rate of Increase: 2.0%

Usage Indices

From Date	Duration	Factor
June 1, 2003	Remaining	100%

Non-Recurring OM&R: Major Repair1

Years/Months: 5 years 0 months
Amount: $5,000
Annual Rate of Increase: 0%

Non-Recurring OM&R: Major Repair2

Years/Months: 10 years 0 months
Amount: $5,000
Annual Rate of Increase: 0%

Non-Recurring OM&R: Major Repair3

Years/Months: 15 years 0 months
Amount: $5,000
Annual Rate of Increase: 0%

Alternative: DX Split System

Comment: Install split-system central AC unit, with new air distribution system

Energy: Electricity

Annual Consumption: 120,330.0 kWh
Price per Unit: $0.08711
Demand Charge: $0
Utility Rebate: $0
Location: Virginia
Rate Schedule: Industrial
State: Virginia

Usage Indices

From Date	Duration	Usage Index
June 1, 2003	Remaining	100%

Component: AC System and Air Distribution

Initial Investment

Initial Cost (base-year $):	$210,000
Annual Rate of Increase:	0%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Replacement: Compressor/Condens

Years/Months:	15 years 0 months
Amount:	$31,130
Annual Rate Of Increase:	0%
Expected Asset Life:	15 years 0 months
Residual Value Factor:	67%

Routine Recurring OM&R: Routine OM&R

Amount:	$530
Annual Rate of Increase:	0%

Usage Indices

From Date	Duration	Factor
June 1, 2003	Remaining	100%

Non-Recurring OM&R: Scheduled Repair1

Years/Months:	5 years 0 months
Amount:	$6,300
Annual Rate of Increase:	0%

Non-Recurring OM&R: Scheduled Repair2

Years/Months:	10 years 0 months
Amount:	$6,300
Annual Rate of Increase:	0%

Non-Recurring OM&R: Scheduled Repair3

Years/Months:	15 years 0 months
Amount:	$6,300
Annual Rate of Increase:	0%

Alternative: Central Plant Connection

Comment: Install piping network to connect office building to central chilled water plant

Energy: Electricity

Annual Consumption:	112,000.0 kWh
Price per Unit:	$0.08711
Demand Charge:	$0
Utility Rebate:	$0
Location:	Virginia
Rate Schedule:	Industrial
State:	Virginia

Usage Indices

From Date	Duration	Usage Index
June 1, 2003	Remaining	100%

Component: Piping Network and Air Distribution

Initial Investment

Initial Cost (base-year $):	$275,000
Annual Rate of Increase:	0%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Routine Recurring OM&R: Routine OM&R

Amount:	$126
Annual Rate of Increase:	0%

Usage Indices

From Date	Duration	Factor
June 1, 2003	Remaining	100%

Non-Recurring OM&R: Scheduled Repair1

Years/Months:	6 years 0 months
Amount:	$950
Annual Rate of Increase:	0%

Non-Recurring OM&R: Scheduled Repair2

Years/Months:	12 years 0 months
Amount:	$950
Annual Rate of Increase:	0%

Non-Recurring OM&R: Scheduled Repair3

Years/Months:	18 years 0 months
Amount:	$950
Annual Rate of Increase:	0%

Alternative: Postponed Central Plant Connection

Comment: Postpone installation of piping network to2005 to coincide with general overhaul of Central Plant. The AC system would become operational in 2005

Energy: Electricity - before connection

Annual Consumption:	285,000.0 kWh
Price per Unit:	$0.08711
Demand Charge:	$0
Utility Rebate:	$0
Location:	Virginia
Rate Schedule:	Industrial
State:	Virginia

Usage Indices

From Date	Duration	Usage Index
June 1, 2003	3 years 0 months	100%
June 1, 2006	Remaining	0%

Energy: Electricity - after connection

Annual Consumption:	112,000.0 kWh
Price per Unit:	$0.08711
Demand Charge:	$0
Utility Rebate:	$0
Location:	Virginia
Rate Schedule:	Industrial
State:	Virginia

Usage Indices

From Date	Duration	Usage Index
June 1, 2003	3 years 0 months	0%
June 1, 2006	Remaining	100%

Component: Initial Investment

Initial Cost (base-year $):	$220,000
Annual Rate of Increase:	0%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	15%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
3 years 0 months	June 1, 2005	100%

Routine Recurring OM&R: Routine OM&R - before connection

Amount: $1,050

Annual Rate of Increase: 2.0%

Usage Indices

From Date	Duration	Factor
June 1, 2003	3 years 0 months	100%
June 1, 2006	Remaining	0%

Routine Recurring OM&R: Routine OM&R - after connection

Amount: $126

Annual Rate of Increase: 0%

Usage Indices

From Date	Duration	Factor
June 1, 2003	3 years 0 months	0%
June 1, 2006	Remaining	100%

Non-Recurring OM&R: Scheduled Repair1

Years/Months: 9 years 0 months

Amount: $950

Annual Rate of Increase: 0%

Non-Recurring OM&R: Scheduled Repair2

Years/Months: 15 years 0 months

Amount: $950

Annual Rate of Increase: 0%

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: DX Split System
Alternative: Postponed Central Plant Connection

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise D.xml
Date of Study:	Fri Jan 03 10:45:18 EST 2003
Project Name:	Exercise D
Project Location:	Virginia
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	SKF
Comment	Provide economical and effective air conditioning for the family housing office at the Dahlgren, VA Naval Station.
Base Date:	June 1, 2002
Service Date:	June 1, 2003
Study Period:	21 years 0 months(June 1, 2002 through May 31, 2023)
Discount Rate:	3.2%
Discounting Convention:	Mid-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$210,000	$200,159	$9,841
Future Costs:			
Energy Consumption Costs	$150,904	$182,211	-$31,307
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$21,096	$5,789	$15,307
Capital Replacements	$18,806	$0	$18,806
Residual Value at End of Study Period	-$10,765	-$17,033	$6,268
	------------	------------	------------
Subtotal (for Future Cost Items)	$180,041	$170,967	$9,075
	------------	------------	------------
Total PV Life-Cycle Cost	$390,041	$371,125	$18,916

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	-$15,999
- Increased Total Investment	-$34,915

Net Savings	$18,916

NOTE: Meaningful SIR, AIRR and Payback can not be computed unless incremental savings and total savings are both positive.

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption---- Savings	Life-Cycle Savings
Electricity	120,330.0 kWh	137,959.5 kWh	-17,629.5 kWh	-352,541.2 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption---- Savings	Life-Cycle Savings
Electricity	410.6 MBtu	470.7 MBtu	-60.2 MBtu	-1,202.9 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO_2	110,453.80 kg	126,627.62 kg	-16,173.82 kg	-323,432.16 kg
SO_2	236.63 kg	273.98 kg	-37.35 kg	-746.88 kg
NO_x	252.15 kg	289.07 kg	-36.92 kg	-738.35 kg
Total:				
CO_2	110,453.80 kg	126,627.62 kg	-16,173.82 kg	-323,432.16 kg
SO_2	236.63 kg	273.98 kg	-37.35 kg	-746.88 kg
NO_x	252.15 kg	289.07 kg	-36.92 kg	-738.35 kg

Module E

Replace Chiller or Purchase Chilled Water

Objectives: Upon completion of this module, you will know

- **how to compare LCCs of capital investments and outsourcing,**
- **when to include inflation estimates in federal LCCAs, and**
- **how to use BLCC to evaluate contracted costs that include inflation adjustments.**

Pros and Cons of Chiller Replacement versus Chilled Water Contract

- **Chiller replacement:**
  - High initial investment cost
  - Significant maintenance (building engineer needed on site)
  - Fixed output capacity
  - Scheduled shutdowns may be inconvenient or impractical
  - Performance degradation over time
  - Not subject to contract renewal negotiations -- less uncertainty

- **Chilled water contract:**
  - Flexible contract length
  - Low initial cost
  - Negligible maintenance
  - Flexible capacity
  - Higher reliability; no down time for maintenance
  - Metered output
  - Contract subject to renegotiation at expiration (uncertainty)

Requires Careful Analysis

Analysis of options <u>may</u> include

- **Expenses for**
  - **Capacity and energy**
  - **Either make-up water or unreturned chilled water**
  - **Low delta-T on chilled water**
  - **Labor, OM&R, other**
- **Price adjustments (escalation clauses) may be required for capacity and energy charges based on**
  - **Inflation (CPI)**
  - **Fuel combination used to drive the chillers**

Example E

Purchase Chiller

Versus

Purchase Chilled Water

Austin, Texas

Industrial rates

Base date of analysis is April, 2002

Example E
Chiller Replacement:

Investment costs:

- Initial cost = $350,000
- Residual value = 0

O M & R costs:

- Annual kWh cost (450,000 kWh @ $0.05/kWh) = $22,500
- Annual kW demand charge = $5,000
- Annual make-up water cost = $2,100
- Annual in-house labor = $10,000
- Annual service contract/supplies = $5,000
- Expected life = 20 years with refurbishment at end of year 10 (@ 40% of initial cost)

Energy and demand price change at DOE escalation rates.
All other costs escalate at rate of inflation.

Example E
Purchase Chilled Water

Investment costs:

- **Initial system modification = $10,000**
- **Residual value = 0**

O M & R costs:

- **Annual energy charge (390,000 @ $.07/ton hr.) = $27,300**
- **Annual kW demand charge (230 @ $13.00/ton x 12) = $35,880**
  - **230 ton load**
  - **390,000 ton hours estimated use**

Energy cost to escalate 50% on rate of natural gas price escalation and 50% on rate of electricity escalation.

Demand charge is fixed (no change).

Current-Dollar or Constant-Dollar Analysis?

- Use constant dollars when contract includes general inflation adjustment for all costs.

- Use current dollars when contract has different escalation rates for different costs.

Chiller Replacement – 20-Year Analysis

Current-dollar analysis using DOE nominal discount rate = 5.6% and inflation rate =2.3%.

	Cost at Base Date	Discount Factor[a]	Present Value
Initial cost	$350,000	1.000	$350,000
Annual electric cost	22,500	14.53[b]	326,925
Annual kW demand charge	5,000	14.53[b]	72,650
Annual make-up water	2,100	14.57	30,597
Annual in-house labor	10,000	14.57	145,700
Annual service contract	5,000	14.57	72,850
Scheduled refurbishment (year 10)	140,000	0.73	102,200
Residual value (year 20)	0	0.53	0
Total PV Cost			$1,100,922

[a] Discount factors calculated using Discount software.

[b] Based on DOE industrial electric price escalation rates for region 3 with 2.3% inflation.

Purchase Chilled Water – 20-Year Analysis

		Cost at Base Date	Discount Factor	Present Value
Initial system modification		$10,000	1.000	$10,000
Annual costs (20 years):				
Energy charge:				
(390,000 ton-hr@$0.07)	$27,300			
Amount subject to gas price adj.	50%=	13,650	17.35[a]	236,828
Amount subject to elec. price adj.	50%=	13,650	14.53[b]	198,335
Basic capacity charge (230 tons)		35,880	11.85	425,178
Total 20-year cost				$870,341

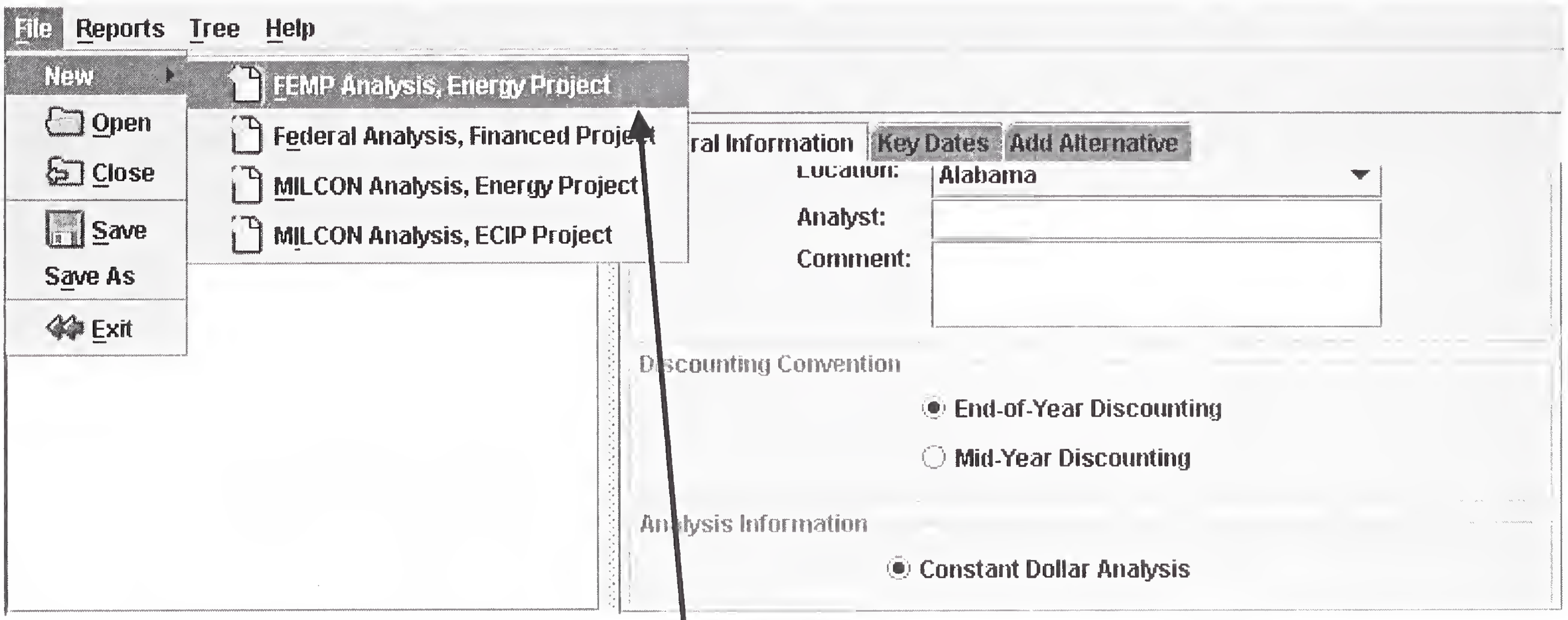
[a] Based on DOE industrial gas price escalation rates for Region 3 with 2.3% inflation.
[b] Based on DOE industrial electric price escalation rates for Region 3 with 2.3% inflation.

LCC Summary

20-Year Analysis	
PV 20-year chiller replacement cost	$1,100,922
PV 20-year chilled water contract cost **	870,341
Net Savings	$230,581

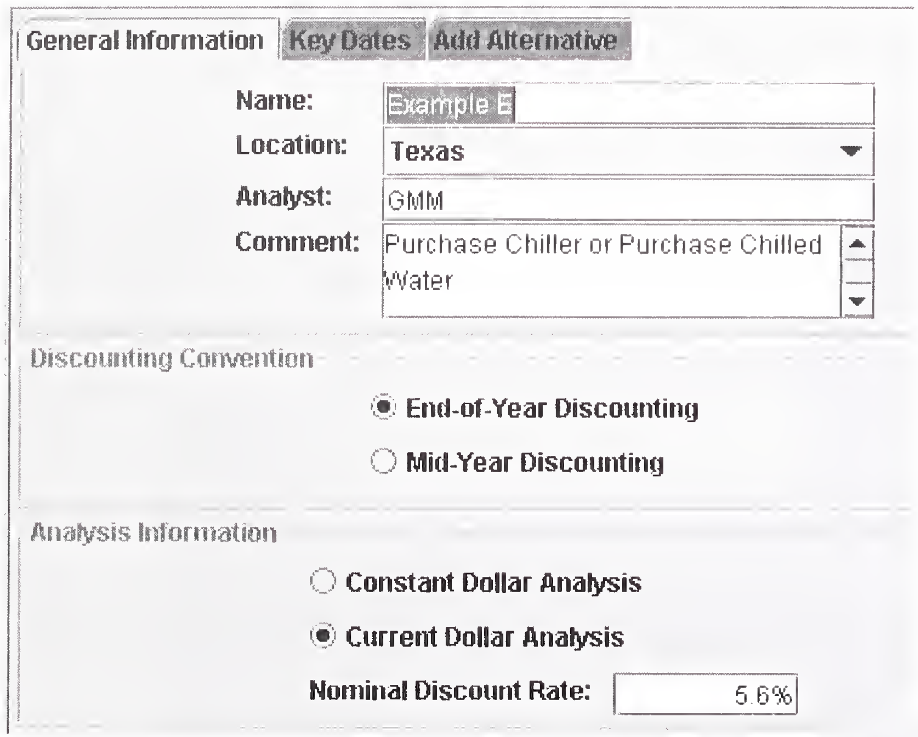
** Lowest life-cycle cost option

Starting BLCC 5 Analysis
Select Analysis Type



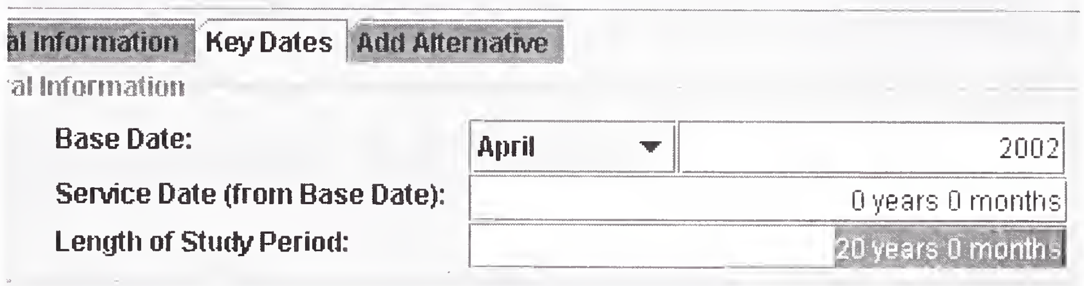
Select a **New** analysis using
FEMP Analysis, Energy Project

Set Project Information

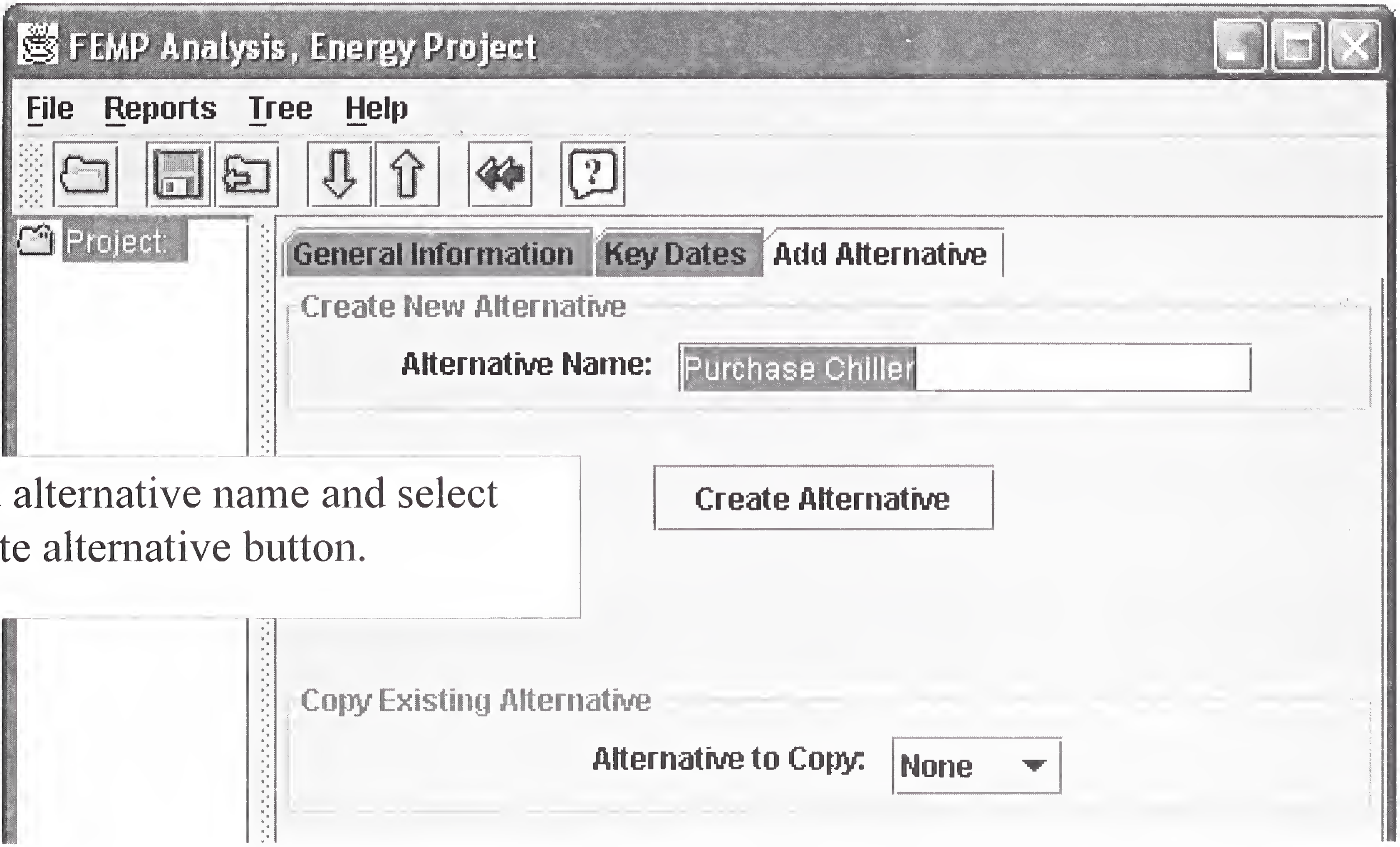


Enter project data including name, location, analyst, and comments; discounting convention; and choose constant or **current** dollars.

Enter key dates including base date, service date and study period.



Add First Altertive

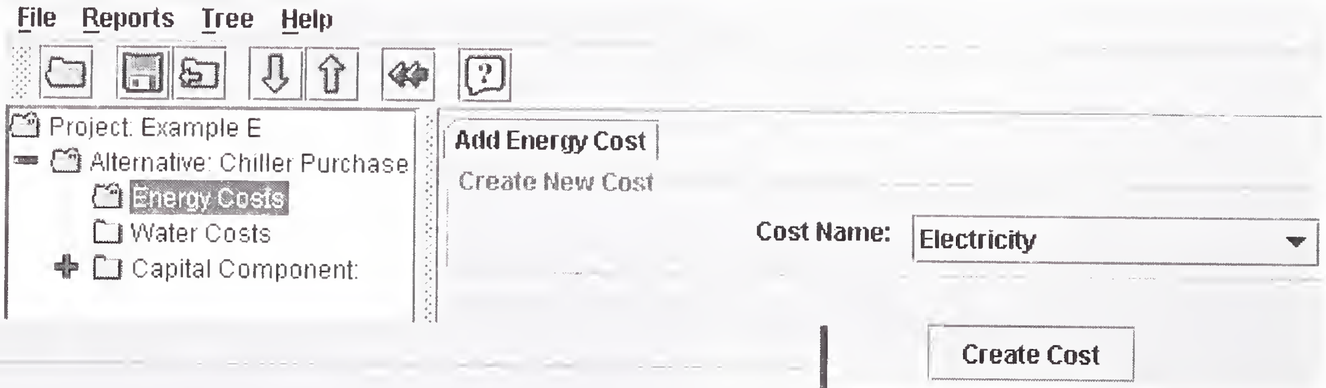


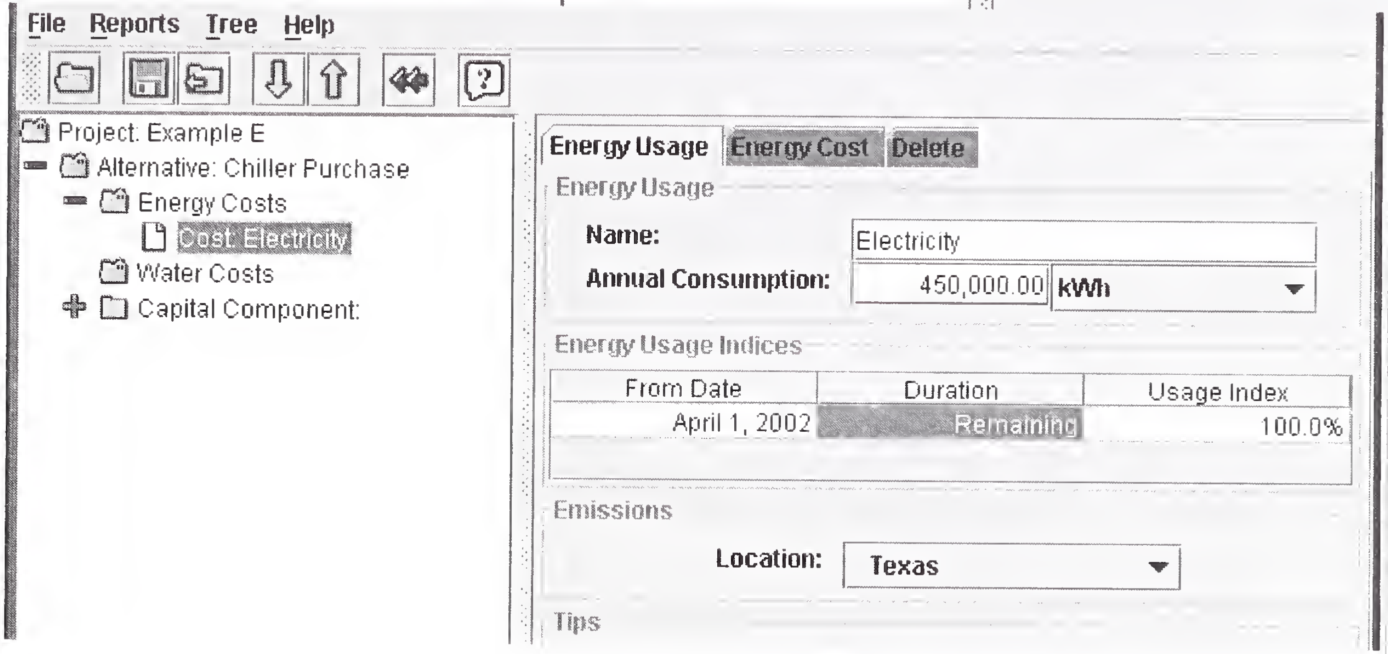
Add alternative name and select create alternative button.

Energy Usage Screen

Energy Type, Consumption, and Use Indices

Select energy type (Electricity) and press create cost button.

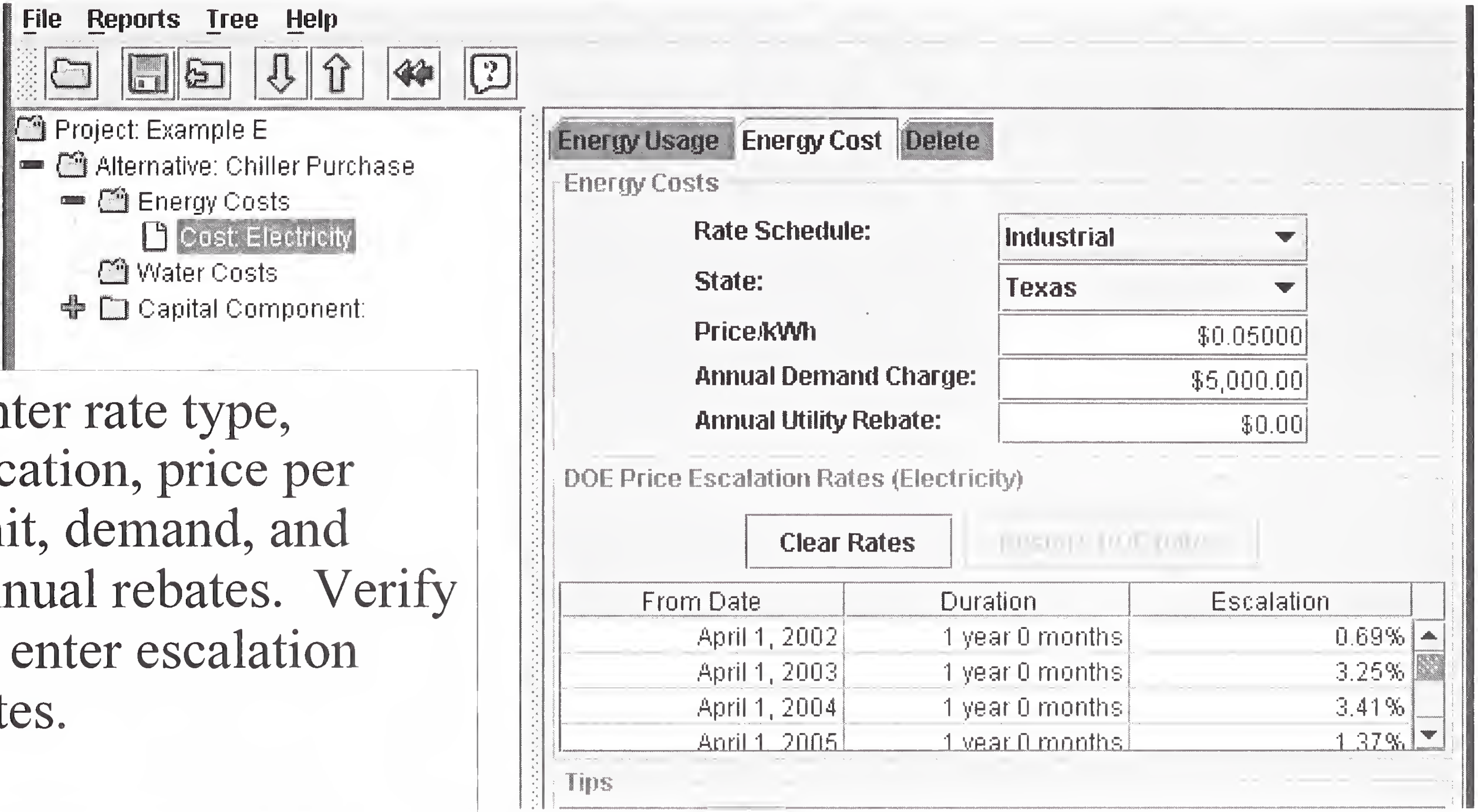




Enter annual consumption, units, and energy use indices. Enter location for emissions.

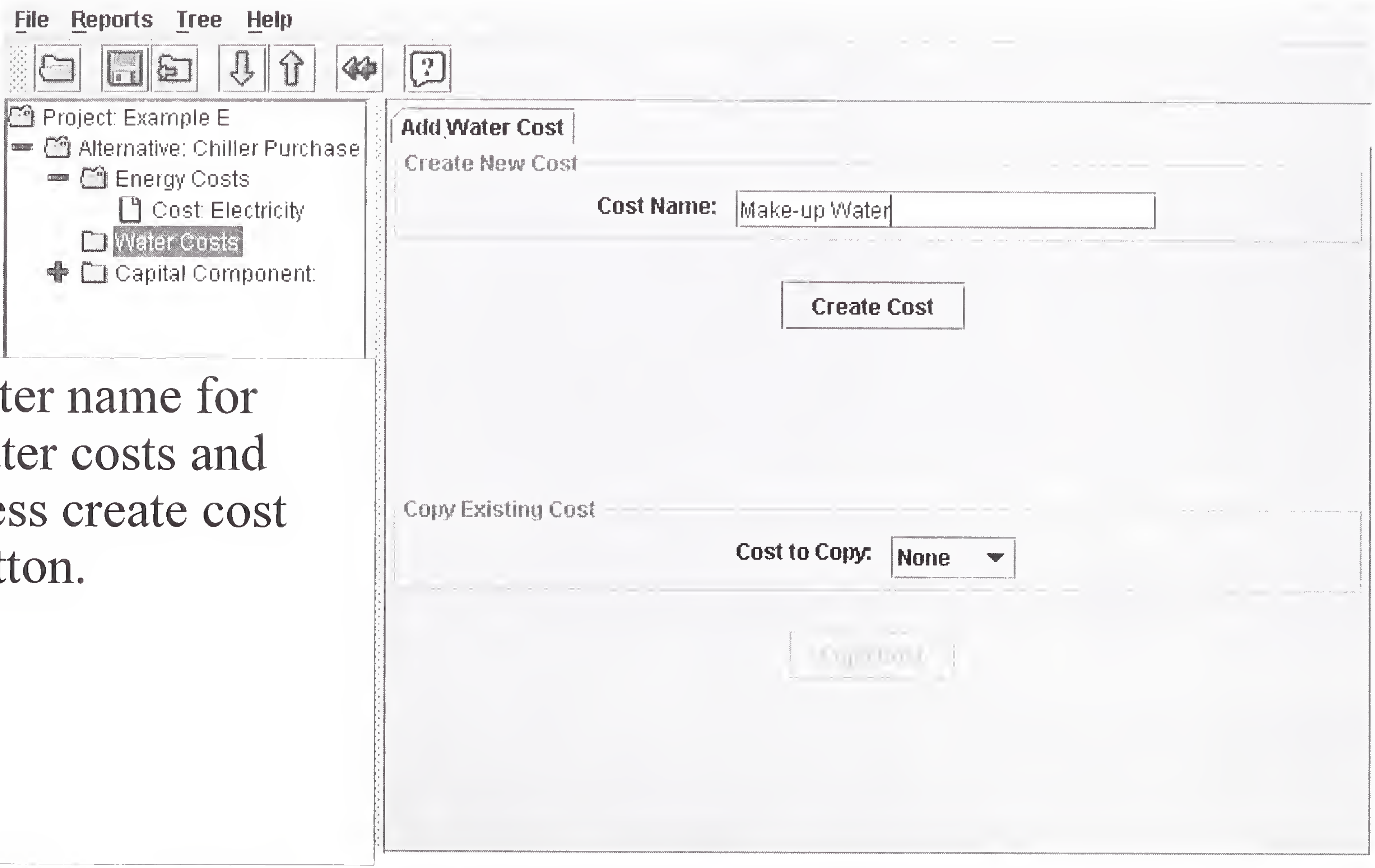
Energy Costs Screen

Energy and Demand Charges, Escalation Rates



Enter rate type, location, price per unit, demand, and annual rebates. Verify or enter escalation rates.

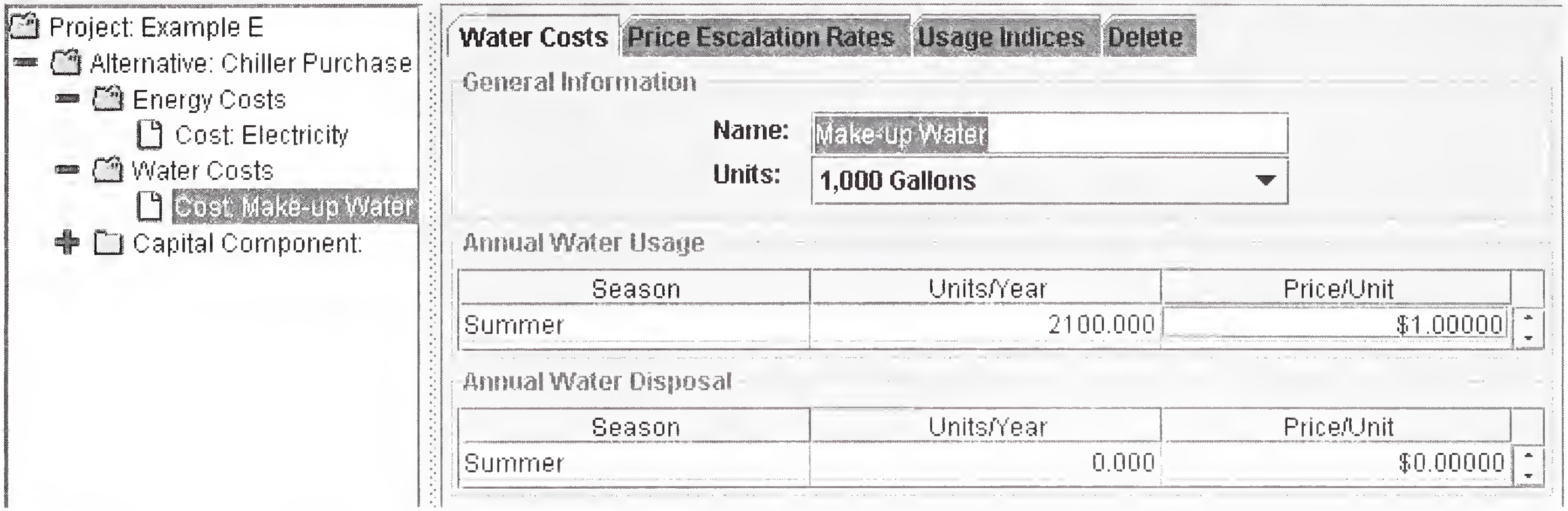
Add Water Cost Screen



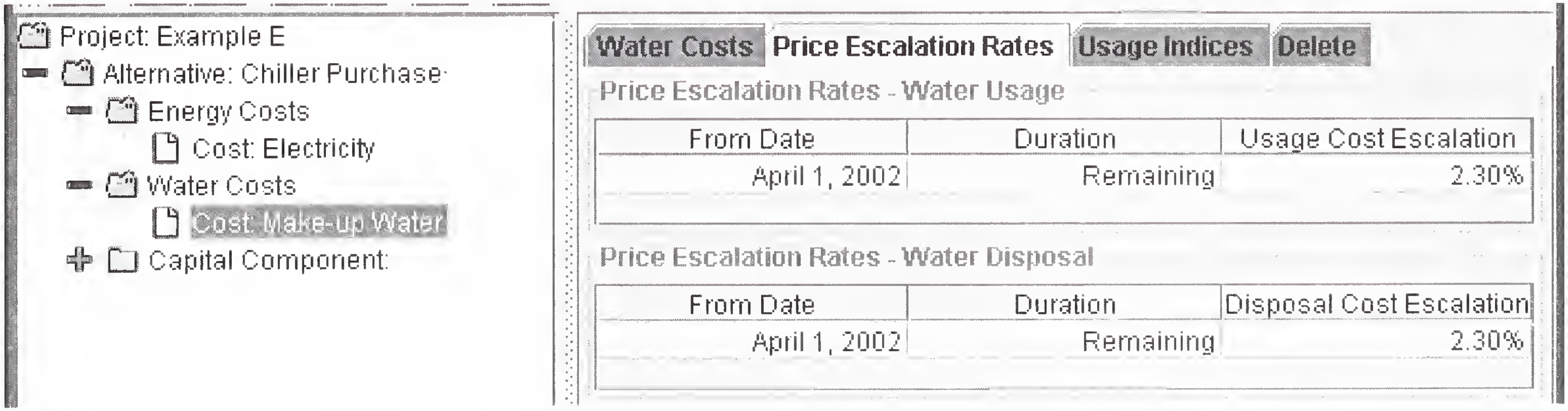
Enter name for water costs and press create cost button.

Water Costs Screens

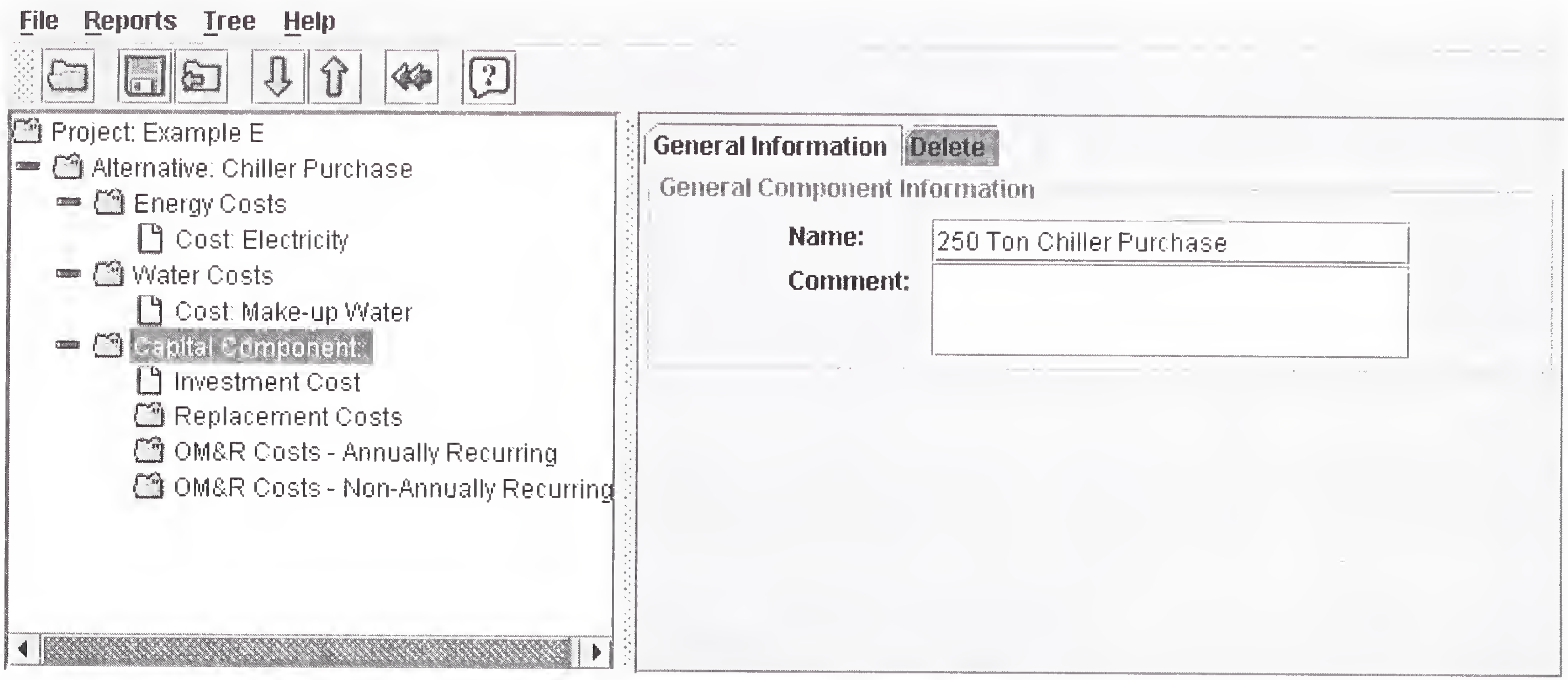
Enter units, consumption, and price per unit.



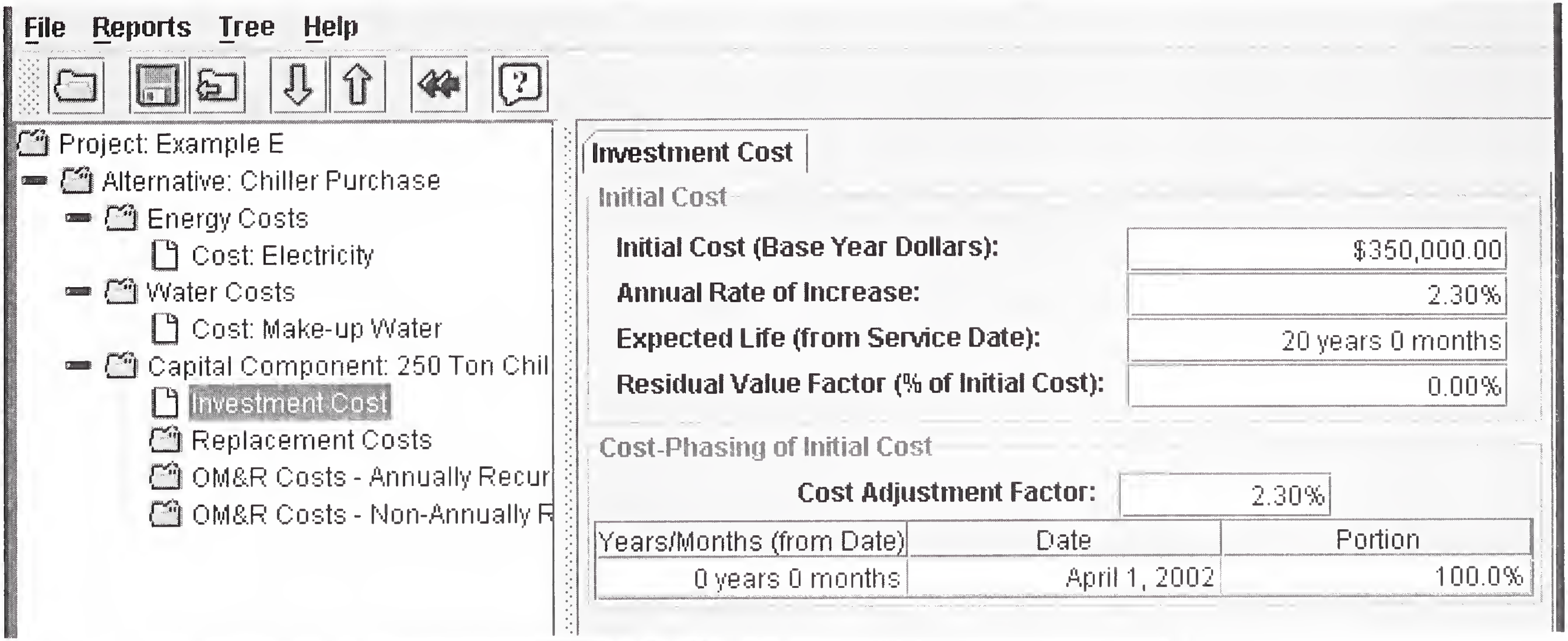
Price escalation will be at the rate of general inflation.



Investment Costs Screens

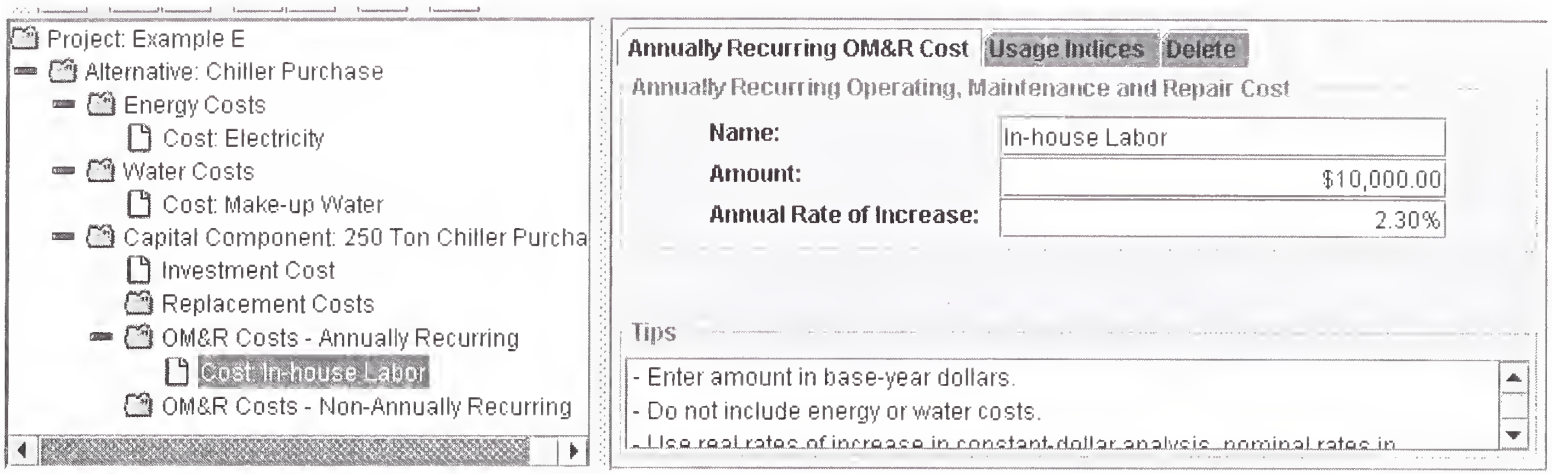


Investment Costs



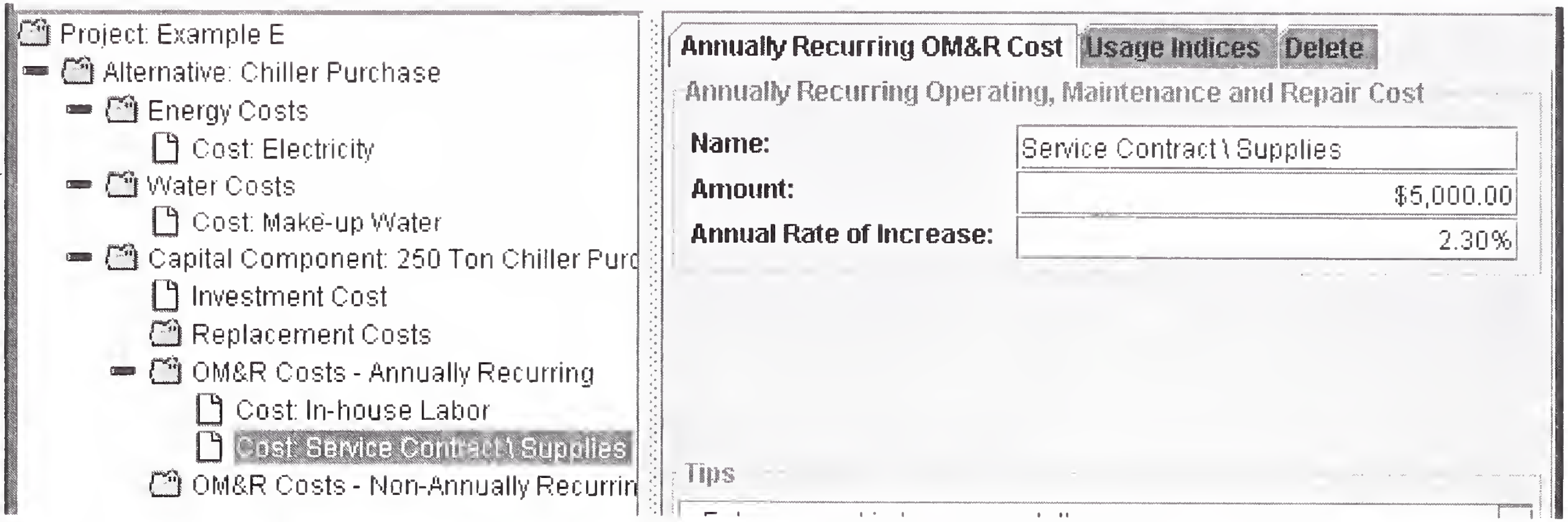
Enter investment cost, life, rate of increase, residual value, cost adjustment, and cost phasing. Note the rate of increase and cost adjustment default to the inflation rate.

Annually Recurring OM&R Costs



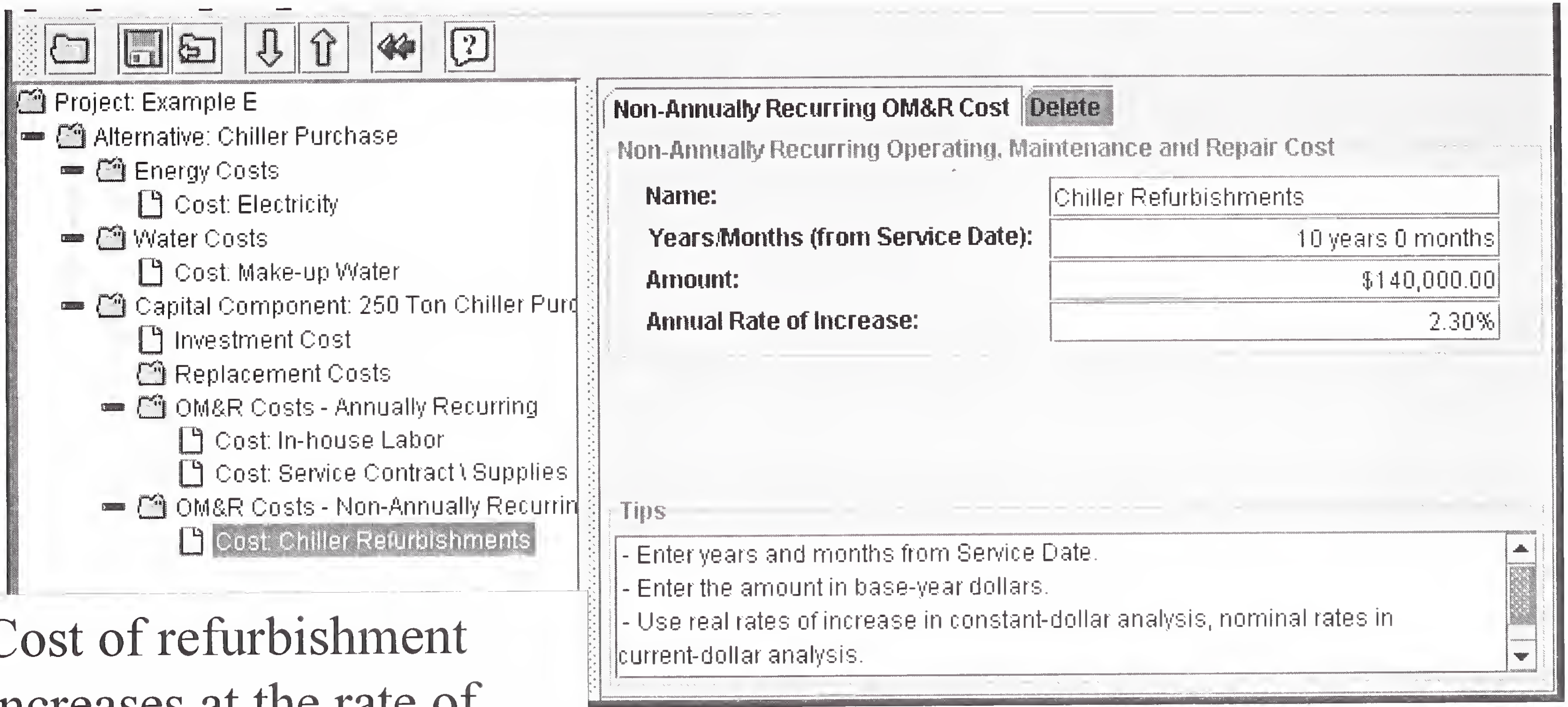
In-house labor

Service contract and supplies



Note: You can add several energy, water, capital component, and annual or non-annual costs.

Non-Annually Recurring OM&R Costs



Cost of refurbishment increases at the rate of general inflation.

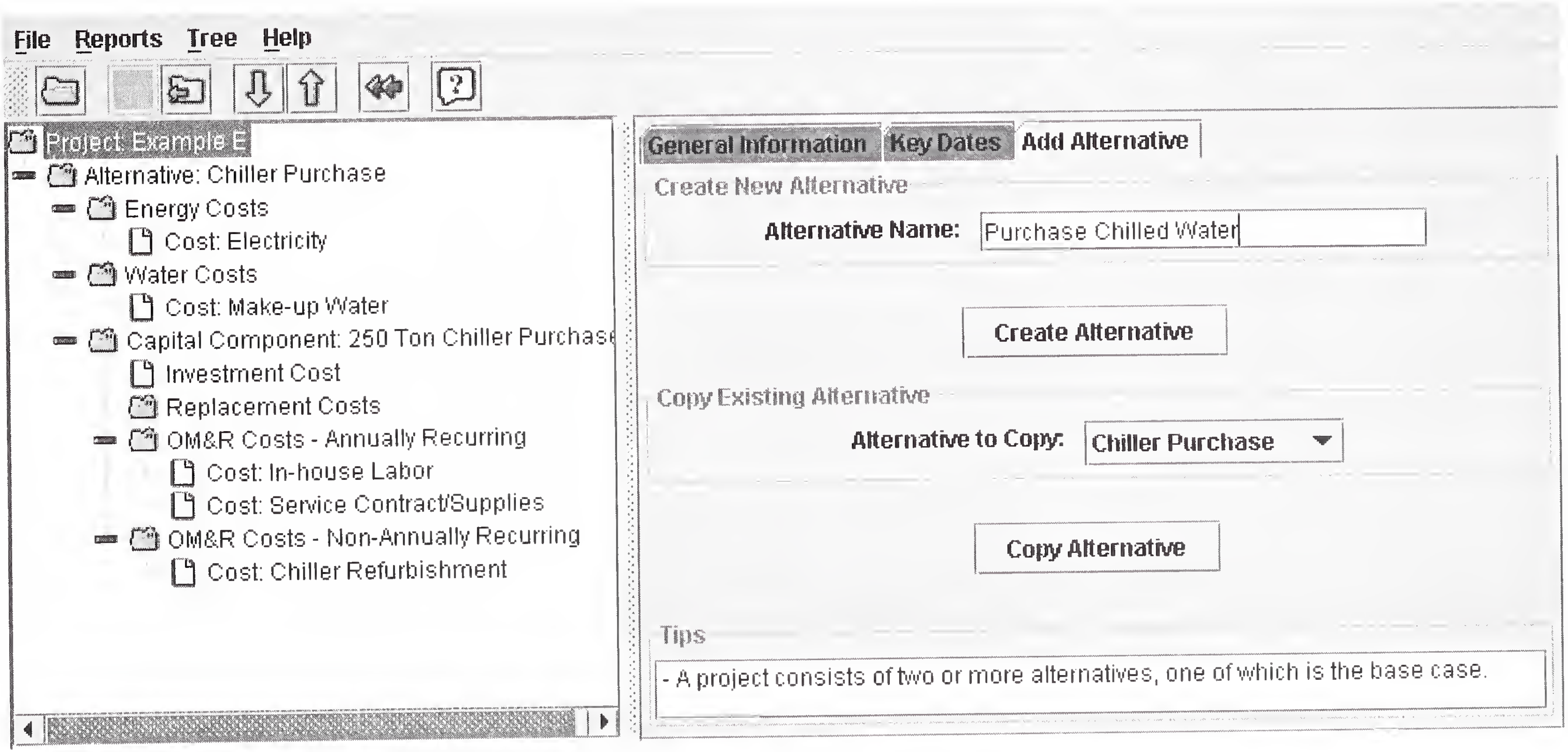
Summary LCC for Replace Chiller Alternative

Alternative: Chiller Purchase

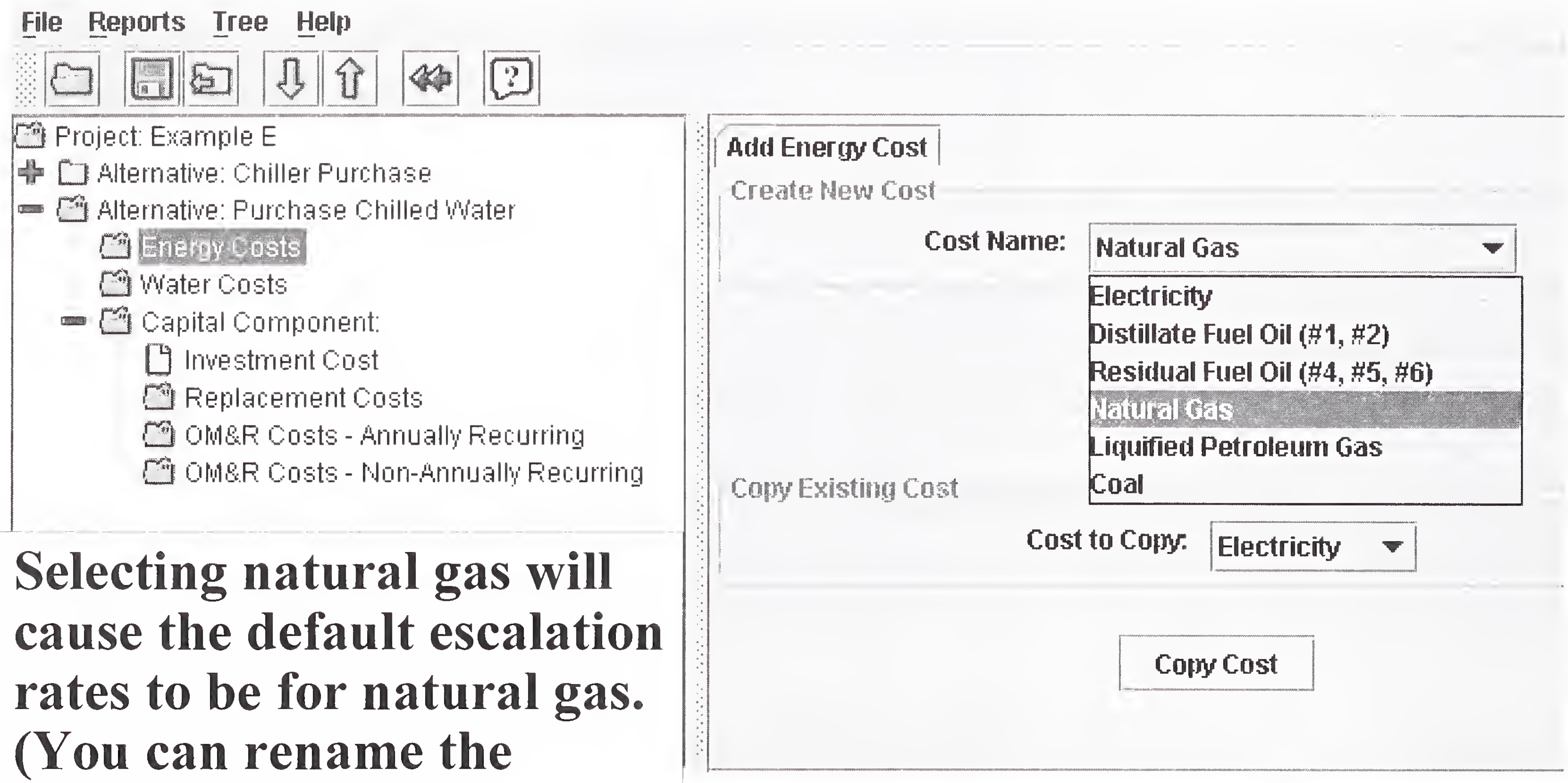
LCC Summary

	Present Value	Annual Value
Initial Cost	$350,000	$29,469
Energy Consumption Costs	$327,711	$27,592
Energy Demand Costs	$72,825	$6,132
Energy Utility Rebates	$0	$0
Water Usage Costs	$30,675	$2,583
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$219,108	$18,448
Non-Annually Recurring OM&R Costs	$102,167	$8,602
Replacement Costs	$0	$0
Less Remaining Value	$0	$0
	------------	------------
Total Life-Cycle Cost	$1,102,486	$92,826

Add Purchase Chilled Water Alternative



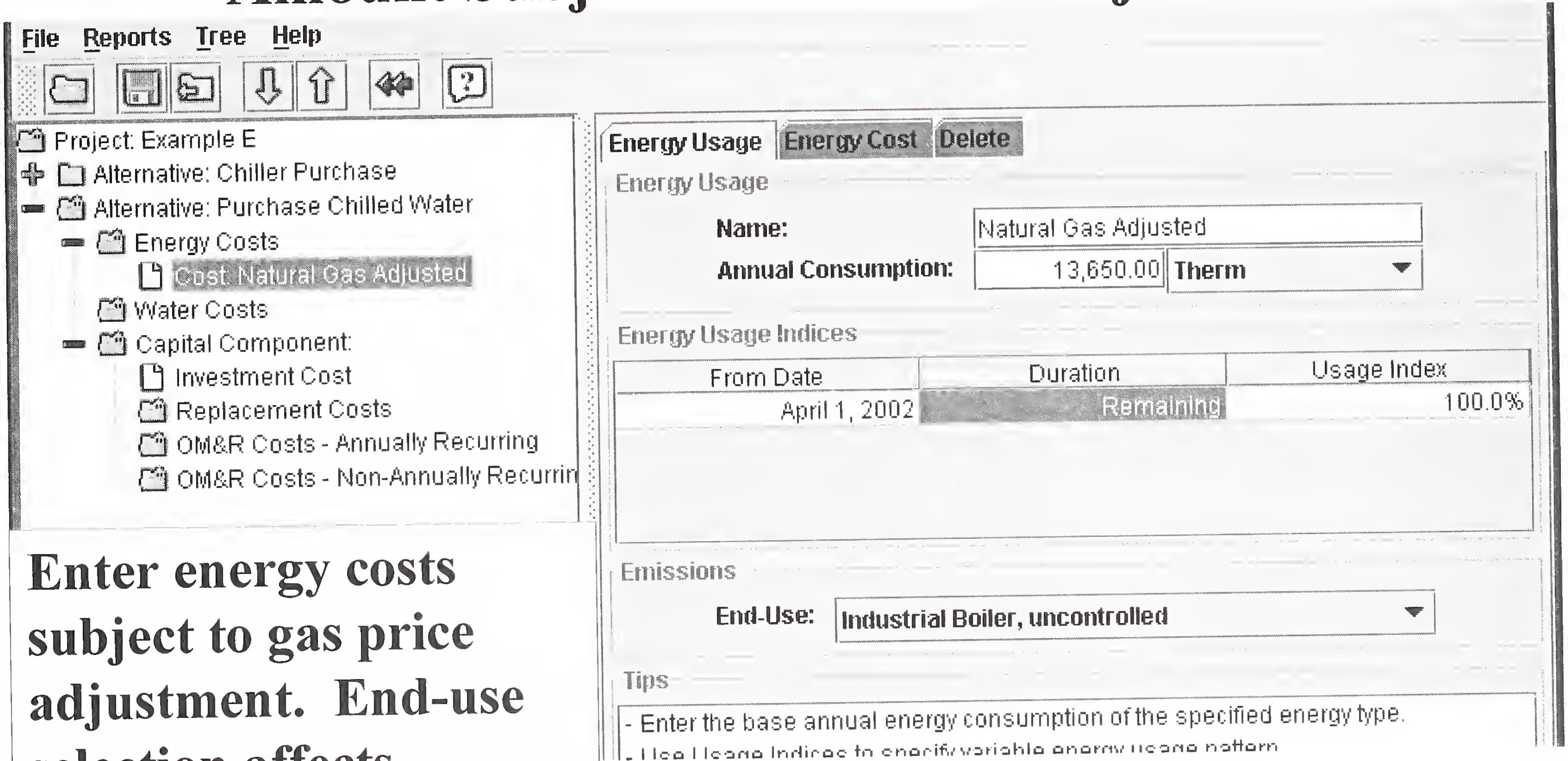
Adding Energy Costs –
Amount Subject to Gas Price Adjustment



Selecting natural gas will cause the default escalation rates to be for natural gas. (You can rename the energy cost.)

Energy Usage Screen –

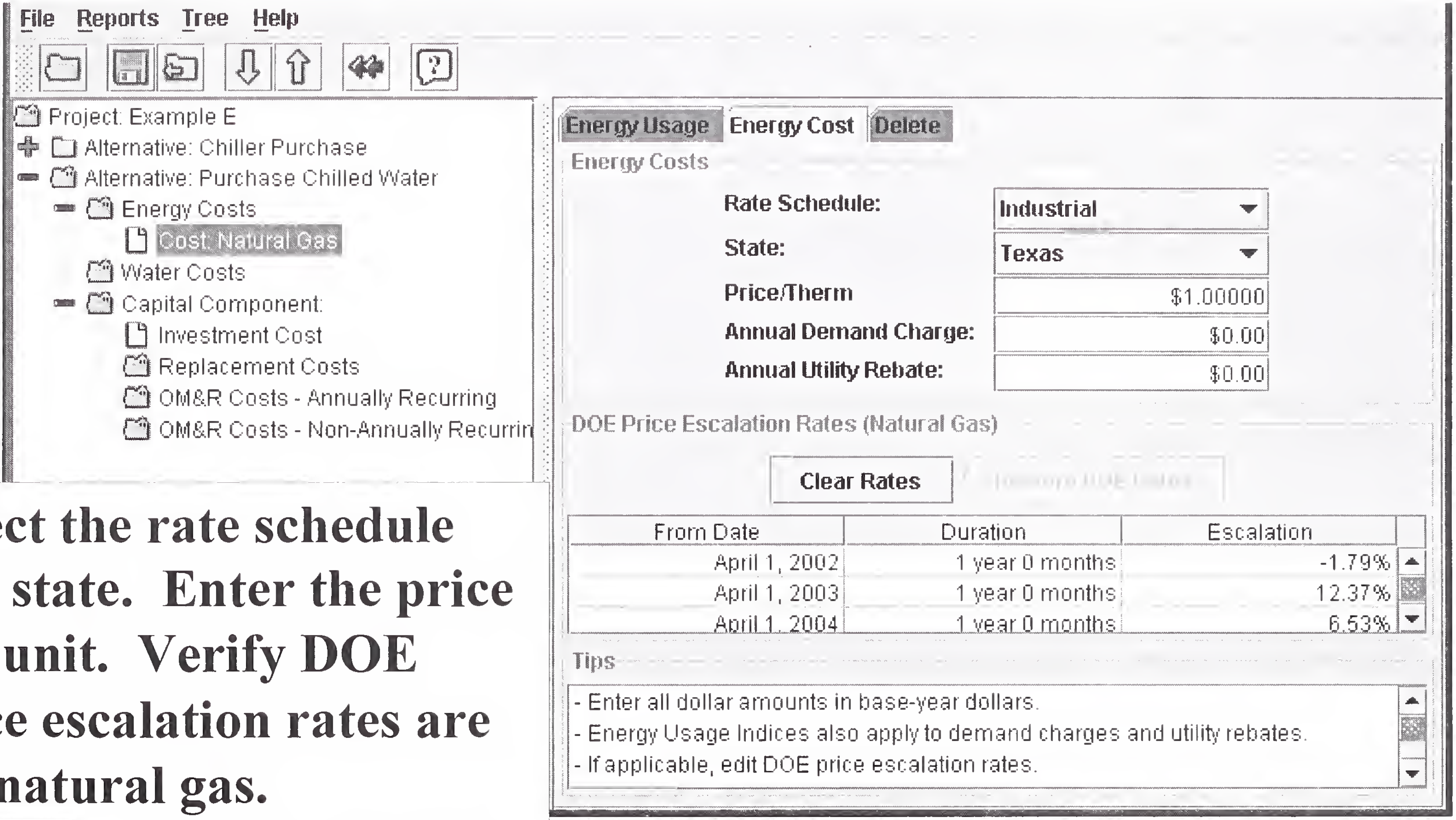
Amount Subject to Gas Price Adjustment



Enter energy costs subject to gas price adjustment. End-use selection affects emissions only.

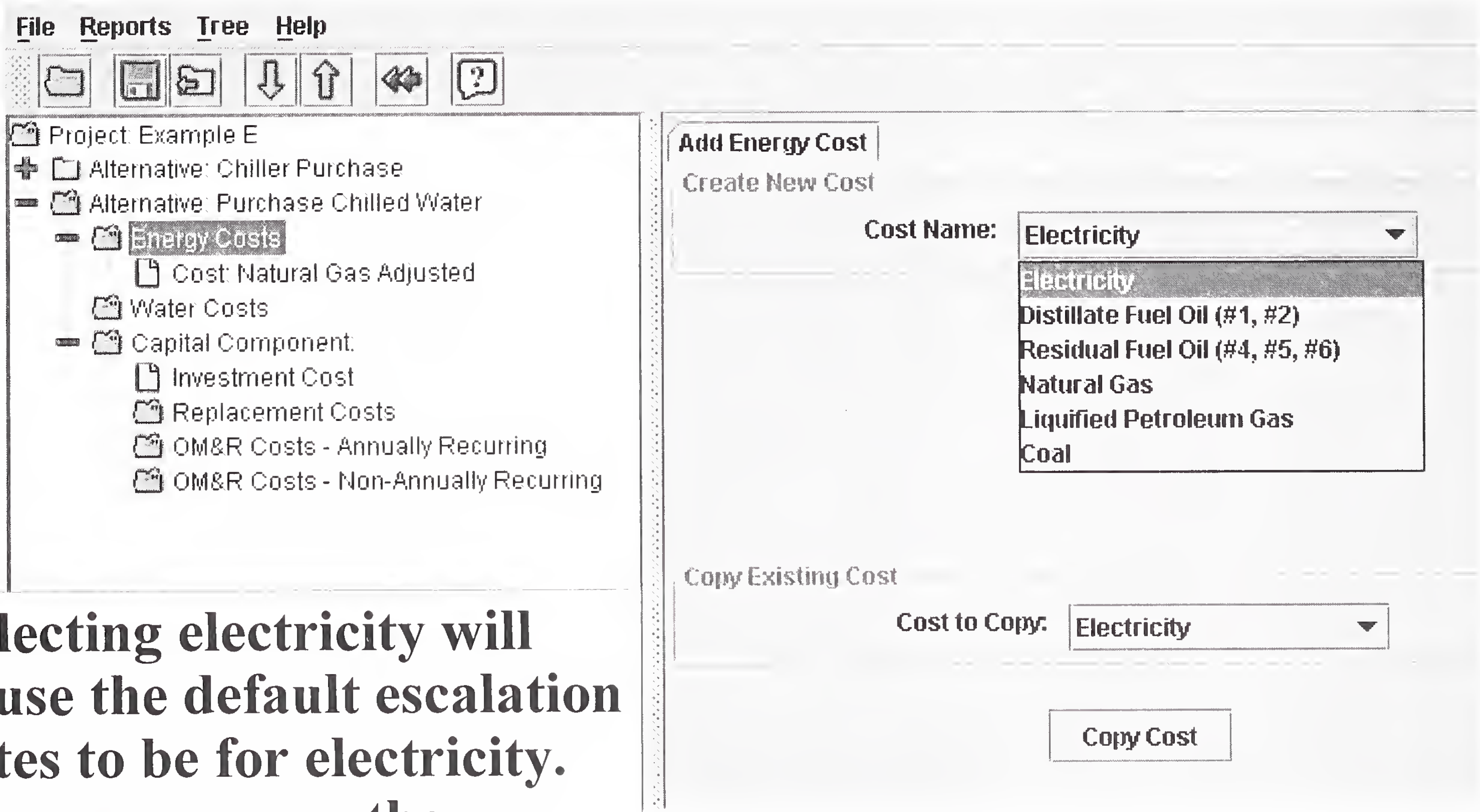
Energy Cost Screen –

Amount Subject to Gas Price Adjustment



Select the rate schedule and state. Enter the price per unit. Verify DOE price escalation rates are for natural gas.

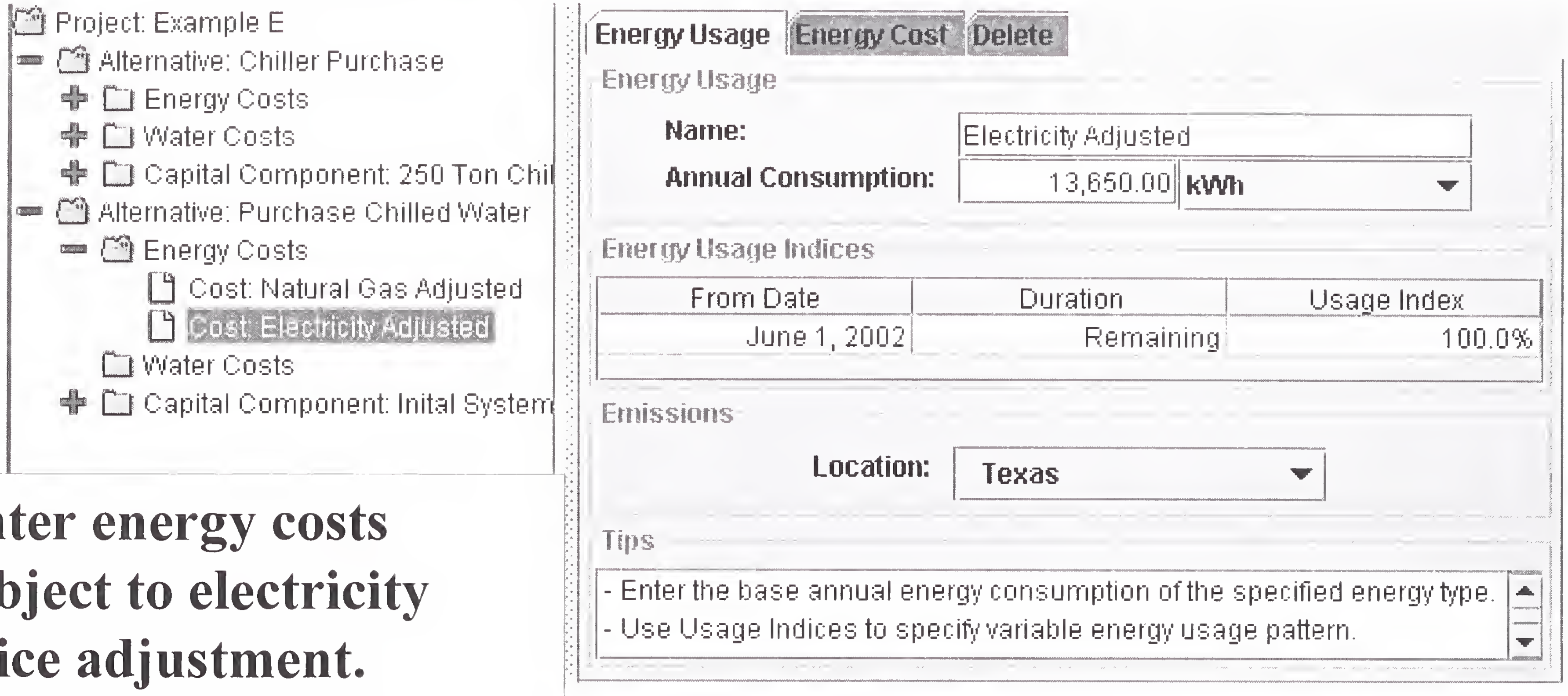
Adding Energy Costs –
Amount Subject to Electric Price Adjustment



Selecting electricity will cause the default escalation rates to be for electricity. You can rename the energy cost.

Energy Usage Screen –

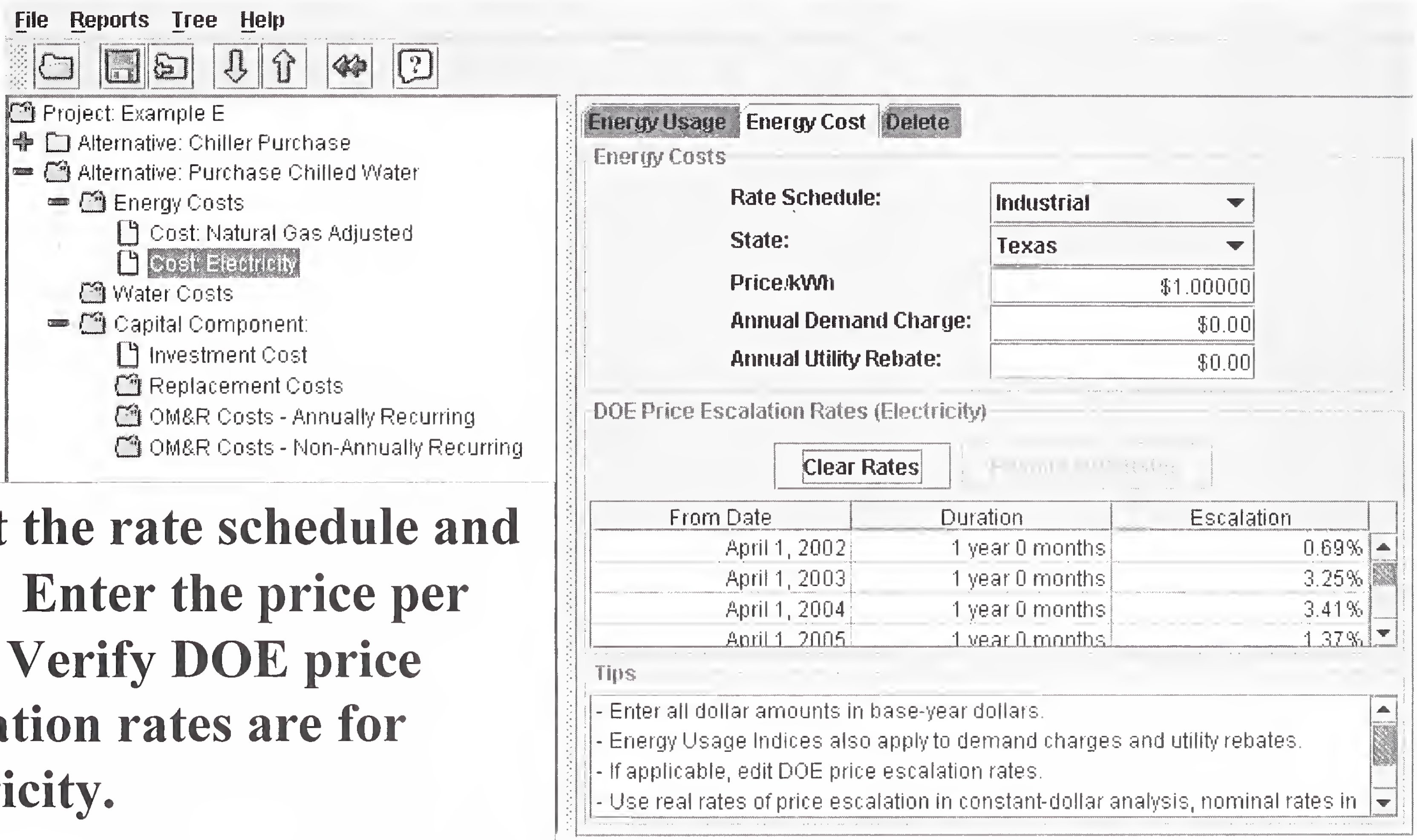
Amount Subject to Gas Price Adjustment



Enter energy costs subject to electricity price adjustment. Location selection affects emissions only.

Energy Cost Screen –

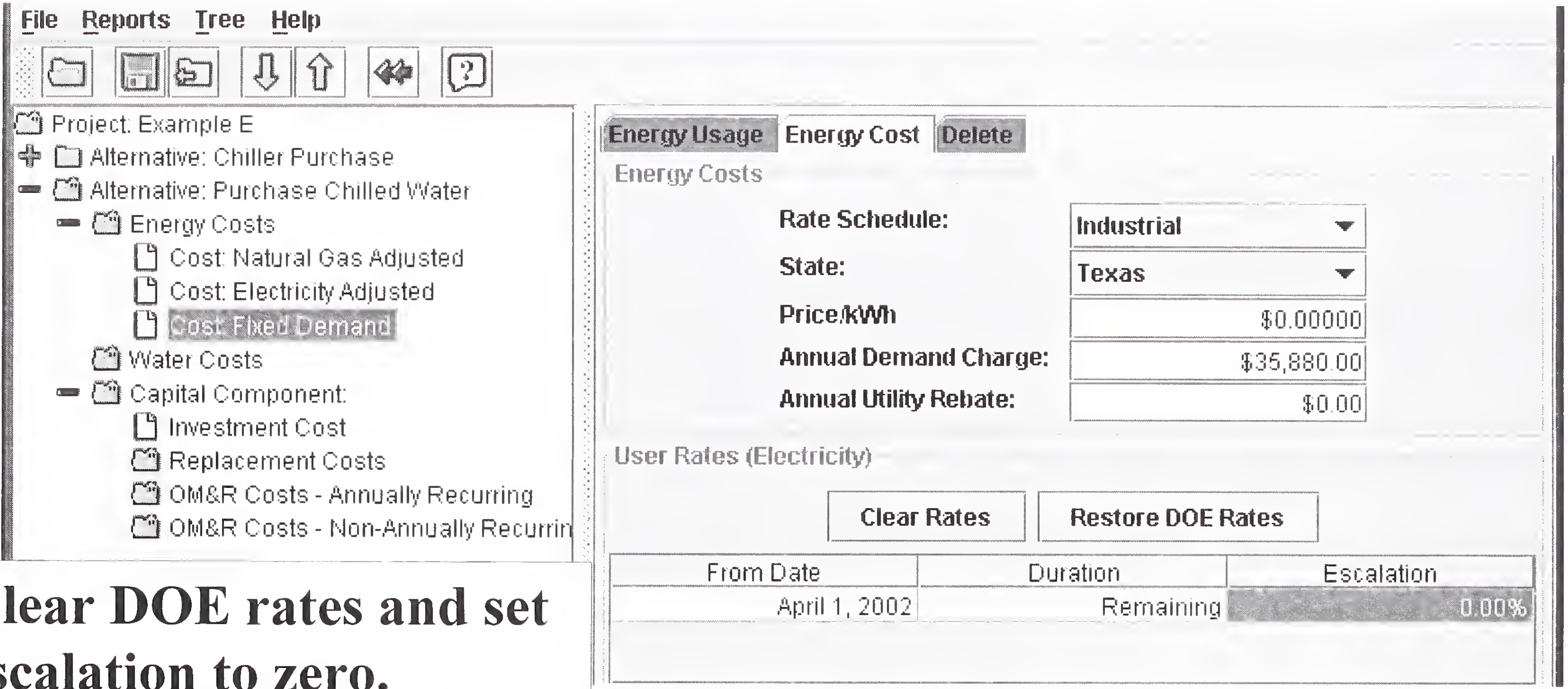
Amount Subject to Gas Price Adjustment



Select the rate schedule and state. Enter the price per unit. Verify DOE price escalation rates are for electricity.

Fixed Demand Charges

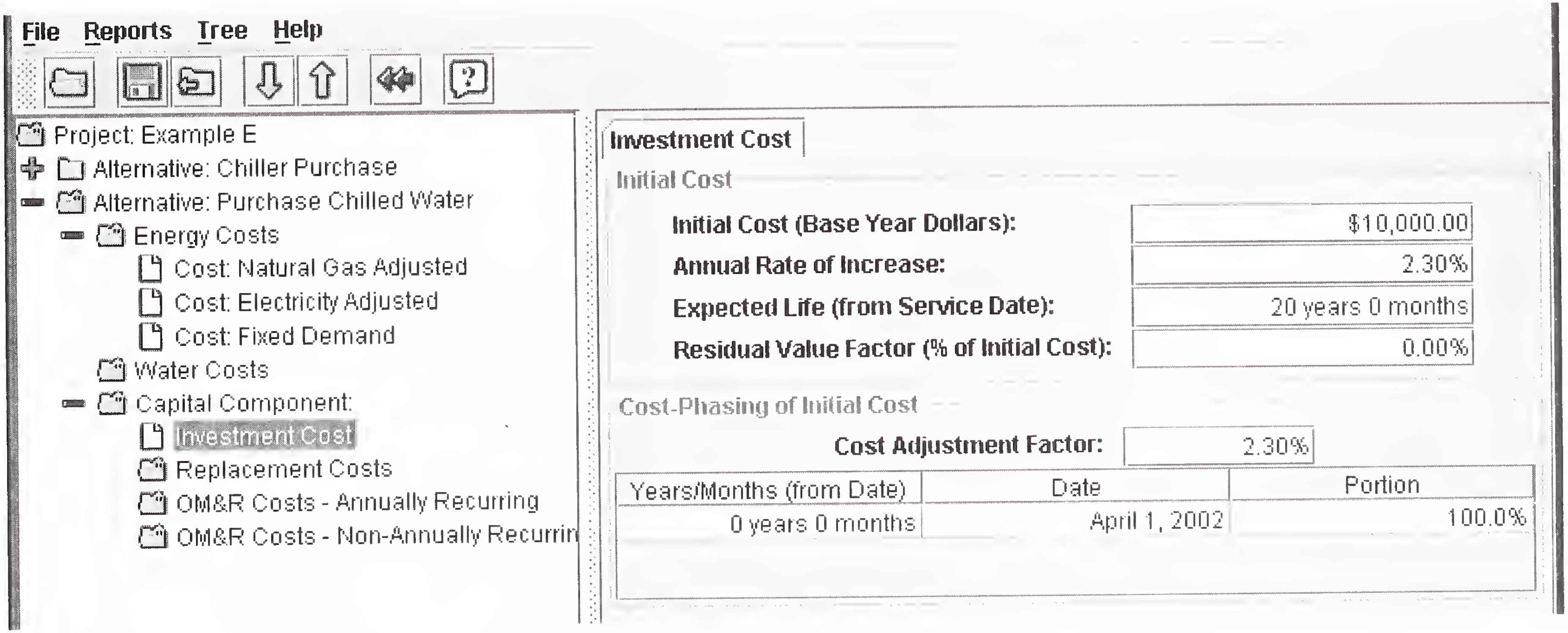
Add a third energy screen for the annual demand charge.



Clear DOE rates and set escalation to zero.

Initial System Modification

Enter initial system modification costs and expected life.



Summary LCC for Purchase Chilled Water Alternative

Alternative: Purchase Chilled Water

LCC Summary

	Present Value	Annual Value
Initial Cost	$10,000	$842
Energy Consumption Costs	$434,087	$36,549
Energy Demand Costs	$426,231	$35,887
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$0	$0
Non-Annually Recurring OM&R Costs	$0	$0
Replacement Costs	$0	$0
Less Remaining Value	$0	$0
Total Life-Cycle Cost	$870,318	$73,278

Comparative Analysis

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$10,000	$350,000	-$340,000
Future Costs:			
Energy Consumption Costs	$434,087	$327,711	$106,376
Energy Demand Charges	$426,231	$72,825	$353,406
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$30,675	-$30,675
Recurring and Non-Recurring OM&R Costs	$0	$321,276	-$321,276
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	$0	$0
	------------	------------	------------
Subtotal (for Future Cost Items)	$860,318	$752,486	$107,832
	------------	------------	------------
Total PV Life-Cycle Cost	$870,318	$1,102,486	-$232,168

Comparative Analysis

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$107,832
- Increased Total Investment	$340,000

Net Savings	-$232,168

Savings-to-Investment Ratio (SIR)

SIR = 0.32

SIR is lower than 1.0; project alternative is not cost effective.

Adjusted Internal Rate of Return

AIRR = -0.32%

AIRR is lower than your discount rate; project alternative is not cost effective.

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Simple Payback never reached during study period.

Discounted Payback never reached during study period.

Exercise E

PROBLEM STATEMENT

The manager of the buildings is uncertain about leaving the supply of chilled water up to a third party. He has asked you to compare the life-cycle cost of purchasing chilled water for a 20-year period versus purchasing chilled water for 10 years and then buying a chiller. The base date is April 2002. The project in in Texas and has industrial utility rates.

Alternative A:

Purchase chilled water for 20 years with costs the same as previous example.

Alternative B:

To purchase chilled water for 10 years and then purchase a chiller that has the following costs:

First 10 years

Purchase chilled water contract cost = $10,000

Annual capacity charge of $35,880, which is fixed.

Energy charge of $27,300 of which 50% is adjusted for changing natural gas prices and 50% is adjusted for changing electricity charges.

Years 11-20

Purchase chiller in year 10 = $350,000

Energy costs for 450,000 kWh at $0.05 per kWh plus $5,000 demand charges, both adjusted for changing electricity prices.

Make-up water costs of $2,100 annually, adjusted for inflation.

In-house labor of $10,000 annually.

Service contract of $5,000 annually.

The chiller residual value after 10 years of use and needing a refurbishment will be $350,000/2 –$140,000 = $35,000 or ten percent.

Hint: Use energy and cost indices to control when charges start and stop.

Solution to Exercise E

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise E.xml
Date of Study:	Mon Dec 23 13:18:03 EST 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Exercise E
Project Location:	Texas
Analyst:	GMM
Comment:	Purchase Chilled Water vs Purchase chilled water for 10 years and then purchase chiller
Base Date:	April 1, 2002
Service Date:	April 1, 2002
Study Period:	20 years 0 months (April 1, 2002 through March 31, 2022)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are NOMINAL (inclusive of general inflation)

Alternative: Purchase Chilled Water

Energy: Natural Gas Adjusted

Annual Consumption:	13,650.0 Therm
Price per Unit:	$1.00000
Demand Charge:	$0
Utility Rebate:	$0
End-Use:	Industrial Boiler, uncontrolled
Rate Schedule:	Industrial
State:	Texas

Usage Indices

From Date	Duration	Usage Index
April 1, 2002	Remaining	100%

Energy: Electricity Adjusted

Annual Consumption:	13,650.0 kWh
Price per Unit:	$1.00000
Demand Charge:	$0
Utility Rebate:	$0
Location:	Texas
Rate Schedule:	Industrial

State: Texas

Usage Indices

From Date	Duration	Usage Index
April 1, 2002	Remaining	100%

Energy: Fixed Demand

Annual Consumption: 0.0 kWh
Price per Unit: $0.00000
Demand Charge: $35,880
Utility Rebate: $0
Location: Texas
Rate Schedule: Industrial
State: Texas

Usage Indices

From Date	Duration	Usage Index
April 1, 2002	Remaining	100%

Escalation Rates

From Date	Duration	Escalation
April 1, 2002	Remaining	0%

Component: Inital System Modification

Initial Investment

Initial Cost (base-year $): $10,000
Annual Rate of Increase: 2.3%
Expected Asset Life: 20 years 0 months
Residual Value Factor: 0%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
0 years 0 months	April 1, 2002	100%

Alternative: Purchase Chilled Water then Chiller

Energy: Natural Gas Adjusted

Annual Consumption: 13,650.0 Therm
Price per Unit: $1.00000
Demand Charge: $0
Utility Rebate: $0
End-Use: Industrial Boiler, uncontrolled
Rate Schedule: Industrial

State:	Texas

Usage Indices

From Date	Duration	Usage Index
April 1, 2002	10 years 0 months	100%
April 1, 2012	Remaining	0%

Energy: Electricity Adjusted

Annual Consumption:	13,650.0 kWh
Price per Unit:	$1.00000
Demand Charge:	$0
Utility Rebate:	$0
Location:	Texas
Rate Schedule:	Industrial
State:	Texas

Usage Indices

From Date	Duration	Usage Index
April 1, 2002	10 years 0 months	100%
April 1, 2012	Remaining	0%

Energy: Fixed Demand

Annual Consumption:	0.0 kWh
Price per Unit:	$0.00000
Demand Charge:	$35.880
Utility Rebate:	$0
Location:	Texas
Rate Schedule:	Industrial
State:	Texas

Usage Indices

From Date	Duration	Usage Index
April 1, 2002	10 years 0 months	100%
April 1, 2012	Remaining	0%

Escalation Rates

From Date	Duration	Escalation
April 1, 2002	Remaining	0%

Energy: Electricity Starting in Year 10

Annual Consumption:	450,000.0 kWh
Price per Unit:	$0.05000
Demand Charge:	$5,000
Utility Rebate:	$0
Location:	Texas
Rate Schedule:	Industrial

State: Texas

Usage Indices

From Date	Duration	Usage Index
April 1, 2002	10 years 0 months	0%
April 1, 2012	Remaining	100%

Water: Make-up Water

	Annual Usage		Annual Disposal	
	Units/Year	Price/Unit	Units/Year	Price/Unit
@Summer Rates	2,100.0 ThousGal	$1.00000	0.0 ThousGal	$0.00000
@Winter Rates	0.0 ThousGal	$0.00000	0.0 ThousGal	$0.00000

Escalation Rates - Usage

From Date	Duration	Usage Cost Escalation
April 1, 2002	Remaining	2.3%

Escalation Rates - Disposal

From Date	Duration	Disposal Cost Escalation
April 1, 2002	Remaining	2.3%

Usage Indices - Usage

From Date	Duration	Index
April 1, 2002	10 years 0 months	0%
April 1, 2012	Remaining	100%

Usage Indices - Disposal

From Date	Duration	Index
April 1, 2002	Remaining	100%

Component: Initial System Modification

Initial Investment

Initial Cost (base-year $):	$10,000
Annual Rate of Increase:	2.3%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
0 years 0 months	April 1, 2002	100%

Component: Purchase Chiller in Year 10

Initial Investment

Initial Cost (base-year $):	$350,000
Annual Rate of Increase:	2.3%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	10%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
10 years 0 months	April 1, 2012	100%

Routine Recurring OM&R: In-house labor

Amount:	$10,000
Annual Rate of Increase:	2.3%

Usage Indices

From Date	Duration	Factor
April 1, 2002	10 years 0 months	0%
April 1, 2012	Remaining	100%

Routine Recurring OM&R: Service Contract

Amount:	$5,000
Annual Rate of Increase:	2.3%

Usage Indices

From Date	Duration	Factor
April 1, 2002	10 years 0 months	0%
April 1, 2012	Remaining	100%

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Purchase Chilled Water
Alternative: Purchase Chilled Water then Chiller

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise E.xml
Date of Study:	Mon Dec 23 13:18:28 EST 2002
Project Name:	Exercise E
Project Location:	Texas
Analysis Type:	FEMP Analysis, Energy Project
Analyst:	GMM
Comment	Purchase Chilled Water vs Purchase chilled water for 10 years and then purchase chiller
Base Date:	April 1. 2002
Service Date:	April 1, 2002
Study Period:	20 years 0 months(April 1, 2002 through March 31, 2022)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$10,000	$265,418	-$255,418
Future Costs:			
Energy Consumption Costs	$436,272	$382,426	$53,846
Energy Demand Charges	$426,231	$300,580	$125,651
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$12,942	-$12,942
Recurring and Non-Recurring OM&R Costs	$0	$92,442	-$92,442
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	-$18,643	$18,643
	------------	------------	------------
Subtotal (for Future Cost Items)	$862,503	$769,747	$92,756
	------------	------------	------------
Total PV Life-Cycle Cost	$872,503	$1,035,166	-$162,663

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$74,113
- Increased Total Investment	$236,776

Net Savings	-$162,663

Savings-to-Investment Ratio (SIR)

SIR = 0.31

SIR is lower than 1.0; project alternative is not cost effective.

Adjusted Internal Rate of Return

AIRR = -0.38%

AIRR is lower than your discount rate; project alternative is not cost effective.

Payback Period

Estimated Years to Payback (from beginning of Service Period)

Discounted Payback never reached during study period.

Simple Payback occurs in year 1

Simple Payback is negated in year 11

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	13,650.0 kWh	231,765.3 kWh	-218,115.3 kWh	-4,361,708.0 kWh
Natural Gas	13,650.0 Therm	6,826.9 Therm	6,823.1 Therm	136,443.9 Therm

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	46.6 MBtu	790.8 MBtu	-744.2 MBtu	-14,882.8 MBtu
Natural Gas	1,365.0 MBtu	682.7 MBtu	682.3 MBtu	13,644.4 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				

CO2	11,767.10 kg	199,846.78 kg	-188,079.68 kg	-3,761,078.68 kg
SO2	20.54 kg	342.50 kg	-321.96 kg	-6,438.33 kg
NOx	33.47 kg	568.42 kg	-534.95 kg	-10,697.56 kg
Natural Gas				
CO2	72,104.13 kg	36,052.06 kg	36,052.06 kg	720,942.59 kg
SO2	581.90 kg	290.95 kg	290.95 kg	5,818.23 kg
NOx	84.98 kg	42.49 kg	42.49 kg	849.69 kg
Total:				
CO2	83,871.23 kg	235,898.85 kg	-152,027.62 kg	-3,040,136.09 kg
SO2	602.44 kg	633.45 kg	-31.01 kg	-620.09 kg
NOx	118.45 kg	610.91 kg	-492.46 kg	-9,847.86 kg

Module F

Evaluation of Alternative Financing Contracts

Objectives: Upon completion of this module, you will know how to

- **structure alternative financing (AF) projects for LCCA.**
  - **Energy Savings Performance Contracts (ESPCs)**
  - **Utility Energy Services Contracts (UCs)**
- **use BLCC5 to perform the analysis.**

Typical ESPC Process

Year 1:

Kick-off meeting

ESCO survey and calculations

Submittal of initial proposal

Agency Notice of Intent to Award

ESCO detailed survey and calculations

Submittal of final proposal

Negotiations

Agency award of Delivery Order

Typical ESPC Process (cont'd.)

Year 2:
ESCO design
Review, comments, negotiations

Construction
Site acceptance of project

Contract term:
Beginning of performance period
Annual M&V
Adjustment of ESCO payments if appropriate
End of contract term

Typical ESPC Payments

- Pre-performance payments:
  - Project facilitation fee
  - Down payment (from avoided costs)
  - Payment for energy savings during construction period
- Performance period - contract term:
  - Contract payments (loan, OM&R, M&V)
  - Energy costs
- End of contract:
  - OM&R costs, energy costs

Steps in LCCA of AF Contracts

- Select the systems and equipment to impact and at what level.
- Perform LCCAs for individual ECMs.
- Determine which ECMs to bundle.
- Evaluate project for cost effectiveness compared with status quo or other strategies.

Typical AF Costs and Benefits

- Acquisition and debt service
  - Principal
  - Interest
- Performance Period Expenses
  - Management and administration
  - Measurement and verification
  - Overhead and profit
  - O&M *
  - Repair and replacement*
- Down payment
- Energy costs

* Capitalization of traditional operating expenses blurs the lines between investment and operational costs.

Bundling of ECMs

- **Bundling of independent projects**
  - **Each individual project should be cost effective.**
  - **EO 13123 allows bundling of non-cost-effective ECMs with those that generate high NS.**
  - **Bundling does not guarantee maximization of NS for government investments overall.**
- **Bundling of interdependent projects**
  - **Analysts must account for interaction among systems.**
  - **Energy consumption of different combinations needs to be recalculated.**

Example F

Evaluation of ESPC Contract

PROBLEM STATEMENT

The building manager of the Jefferson Training Facility in Tennessee has been investigating the possibility of financing, through an Energy Savings Performance Contract, an upgrade of the facility's hot water system and other energy conservation measures. In collaboration with an ESCO, she has identified five retrofit measures, which, according to the ESCO proposal, would result in operational cost savings of approximately $120K annually. With the current maintenance and repair schedule, the existing system could be kept functional for another 25 years.

Options

Maintain status quo with current maintenance and repair schedule.

Install the following Energy Conservation Measures (ECM):

1.	Install new natural gas hot water boilers	$262,500
2.	Convert existing, electric DHW heating system to natural gas DHW system	$50,000
3.	Install campus-wide direct digital control (DDC) system	$412,500
4.	Improve lighting system	$250,000
5.	Convert constant HW and CW loops to variable flow	<u>$187,500</u>
		$1,162,500

Example F (cont.)

ANALYSIS

Perform an LCC analysis to determine whether the project would be life-cycle cost effective if it were financed. Are the expected non-discounted annual savings sufficient in each year to cover the proposed contract payments? Does your analysis confirm the ESCO's estimate of annual operational savings of $120K?

Scenario

The building manager has already performed LCCAs on the individual ECMs and found them to be cost effective. She has decided to bundle the ECMs into one project, which she will compare with the base case of doing nothing.

General project information

- ECMs in Training Facility, Jefferson, TN
- current-dollar analysis
- end-of-year discounting
- discount rate: 5.6% nominal
- inflation rate: 2.3%
- DOE energy price escalation rates
- all costs, except debt service payments, increase at rate of inflation

Key Dates

- **Base date:** June 2002
- **Implementation period:** 1 year
- **Service date:** June 2003
- **Contract period:** 20 years
- **Study period:** 25 years

Base Case: Status Quo

Initial cost:	$0
Energy consumption:	4,584,396 kWh/yr
Energy price:	$0.04324/kWh, commercial
AR OM&R costs:	$18,300
Expected system life:	25 years

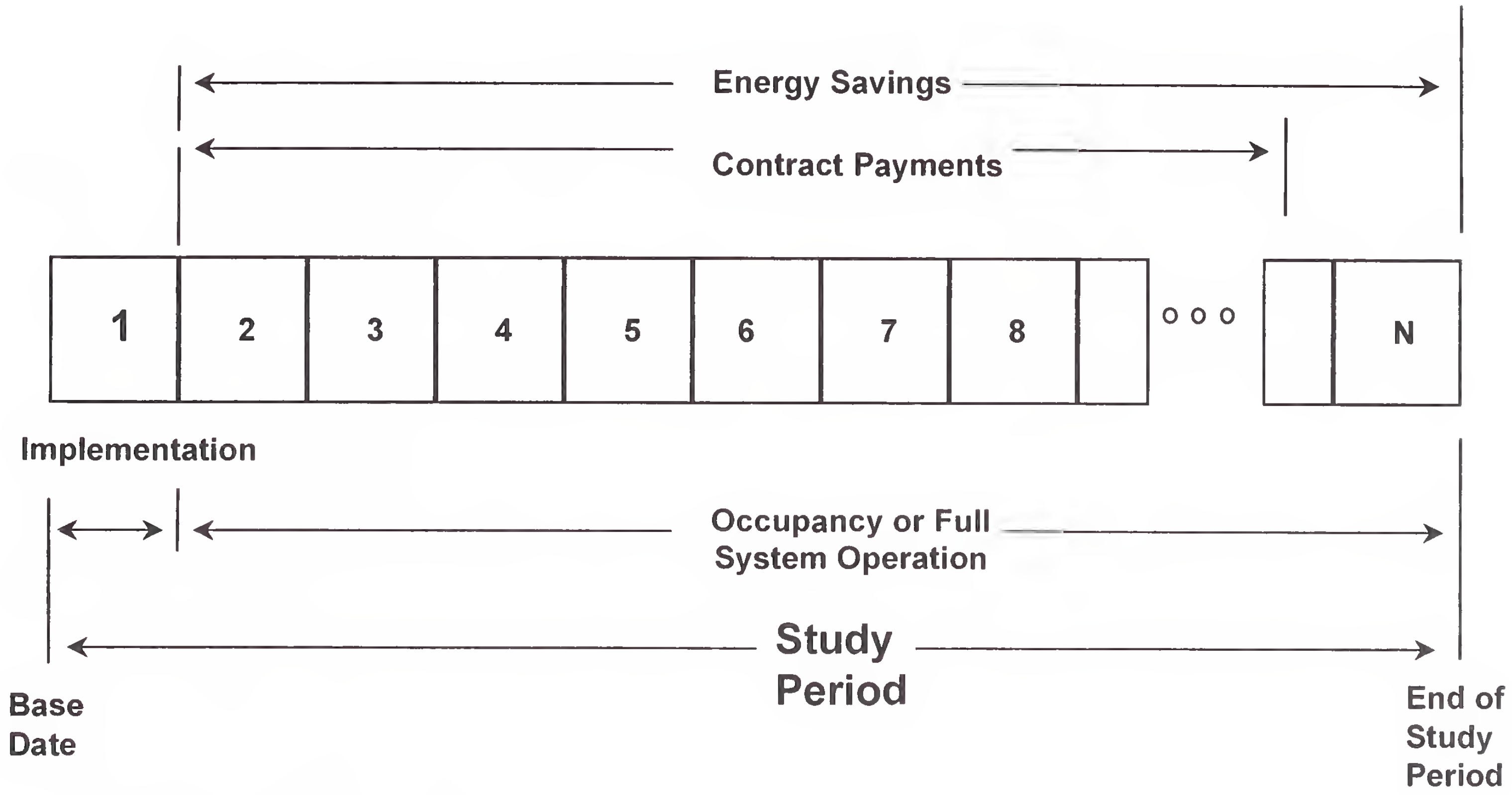
Alternative: ESPC

Initial cost paid by agency:	$29,283
Total capital costs financed:	$1,133,217
Annual contract costs:	
Debt service:	$109,856, fixed
Performance period expenses:	$7,047, increasing at 2.3%
Annual energy costs:	
pre-impl. period:	Electricity: 4,584,396 kWh/yr at $0.04324/kWh, commercial
post-impl. period:	Natural Gas: 109,780 therms at $0.46/therm, comm.

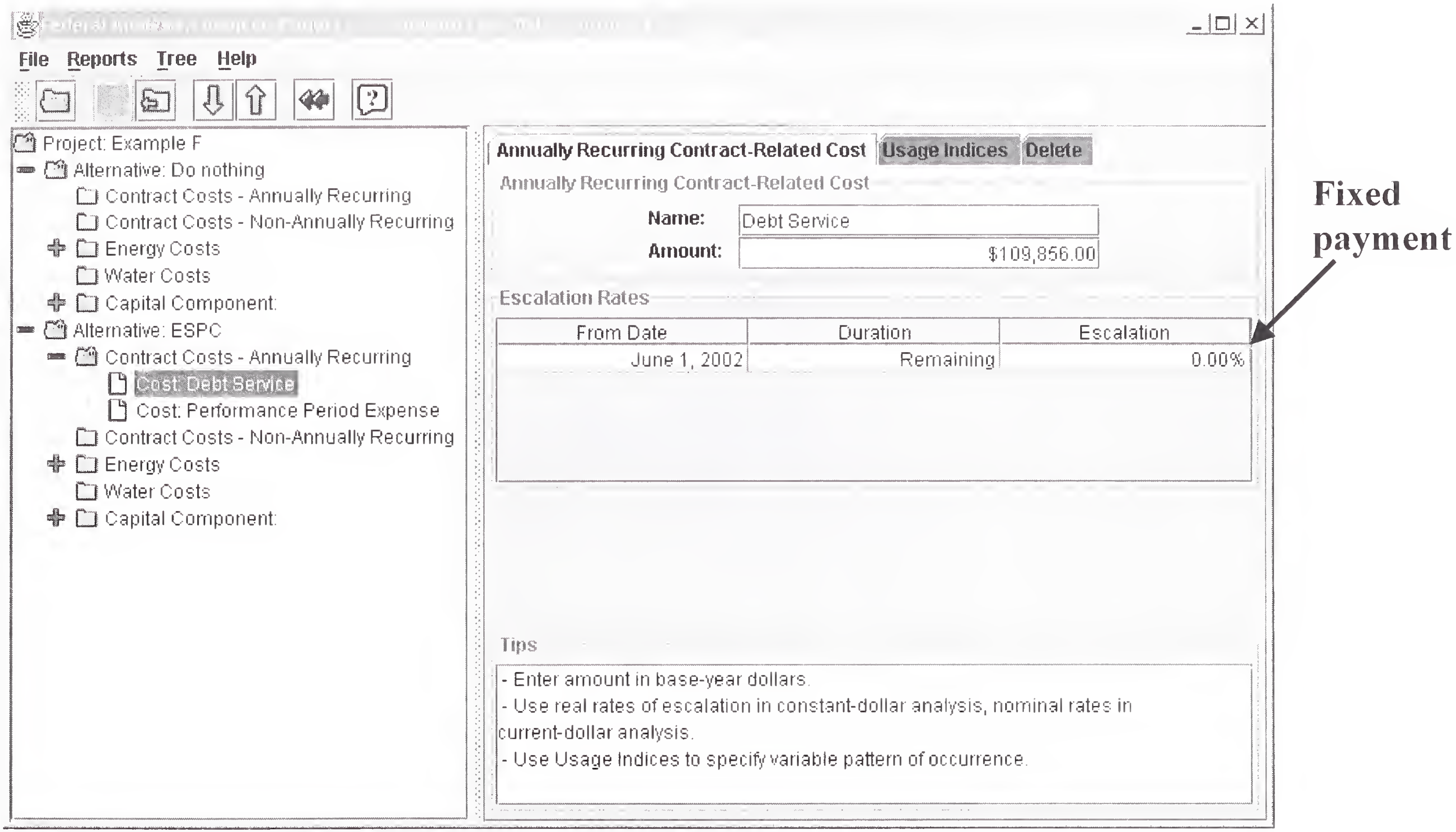
Alternative: ESPC (cont.)

AR OM&R costs	
pre-impl. period:	$18,300
contract period:	included in contract payments
post-contract period:	$4,871
Expected system life:	25 years
residual value:	4%

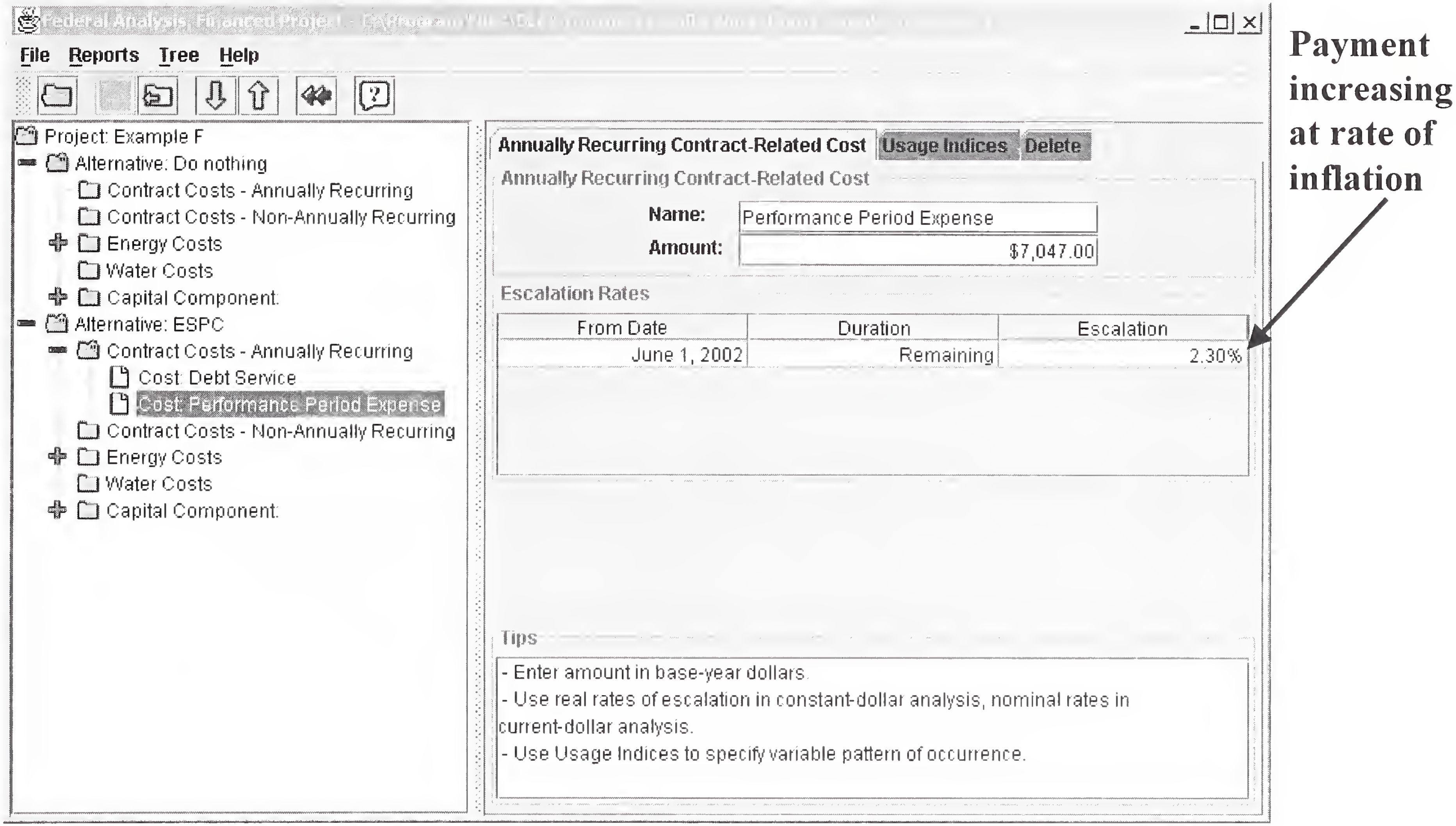
ESPC Project Timing



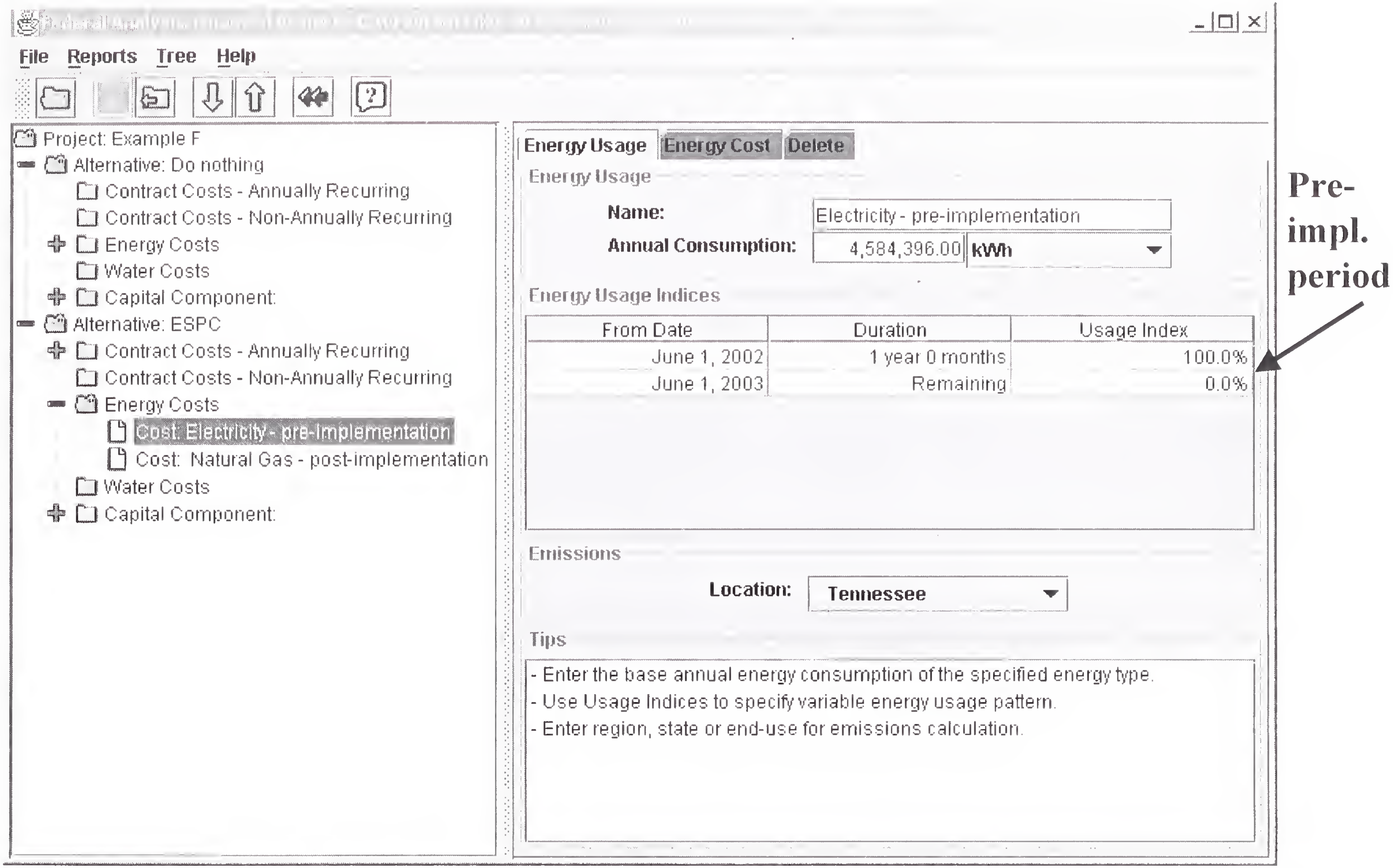
ESPC: Debt Service



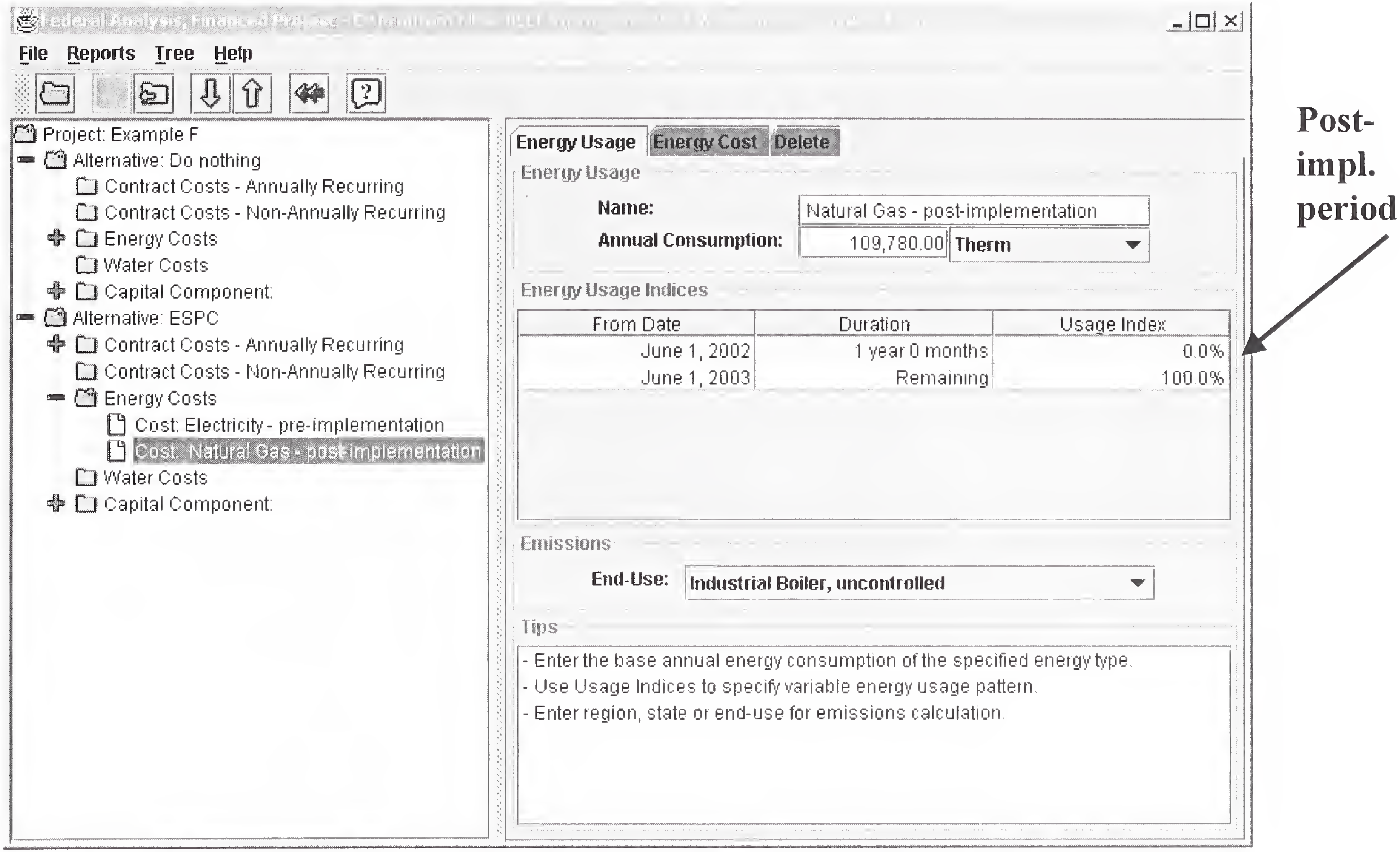
ESPC: Performance Period Expenses



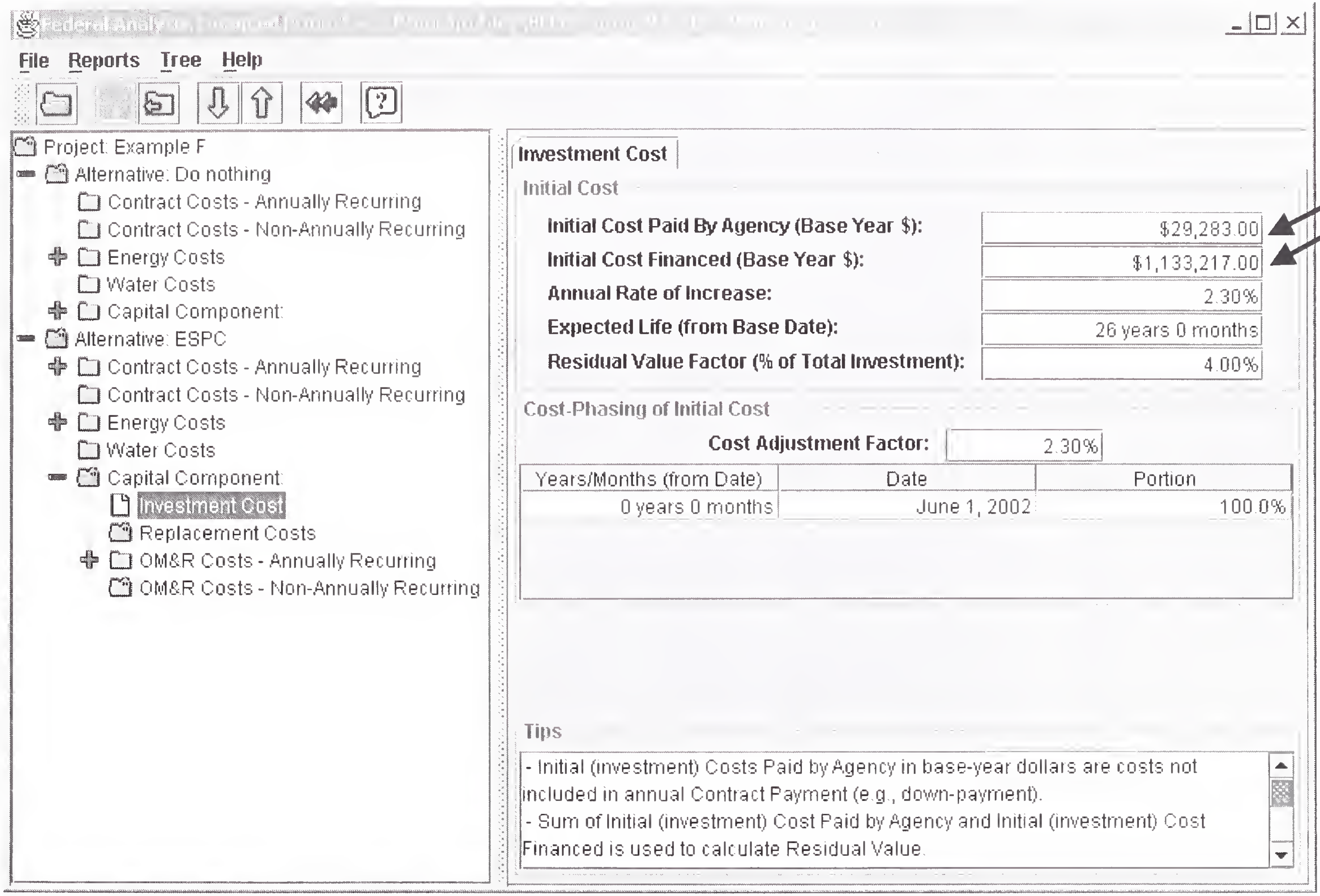
ESPC: Electricity Usage



ESPC: Natural Gas Usage

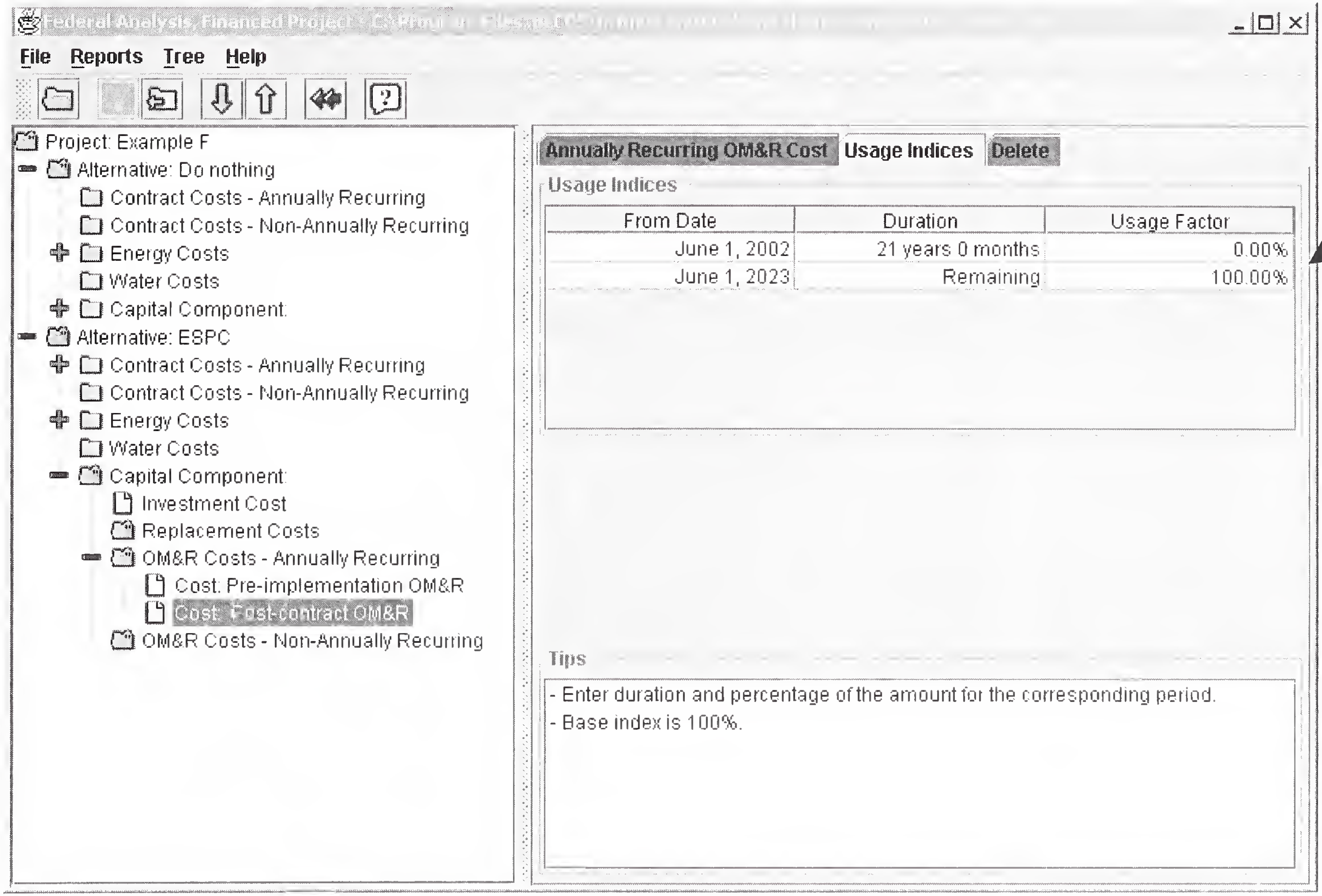


ESPC: Initial Investment Costs



Initial Costs

ESPC: OM&R Costs



Post-contract period

Comparative Analysis Report

File

Comparison of Present-Value Costs

PV Life-Cycle Cost	Do nothing Base Case	ESPC Alternative	Savings from Alternative
Initial Investment Costs Paid By Agency:			
Capital Requirements as of Base Date	$0	$29,283	-$29,283
Future Costs:			
Recurring and Non-Recurring Contract Costs	$0	$1,335,857	-$1,335,857
Energy Consumption Costs	$3,315,634	$1,025,607	$2,290,028
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$311,699	$27,035	$284,664
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	-$21,160	$21,160
	------------	------------	------------
Subtotal (for Future Cost Items)	$3,627,333	$2,367,339	$1,259,994
	------------	------------	------------
Total PV Life-Cycle Cost	$3,627,333	$2,396,622	$1,230,711

Lowest LCC

Net Savings from Alternative Compared with Base Case

PV of Operational Savings	$2,574,691
- PV of Differential Costs	$1,343,980

Net Savings	$1,230,711

Comparative Analysis Report

Comparative Analysis Report

File

Comparison of Contract Payments and Savings from Alternative (undiscounted)

Year Beginning	Savings in Contract Costs	Savings in Energy Costs	Savings in Total Operational Costs	Savings in Total Costs
Jun 2002	$0	$0	$0	-$29,283
Jun 2003	-$117,231	$151,935	$171,086	$53,855
Jun 2004	-$117,400	$155,747	$175,338	$57,938
Jun 2005	-$117,574	$156,930	$176,971	$59,398
Jun 2006	-$117,751	$158,935	$179,437	$61,686
Jun 2007	-$117,933	$161,958	$182,933	$65,000
Jun 2008	-$118,119	$164,951	$186,408	$68,289
Jun 2009	-$118,308	$168,736	$190,685	$72,377
Jun 2010	-$118,503	$172,552	$195,007	$76,504
Jun 2011	-$118,702	$176,342	$199,314	$80,612
Jun 2012	-$118,905	$180,017	$203,516	$84,611
Jun 2013	-$119,113	$183,697	$207,737	$88,624
Jun 2014	-$119,326	$187,915	$212,507	$93,181
Jun 2015	-$119,544	$193,404	$218,563	$99,019
Jun 2016	-$119,767	$198,941	$224,678	$104,911
Jun 2017	-$119,995	$205,025	$231,354	$111,359
Jun 2018	-$120,228	$210,739	$237,673	$117,445
Jun 2019	-$120,467	$216,563	$244,118	$123,651
Jun 2020	-$120,711	$221,965	$250,154	$129,443
Jun 2021	-$120,960	$227,387	$256,223	$135,263
Jun 2022	-$121,215	$233,085	$262,584	$141,369

contract term

Annual Operational Savings > $120K (non-discounted)

Annual Total Savings (non-discounted)

Annualized PV Savings

Use Uniform Capital Recovery Factor (UCR) to annualize Net Savings.

Annual NS = Total Net Savings x UCR
= $1,230,711 x 0.0753
= $92,673

(UCR = 1/UPV, calculated using BLCC4 DISCOUNT Program)

Summary LCC Report

Summary Report

File

Annually Recurring OM&R Costs	$311,699	$23,406
Non-Annually Recurring OM&R Costs	$0	$0
Replacement Costs	$0	$0
Less Remaining Value	$0	$0
	------------	------------
Total Life-Cycle Cost	$3,627,333	$272,378

BC: Do nothing
Annualized PV LCC

Alternative: ESPC

LCC Summary

	Present Value	Annual Value
Initial Cost Paid By Agency	$29,283	$2,199
Annually Recurring Contract Costs	$1,335,857	$100,310
Non-Annually Recurring Contract Costs	$0	$0
Energy Consumption Costs	$1,025,607	$77,013
Energy Demand Costs	$0	$0
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$27,035	$2,030
Non-Annually Recurring OM&R Costs	$0	$0
Replacement Costs	$0	$0
Less Remaining Value	-$21,160	-$1,589
	------------	------------
Total Life-Cycle Cost	$2,396,622	$179,963

Annualized PV Net Savings:
$272,378 - $179,963 = $92,415

Alt: ESPC
Annualized PV LCC

Summary of Analysis Results

- ESPC project is cost effective.
  - LCC lower than for status quo (Lowest LCC Report)
  - positive NS for alternative (Comparative Analysis Report)
  - annual non-discounted operational savings > than contract payments (Comparative Analysis Report)
  - operational savings proposed by ESCO confirmed (Comparative Analysis Report)

- Other considerations:
  - emissions reduction achieved with ESPC project (Comparative Analysis Report)

Exercise F

Financing Solar Water Heating System for a U.S. Coast Guard Base

PROBLEM STATEMENT

The U.S. Coast Guard (CG) in Honolulu is seeking to evaluate the feasibility of utility financing to replace an existing electric resistance water heating system with a solar water heating system for 280 residences. To maintain the existing system, CG is planning to replace heater tanks at the rate of 28 tanks per year (assuming a 10-year useful life), with the first set of tank replacements being completed one year from the base date. As an alternative, they could replace the existing systems with an energy-efficient solar system that would be installed and financed through a contract with the local utility company and would be ready for operation in one year. CG would make a down payment of 15 percent of the total initial capital investment of $1,000,000 at the base date and finance the remaining 85 percent over a contract term of 10 years, beginning one year from the base date. CG performs a life-cycle cost analysis to determine if the utility proposal is cost effective relative to the base case of keeping the existing system.

General Information

Location:	Honolulu, HI
Base date:	June 2002
Service date:	June 2003 for both the base case and the alternative
Study period:	21 years from base date
Government discount rate:	5.6 percent (including inflation)
Discounting convention:	Amounts discounted from end of each year to base date
Rate of general inflation:	2.3 percent (use current-dollar analysis)
Electricity price:	$0.05/kWh, industrial rate

Exercise F (cont.)

Base Case: Maintain and Repair Existing System

Annual electricity cost:	$148,750 (= 2,975,000 kWh at $0.05)
Initial capital investment:	None
Capital replacement costs:	
Years 6, 11, and 16:	$23,760 for anode replacements
Annually recurring OM&R costs:	$32,220 for tank replacements, at the rate of 28 tanks per year, assuming a 10-year tank life

Alternative 1: Solar Water Heating System Financed through Utility Contract

Contract-related data:	
Contract term:	10 years, beginning one year from base date
Loan payments:	$123,833 per year during contract term, fixed
Administrative costs:	$1,000 per year during contract term, increasing at the rate of inflation
Oversight costs:	$1,800 at contract date
Annual electricity cost:	$27,100 (= 542,000 kWh at $0.05)
Initial capital investment:	$1,000,000
	15% (=$150,000) down payment at base date
	85% (= $850,000) financed through UC

Exercise F (cont.)

Capital Replacement costs:	
Year 11:	$30,000 for replacing anodes and controls
Year 11:	$230,400 for replacing tanks
Year 16:	$18,580 for replacing valves, residual value 73%
Annually recurring OM&R costs:	$7,600 for routine maintenance, included in loan payment during contract term

Solution to Exercise F

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise F.xml
Date of Study:	Mon Dec 23 14:42:32 EST 2002
Analysis Type:	Federal Analysis, Financed Project
Project Name:	Exercise F
Project Location:	Hawaii
Analyst:	CDE
Comment:	Evaluate feasibility of replacing electric resistance water heating system with solar system financed through utility energy services contract
Base Date:	June 1, 2002
Study Period:	21 years 0 months (June 1, 2002 through May 31, 2023)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are NOMINAL (inclusive of general inflation)

Alternative: Existing system

Comment: Maintaining the system requires tank replacements at a rate of 28 tanks per year

Energy: Electricity

Annual Consumption:	2,975,000.0 kWh
Price per Unit:	$0.05000
Demand Charge:	$0
Utility Rebate:	$0
Location:	Hawaii
Rate Schedule:	Industrial
State:	Hawaii

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	Remaining	100%

Component:

Initial Investment

Initial Cost Paid By Agency (base-year $):	$0
Initial Cost Financed (base-year $):	$0
Annual Rate of Increase:	2.3%
Expected Asset Life:	20 years 0 months

Residual Value Factor: 0%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Replacement: Year 6 Anode Replacement

Years/Months:	6 years 0 months
Amount:	$23,760
Annual Rate Of Increase:	2.3%
Expected Asset Life:	5 years 0 months
Residual Value Factor:	0%

Replacement: Year 11 Anode Replacement

Years/Months:	11 years 0 months
Amount:	$23,760
Annual Rate Of Increase:	2.3%
Expected Asset Life:	5 years 0 months
Residual Value Factor:	0%

Replacement: Year 16 Anode Replacement

Years/Months:	16 years 0 months
Amount:	$23,760
Annual Rate Of Increase:	2.3%
Expected Asset Life:	5 years 0 months
Residual Value Factor:	20%

Routine Recurring OM&R: Tank replacements

Amount:	$32,220
Annual Rate of Increase:	2.3%

Usage Indices

From Date	Duration	Factor
June 1, 2002	1 year 0 months	0%
June 1, 2003	Remaining	100%

Alternative: Solar Water Heating System

Comment: 85% of the cost of the solar water heating system will be financed through a utility contract

Recurring Contract: Annual Loan Payment

Amount: $123,833

Escalation Rates

From Date	Duration	Escalation

From Date	Duration	Escalation
June 1, 2002	Remaining	0%

Usage Indices

From Date	Duration	Factor
June 1, 2002	1 year 0 months	0%
June 1, 2003	10 years 0 months	100%
June 1, 2013	Remaining	0%

Recurring Contract: Administrative Costs

Amount: $1,000

Escalation Rates

From Date	Duration	Escalation
June 1, 2002	Remaining	2.3%

Usage Indices

From Date	Duration	Factor
June 1, 2002	1 year 0 months	0%
June 1, 2003	10 years 0 months	100%
June 1, 2013	Remaining	0%

Years/Months:	1 year 0 months
Amount:	$1,800
Annual Rate of Increase:	2.3%

Energy: Electricity after impl.

Annual Consumption:	542,000.0 kWh
Price per Unit:	$0.05000
Demand Charge:	$0
Utility Rebate:	$0
Location:	Hawaii
Rate Schedule:	Industrial
State:	Hawaii

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	1 year 0 months	0%
June 1, 2003	Remaining	100%

Energy: Electricity before impl.

Annual Consumption:	2,975,000.0 kWh
Price per Unit:	$0.05000
Demand Charge:	$0
Utility Rebate:	$0
Location:	Hawaii
Rate Schedule:	Industrial
State:	Hawaii

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	1 year 0 months	100%
June 1, 2003	Remaining	0%

Component:

Initial Investment

Initial Cost Paid By Agency (base-year $):	$150,000
Initial Cost Financed (base-year $):	$850,000
Annual Rate of Increase:	2.3%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Replacement: Anodes/Controls

Years/Months:	11 years 0 months
Amount:	$30,000
Annual Rate Of Increase:	2.3%
Expected Asset Life:	10 years 0 months
Residual Value Factor:	0%

Replacement: Tanks

Years/Months:	11 years 0 months
Amount:	$230,400
Annual Rate Of Increase:	2.3%
Expected Asset Life:	10 years 0 months
Residual Value Factor:	0%

Replacement: Valves

Years Months	15 years 0 months
Amount:	$13,530
Annual Rate Of Increase:	2.3%
Expected Asset Life:	15 years 0 months
Residual Value Factor:	73%

Routine Recurring OM&R: Routine OM&R

Amount:	$7,600
Annual Rate of Increase:	2.3%

Usage Indices

From Date	Duration	Factor
June 1, 2002	11 years 0 months	0%
June 1, 2013	Remaining	100%

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Existing system
Alternative: Solar Water Heating System

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise F.xml
Date of Study:	Mon Dec 23 14:42:44 EST 2002
Project Name:	Exercise F
Project Location:	Hawaii
Analysis Type:	Federal Analysis, Financed Project
Analyst:	CDE
Comment	Evaluate feasibility of replacing electric resistance water heating system with solar system financed through utility energy services contract
Base Date:	June 1, 2002
Study Period:	21 years 0 months (June 1, 2002 through May 31, 2023)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs Paid By Agency:			
Capital Requirements as of Base Date	$0	$150,000	-$150,000
Future Costs:			
Recurring and Non-Recurring Contract Costs	$0	$891,050	-$891,050
Energy Consumption Costs	$1,892,908	$454,496	$1,438,412
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$456,050	$45,385	$410,665
Capital Replacements	$50,823	$195,367	-$144,544
Residual Value at End of Study Period	-$2,453	-$7,001	$4,548
	------------	------------	------------
Subtotal (for Future Cost Items)	$2,397,329	$1,579,298	$818,032
	------------	------------	------------
Total PV Life-Cycle Cost	$2,397,329	$1,729,298	$668,032

Net Savings from Alternative Compared with Base Case

PV of Operational Savings $1,849,078
- PV of Differential Costs $1,181,046

Net Savings $668,032

NOTE: Meaningful SIR, AIRR and Payback can not be computed for Financed Projects.

Comparison of Contract Payments and Savings from Alternative

(undiscounted)

Year Beginning	Savings in Contract Costs	Savings in Energy Costs	Savings in Total Operational Costs	Savings in Total Costs
Jun 2002	$0	$0	$0	-$150,000
Jun 2003	-$126,721	$113,268	$146,986	$20,265
Jun 2004	-$124,904	$111,822	$146,315	$21,411
Jun 2005	-$124,928	$112,597	$147,883	$22,955
Jun 2006	-$124,953	$114,904	$151,001	$26,048
Jun 2007	-$124,979	$118,094	$155,023	$30,044
Jun 2008	-$125,005	$121,286	$159,064	$61,292
Jun 2009	-$125,032	$124,168	$162,814	$37,781
Jun 2010	-$125,060	$126,509	$166,043	$40,983
Jun 2011	-$125,088	$126,192	$166,638	$41,549
Jun 2012	-$125,117	$128,083	$169,458	$44,340
Jun 2013	$0	$130,595	$162,937	-$140,960
Jun 2014	$0	$133,649	$166,734	$166,734
Jun 2015	$0	$137,036	$170,884	$170,884
Jun 2016	$0	$140,334	$174,960	$174,960
Jun 2017	$0	$143,371	$178,793	$178,793
Jun 2018	$0	$146,628	$182,864	$190,317
Jun 2019	$0	$149,712	$186,783	$186,783
Jun 2020	$0	$152,548	$190,471	$190,471
Jun 2021	$0	$155,434	$194,229	$194,229
Jun 2022	$0	$158,365	$198,049	$212,253

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	2,975,000.0 kWh	657,796.7 kWh	2,317,203.3 kWh	48,653,338.8 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	10,151.1 MBtu	2,244.5 MBtu	7,906.6 MBtu	166,012.0 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO_2	2,322,274.32 kg	513,520.93 kg	1,808,753.40 kg	37,977,631.27 kg
SO_2	4,079.77 kg	922.08 kg	3,157.69 kg	66,300.61 kg
NO_x	4,402.53 kg	973.52 kg	3,429.00 kg	71,997.34 kg
Total:				
CO_2	2,322,274.32 kg	513,520.93 kg	1,808,753.40 kg	37,977,631.27 kg
SO_2	4,079.77 kg	922.08 kg	3,157.69 kg	66,300.61 kg
NO_x	4,402.53 kg	973.52 kg	3,429.00 kg	71,997.34 kg

Module G
Exercises

Exercise G1

Water Conservation

A military barracks at Fort Meade, MD, housing 200 enlisted men, uses 800,000 gallons of water per year at a cost of $4.00/1000 gallons of use plus, $5.00/1000 gallons sewer charge. This barracks is scheduled to be replaced with a new barracks in seven years. A water conservation project is proposed that will reduce usage and disposal by 25% at an initial cost of $5,000, and has no maintenance costs over the seven years of remaining building life. All of the project components have a life expectancy of seven years or more. Water usage and disposal prices are expected to increase by an average of 5%/year over general inflation for the remaining life of the building. During the last two years of the barracks' life, the occupancy level (and thus water consumption) is expected to be half of the current level.

The base date and beneficial occupancy date are specified as June 2002. Use the mid-year discounting convention.

Using the MILCON module in BLCC5, compute the life-cycle water-related costs before and after the retrofit project. Compute the net savings and savings-to-investment ratio. Would you recommend this project be undertaken?

Exercise G2

Energy and Water Conservation Project under the DoD Energy Conservation Investment Program

The energy managers at a DoD ammunitions storage plant in Missouri plan to retrofit an existing hot water system in one of their warehouses. They intend to apply for ECIP funding and are using BLCC5 to perform and format the economic analysis of the project in accordance with the ECIP application requirements.

The estimated costs and savings for the project are as follows:

Total estimated project cost: $22,100, of which 6% is attributed to SIOH (supervision, inspection and overhead) and 10% to Design Cost. The existing system has a salvage value of $200, and a public utility rebate of $1,900 is available. The new system will use more coal than the existing system.

Expected annual savings/costs are as follows:

Savings in electricity:	34 MBtu at $556.00/MBtu, industrial rate
Increased coal usage:	100 MBtu at $1.00/MBtu, industrial rate
Water/sewer savings:	4.0 million gallons at $1,000.00/Mgal
OM&R cost savings:	$400/year
Non-annually recurring OM&R savings:	$2,400 in years 10 and 15.

Determine present value life-cycle cost savings, savings-to-investment ratio, and payback period for the project.

Exercise G3

Chiller Replacement

As energy manager of a federal research facility, you are tasked with replacing the existing 1000-ton chiller, which has an expected remaining life of 10 years but must be replaced to eliminate CFC usage. You have submitted technical specifications and operating conditions to all large chiller manufacturers and asked for bid responses which are to include the following cost and energy-related data: first cost, annual energy costs based on current electricity costs, and the operating schedule that you submit. The manufacturers must calculate annual energy usage and peak energy usage for their system using a standardized energy-estimating method. You inform the manufacturers that you will select the bid with the lowest 25-year life-cycle cost, using current FEMP LCC criteria (3.2 % discount rate and DOE escalation rates (South (Texas), industrial rates) and the BLCC computer program to perform the LCC calculations. Since you expect that maintenance costs after the end of the 10-year service contract will be similar for all systems, O&M costs can be ignored after year 10. Current electricity costs are $.048/kWh for electricity usage (same during winter and summer) and $104/kW-y demand charge for peak kW demand. (Multiply the maximum annual kW demand by $104 to get the annual demand charge.) Water costs and other operating costs are assumed to be similar for all systems for the purpose of this competition. The base date and service date for all LCC analyses are specified as June 2002. Use the end-of-year discounting convention.

Exercise G3 (cont.)

Three manufacturers responded to this submission, with the following proposals:

	Best Freeze	Icy Nights	Snow Drift
First Cost	$360,000	$256,000	$310,000
Annual kWh	$3,125,407	$2,984,564	$2,728,486
Maximum kW	$600	$560	$530
Service Contract Year:			
1	$4,000	$10,000	$0
2	$4,000	$10,000	$0
3	$6,000	$10.000	$0
4	$6,000	$10.000	$0
5	$8,000	$10,000	$15,000
6	$8,000	$10,000	$15,000
7	$10,000	$10,000	$15,000
8	$10,000	$10.000	$15,000
9	$20,000	$10,000	$15,000
10	$20,000	$10.000	$15,000
LCC	**$4,080,906**	**$3,796,736**	**$3,573,108**

Your job is to check the LCC computations submitted by each of the manufacturers before announcing who has won the bid competitions.

Exercise G4

Alternative Financing of Energy Conservation Project

A federal agency in Arizona is considering replacing an existing lighting system in an office building with a new lighting/daylighting system financed through a utility contract. The existing lighting system is expected to be operational for another 15 years. Use BLCC5 to perform an LCC analysis.

Project Information

Location:	Arizona
Base Date:	June 2002
Study Period:	15 years
Contract Term:	10 years
Discount Rate:	5.6 %
Annual Rate of Inflation:	2.3 %
Discounting Convention:	end-of-year

Exercise G4 (cont.)

Base Case

Initial Investment Cost:	0
Energy Type:	Electricity
Annual Usage:	1,082,633 kWh
Price:	$0.04600/kWh, commercial
Annual Demand Charge:	$30,105
Annual OM&R costs:	$5,600

Alternative

Amount Borrowed:	$390,480
Expected Life:	20 years
Residual Value Factor:	25%
Annual Contract Payment:	$62,000, fixed
Energy Type:	Electricity
Annual Usage:	206,911 kWh
Price:	$0.04600/kWh, commercial
Annual Demand Charge: $3,311	
Annual OM&R:	$0 during contract term
	$3,000 in years 11 through 15

Exercise G5

Lease Versus Buy Decision (BLCC4 Exercise)

A federal government agency is considering building a new office building with 60,000 square feet of office space on land that it already owns at an initial cost of $5,000,000. A private investment firm offers to build the same building on private land across the street from the proposed site and lease this facility to the government for 20 years at an annual lease rate of $500,000, with an annual escalation clause that is tied directly to the rate of general inflation. Major building maintenance, which will cost the government $200,000 per year at current prices, is included in the lease amount. All utility costs and other building operating-related costs will be the same for both buildings. The building has an expected life of 50 years and a residual value at the end of the study period equal to 50% of its initial cost, in constant dollar terms. Which alternative is more advantageous to the government?

Use the Federal Analysis--Projects Subject to OMB A-94 Module in BLCC4. June 2002 should be used for the base date and service date. Use the end-of-year discounting convention. The projected annual rate of general inflation is 2.3%. Can this analysis be performed in constant dollars?

Exercise G6

Representative ESPC Project Analysis

The data used in this example are average data from the 71 Super ESPC projects awarded through 2001 and from a group of projects funded from appropriations within a two-year period. One scenario compares the ESPC data to data that take into account the average delay that agencies experience in obtaining funding, the other scenario assumes that the development schedule for an appropriations-funded project is the same as for the average Super ESPC project.

Perform an LCC analysis to determine whether, on average, ESPCs are cost-effective when compared with projects funded by agencies from appropriations. Evaluate the ESPC project against

(1) an experience-based agency-funded project and

(2) an agency-funded project where a more efficient, "best-case" project development schedule is assumed.

Note: *Only data on energy costs saved by the energy conservation measures are available. There is no description of the "status quo." Therefore, for all three alternatives enter only the "excess" energy costs during the implementation periods and zero energy costs thereafter. Excess energy costs in this case include energy-related operation, maintenance, repair and replacement (OMR&R) costs.*

Exercise G6 (cont.)

Use the following average input values to perform the analysis in BLCC5. All amounts are stated in base-year dollars:

General Information	
Location:	U.S. Average
Discount rate:	5.6% nominal
Inflation rate:	2.3%
Analysis:	in current dollars
Discounting convention:	end-of-year
Key Dates	
Base date:	June 2002
Study period:	20 years
Expected asset life:	20 years
Implementation period:	2 years 3 months for ESPC-financed project, 5 years 3 months for experience-based agency-funded project, 2 years 3 months for best-case agency-funded project
Performance (contract) period for ESPC project:	16 years 8 months

Exercise G6 (cont.)

Alternative I: ESPC Project

Guaranteed energy savings:	$354,000 per year, beginning with performance period date (2 years 4 months from base date), increasing at an average rate of 1.87%
Annual contractor payment:	98% of guaranteed savings, beginning 2 years 4 months after base date, increasing at a rate of 1.87%
Project facilitation fee to DOE:	$30,000, 3 months from base date, increasing at 2.3%
Financing procurement costs:	$236,000, 2 years 4 months from base date, increasing at 2.3%
"Excess" energy costs during implementation period:	$354,000 per year during implementation period of 2 years 3 months, increasing at an average rate of 1.87%
Total investment cost:	$3,263,000, increasing at 2.3%
Initial cost paid by agency:	$273,000, 2 years 4 months from base date
Initial cost financed:	$2,990,000
Residual value factor:	11.25%
Post-contract OMR&R costs:	$36,400 annually, increasing at 3.95%

Exercise G6 (cont.)

Alternative II: Experience-Based Agency-Funded Project

"Excess" energy costs:	$354,000 per year during implementation period of 5 years 3 months, increasing at 1.87%
Initial cost paid by agency:	$3,263,000, 2 years 10 months from base date, increasing at 2.3%
Residual value factor:	26.25%
OMR&R costs:	$36,400 annually, beginning after implementation period, increasing at 3.95%
In-house pre-feasibility study:	$2,000, 1 month from base date, increasing at 2.3%
Funding-request – feasibility study:	$600, 7 months from base date, increasing at 2.3%
Cost of feasibility study:	$815,750, 10 months from base date, increasing at 2.3%
Funding request – design/construction:	$600, 2 years 7 month after base date, increasing at 2.3%

Exercise G6 (cont.)

Alternative III: Best-Case Agency-Funded Project

"Excess" energy costs:	$354,000 per year during implementation period of 2 years 3 months, increasing at 1.87%
Initial cost paid by agency:	$3,263,000, 9 months from base date, increasing at 2.3%
Residual value factor:	11.25%
OMR&R costs:	$36,400 annually, beginning after implementation period of 2 years 3 months, increasing at 3.95%
Cost of feasibility study:	$127,257, 1 month from base date, increasing at 2.3%

Solution to Exercise G1

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise G1.xml
Date of Study:	Mon Jun 03 14:43:15 EDT 2002
Analysis Type:	MILCON Analysis, Energy Project
Project Name:	Exercise G1
Project Location:	Maryland
Analyst:	ASR
Comment:	Water conservation in Military Barracks at Fort Meade, MD
Base Date:	June 1, 2002
Beneficial Occupancy Date:	June 1, 2002
Study Period:	7 years 0 months (June 1, 2002 through May 31, 2009)
Discount Rate:	3.2%
Discounting Convention:	Mid-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

Alternative: Existing

Water: Water

	Annual Usage		Annual Disposal	
	Units/Year	**Price/Unit**	**Units/Year**	**Price/Unit**
@Summer Rates	800.0 ThousGal	$4.00000	800.0 ThousGal	$5.00000
@Winter Rates	0.0 ThousGal	$0.00000	0.0 ThousGal	$0.00000

Escalation Rates - Usage

From Date	Duration	Usage Cost Escalation
June 1, 2002	Remaining	5.00%

Escalation Rates - Disposal

From Date	Duration	Disposal Cost Escalation
June 1, 2002	Remaining	5.00%

Usage Indices - Usage

From Date	Duration	Index
June 1, 2002	5 years 0 months	100%
June 1, 2007	Remaining	50%

Usage Indices - Disposal

From Date	Duration	Index
June 1, 2002	5 years 0 months	100%
June 1, 2007	Remaining	50%

Component:

Initial Investment

Initial Cost (base-year $):	$0
Annual Rate of Increase:	0%
Expected Asset Life:	0 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Alternative: Water Project

Comment: The water conservation project will reduce usage and disposal by 25%

Water: Water

	Annual Usage		Annual Disposal	
	Units/Year	Price/Unit	Units/Year	Price/Unit
@Summer Rates	600.0 ThousGal	$4.00000	600.0 ThousGal	$5.00000
@Winter Rates	0.0 ThousGal	$0.00000	0.0 ThousGal	$0.00000

Escalation Rates - Usage

From Date	Duration	Usage Cost Escalation
June 1, 2002	Remaining	5.00%

Escalation Rates - Disposal

From Date	Duration	Disposal Cost Escalation
June 1, 2002	Remaining	5.00%

Usage Indices - Usage

From Date	Duration	Index
June 1, 2002	5 years 0 months	100%
June 1, 2007	Remaining	50%

Usage Indices - Disposal

From Date	Duration	Index
June 1, 2002	5 years 0 months	100%
June 1, 2007	Remaining	50%

Component: Copy of:

Initial Investment

Initial Cost (base-year $):	$5,000
Annual Rate of Increase:	0%
Expected Asset Life:	0 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Existing
Alternative: Water Project

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise G1.xml
Date of Study:	Mon Jun 03 14:43:24 EDT 2002
Project Name:	Exercise G1
Project Location:	Maryland
Analysis Type:	MILCON Analysis, Energy Project
Analyst:	ASR
Comment	Water conservation in Military Barracks at Fort Meade, MD
Base Date:	June 1, 2002
Beneficial Occupancy Date:	June 1, 2002
Study Period:	7 years 0 months(June 1, 2002 through May 31, 2009)
Discount Rate:	3.2%
Discounting Convention:	Mid-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$0	$5,000	-$5,000
Future Costs:			
Energy Consumption Costs	$0	$0	$0
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$45,589	$34,192	$11,397
Routine Recurring and Non-Recurring OM&R Costs	$0	$0	$0
Major Repair and Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	$0	$0
	------------	------------	------------
Subtotal (for Future Cost Items)	$45,589	$34,192	$11,397
	------------	------------	------------
Total PV Life-Cycle Cost	$45,589	$39,192	$6,397

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$11,397
- Increased Total Investment	$5,000

Net Savings	$6,397

Savings-to-Investment Ratio (SIR)

SIR = 2.28

Adjusted Internal Rate of Return

AIRR = 16.09%

Payback Period

Estimated Years to Payback (from beginning of Beneficial Occupancy Period)

Simple Payback occurs in year	3
Discounted Payback occurs in year	3

Solution to Exercise G2

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise G2.xml
Date of Study:	Mon Jun 03 14:47:57 EDT 2002
Analysis Type:	MILCON Analysis, ECIP Project
Project Name:	Exercise G2
Project Location:	Missouri
Analyst:	SKF
Comment:	Energy/Water Conservation Project PN 175 (FY02) - ECIP ABCDE Ammo. Plant, Missouri
Base Date:	June 1, 2002
Beneficial Occupancy Date:	June 1, 2005
Study Period:	25 years 0 months (June 1, 2002 through May 31, 2027)
Discount Rate:	3.2%
Discounting Convention:	Mid-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

Savings from Alternative:

Energy Savings/Cost: Electricity

Annual Savings:	34.0 MBtu
Price per Unit:	$556.00000
Demand Charge:	$0
Utility Rebate:	$0
Location:	Missouri
Rate Schedule:	Industrial
State:	Missouri

Usage Indices

From Date	Duration	Usage Index
June 1, 2005	Remaining	100%

Energy Savings/Cost: Coal

Annual Savings:	-100.0 MBtu
Price per Unit:	$1.00000
Demand Charge:	$0
Utility Rebate:	$0
End-Use:	Pulverized coal fired, Dry bottom

Rate Schedule:	Industrial
State:	Missouri

Usage Indices

From Date	Duration	Usage Index
June 1, 2005	Remaining	100%

Water Savings/Cost: Water

	Annual Usage		Annual Disposal	
	Units/Year	Price/Unit	Units/Year	Price/Unit
@Summer Rates	4,000.0 ThousGal	$1.00000	4,000.0 ThousGal	$1.00000
@Winter Rates	0.0 ThousGal	$0.00000	0.0 ThousGal	$0.00000

Escalation Rates - Usage

From Date	Duration	Usage Cost Escalation
June 1, 2002	Remaining	0%

Escalation Rates - Disposal

From Date	Duration	Disposal Cost Escalation
June 1, 2002	Remaining	0%

Usage Indices - Usage

From Date	Duration	Index
June 1, 2005	Remaining	100%

Usage Indices - Disposal

From Date	Duration	Index
June 1, 2005	Remaining	100%

Capital Component Savings/Costs:

Additional Investment Cost

Construction Cost:	$18,564
SIOH:	$1,326
Design Cost:	$2,210
Total Cost:	$22,100
Salvage Value of Existing Equipment:	$200
Public Utility Company Rebate:	$1,900
Total Investment:	$20,000

Annually Recurring Savings/Cost: Annually Recurring Costs

Amount Saved:	$400
Annual Rate of Increase:	0%

Usage Indices

From Date	Duration	Factor
June 1, 2005	Remaining	100%

Non-Annually Recurring Savings/Costs: NARC 1

Years/Months:	10 years 0 months
Amount Saved:	$2,400
Annual Rate of Increase:	0%

Non-Annually Recurring Savings/Costs: NARC 2

Years/Months:	15 years 0 months
Amount Saved:	$2,400
Annual Rate of Increase:	0%

NIST BLCC 5.1-02: ECIP Report

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

The LCC calculations are based on the FEMP discount rates and energy price escalation rates updated on April 1, 2002.

Location:	Missouri	**Discount Rate:**	3.2%
Project Title:	Exercise G2	**Analyst:**	SKF
Base Date:	June 1, 2002	**Preparation Date:**	Mon Jun 03 14:48:06 EDT 2002
BOD:	June 1, 2005	**Economic Life:**	25 years 0 months
File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise G2.xml		

1. Investment

Construction Cost	$18,564
SIOH	$1,326
Design Cost	$2,210
Total Cost	$22,100
Salvage Value of Existing Equipment	$200
Public Utility Company Rebate	$1,900
Total Investment	$20,000

2. Energy and Water Savings (+) or Cost (-)

Base Date Savings, unit costs, & discounted savings

Item	Unit Cost	Usage Savings	Annual Savings	Discount Factor	Discounted Savings
Electricity	$556.00000	34.0 MBtu	$18,904	14.971	$283,017
Coal	$1.00000	-100.0 MBtu	-$100	13.155	-$1,316
Energy Subtotal		-66.0 MBtu	$18,804		$281,702
Water Usage	$1000.00000	4.0 Mgal	$4,000	14.439	$57,756
Water Disposal	$1000.00000	4.0 Mgal	$4,000	14.439	$57,756
Water Subtotal		8.0 Mgal	$8,000		$115,513
Total			$26,804		$397,215

3. Non-Energy Savings (+) or Cost (-)

Item	Savings/Cost	Occurrence	Discount Factor	Discounted Savings/Cost
Annually Recurring	$400	Annual	14.439	$5,776

Non-Annually Recurring				
NARC 1	$2,400	10 years 0 months	0.730	$1,752
NARC 2	$2,400	15 years 0 months	0.623	$1,496
Non-Annually Recurring Subtotal	$4,800			$2,955
Total	$5,200			$8,731

4. First year savings	$27,396
5. Simple Payback Period (in years)	0.73 (total investment/first-year savings)
6. Total Discounted Operational Savings	$405,945
7. Savings to Investment Ratio (SIR)	20.30 (total discounted operational savings/total investment)
8. Adjusted Internal Rate of Return (AIRR)	16.41% (1+d)*SIR^(1/n)-1; d=discount rate, n=years in study period

Solution to Exercise G3

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise G3.xml
Date of Study:	Mon Jun 03 16:40:29 EDT 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Exercise G3
Project Location:	Texas
Analyst:	ASR
Base Date:	June 1, 2002
Service Date:	June 1, 2002
Study Period:	25 years 0 months (June 1, 2002 through May 31, 2027)
Discount Rate:	3.2%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

Alternative: Best Freeze

Energy: Electricity

Annual Consumption:	3,125,407.0 kWh
Price per Unit:	$0.04800
Demand Charge:	$62,400
Utility Rebate:	$0
Location:	Texas
Rate Schedule:	Industrial
State:	Texas

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	Remaining	100%

Component:

Initial Investment

Initial Cost (base-year $):	$360,000
Annual Rate of Increase:	0%
Expected Asset Life:	25 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Non-Recurring OM&R: Year 1

Years/Months:	1 year 0 months
Amount:	$4,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 2

Years/Months:	2 years 0 months
Amount:	$4,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 3

Years/Months:	3 years 0 months
Amount:	$6,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 4

Years/Months:	4 years 0 months
Amount:	$6,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 5

Years/Months:	5 years 0 months
Amount:	$8,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 6

Years/Months:	6 years 0 months
Amount:	$8,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 7

Years/Months:	7 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 8

Years/Months:	8 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 9

Years/Months:	9 years 0 months
Amount:	$20,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 10

Years/Months:	10 years 0 months
Amount:	$20,000
Annual Rate of Increase:	0%

Alternative: Icy Nights

Energy: Electricity

Annual Consumption:	2,984,564.0 kWh
Price per Unit:	$0.04800
Demand Charge:	$58,240
Utility Rebate:	$0
Location:	Texas
Rate Schedule:	Industrial
State:	Texas

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	Remaining	100%

Component:

Initial Investment

Initial Cost (base-year $):	$256,000
Annual Rate of Increase:	0%
Expected Asset Life:	25 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Non-Recurring OM&R: Year 1

Years/Months:	1 year 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 2

Years/Months:	2 years 0 months

Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 3

Years/Months:	3 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 4

Years/Months:	4 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 5

Years/Months:	5 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 6

Years/Months:	6 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 7

Years/Months:	7 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 8

Years/Months:	8 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 9

Years/Months:	9 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 10

Years/Months:	10 years 0 months
Amount:	$10,000
Annual Rate of Increase:	0%

Alternative: Snow Drift

Energy: Electricity

Annual Consumption:	2,728,486.0 kWh
Price per Unit:	$0.04800
Demand Charge:	$55,120
Utility Rebate:	$0
Location:	Texas
Rate Schedule:	Industrial
State:	Texas

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	Remaining	100%

Component:

Initial Investment

Initial Cost (base-year $):	$310,000
Annual Rate of Increase:	0%
Expected Asset Life:	25 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 0%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Non-Recurring OM&R: Year 1

Years/Months:	1 year 0 months
Amount:	$0
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 2

Years/Months:	2 years 0 months
Amount:	$0
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 3

Years/Months:	3 years 0 months
Amount:	$0
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 4

Years/Months:	4 years 0 months
Amount:	$0
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 5

Years/Months:	5 years 0 months
Amount:	$15,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 6

Years/Months:	6 years 0 months
Amount:	$15,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 7

Years/Months:	7 years 0 months
Amount:	$15,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 8

Years/Months:	8 years 0 months
Amount:	$15,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 9

Years/Months:	9 years 0 months
Amount:	$15,000
Annual Rate of Increase:	0%

Non-Recurring OM&R: Year 10

Years/Months:	10 years 0 months
Amount:	$15,000
Annual Rate of Increase:	0%

NIST BLCC 5.1-02: Summary LCC

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise G3.xml
Date of Study:	Mon Jun 03 16:40:46 EDT 2002
Analysis Type:	FEMP Analysis, Energy Project
Project Name:	Exercise G3
Project Location:	Texas
Analyst:	ASR
Base Date:	June 1, 2002
Service Date:	June 1, 2002
Study Period:	25 years 0 months (June 1, 2002 through May 31, 2027)
Discount Rate:	3.2%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are REAL (exclusive of general inflation)

Alternative: Best Freeze

LCC Summary

	Present Value	Annual Value
Initial Cost	$360,000	$21,139
Energy Consumption Costs	$2,573,274	$151,104
Energy Demand Costs	$1,070,343	$62,851
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$0	$0
Non-Annually Recurring OM&R Costs	$77,289	$4,538
Replacement Costs	$0	$0
Less Remaining Value	$0	$0
	------------	------------
Total Life-Cycle Cost	$4,080,906	$239,632

Alternative: Icy Nights

LCC Summary

	Present Value	Annual Value
Initial Cost	$256,000	$15,032
Energy Consumption Costs	$2,457,312	$144,294
Energy Demand Costs	$998,987	$58,661
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$0	$0
Non-Annually Recurring OM&R Costs	$84,437	$4,958
Replacement Costs	$0	$0
Less Remaining Value	$0	$0
	------------	------------
Total Life-Cycle Cost	$3,796,736	$222,946

Alternative: Snow Drift

LCC Summary

	Present Value	Annual Value
Initial Cost	$310,000	$18,203
Energy Consumption Costs	$2,246,473	$131,914
Energy Demand Costs	$945,469	$55,518
Energy Utility Rebates	$0	$0
Water Usage Costs	$0	$0
Water Disposal Costs	$0	$0
Annually Recurring OM&R Costs	$0	$0
Non-Annually Recurring OM&R Costs	$71,165	$4,179
Replacement Costs	$0	$0
Less Remaining Value	$0	$0
	------------	------------
Total Life-Cycle Cost	$3,573,108	$209,814

Solution to Exercise G4

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise G4.xml
Date of Study:	Mon Jun 03 16:51:15 EDT 2002
Analysis Type:	Federal Analysis, Financed Project
Project Name:	Exercise G4
Project Location:	Arizona
Analyst:	ASR
Comment:	Replace existing lighting system with new system financed through a utility contract.
Base Date:	June 1, 2002
Study Period:	15 years 0 months (June 1, 2002 through May 31, 2017)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are NOMINAL (inclusive of general inflation)

Alternative: Existing

Comment: Base Case: Keep existing system for remaining 15 years of its useful life.

Energy: Electricity

Annual Consumption:	1,082,633.0 kWh
Price per Unit:	$0.04600
Demand Charge:	$30,105
Utility Rebate:	$0
Location:	Arizona
Rate Schedule:	Commercial
State:	Arizona

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	Remaining	100%

Component: Existing System

Comment: Keep existing system for the remaining 15 years of its useful life.

Initial Investment

Initial Cost Paid By Agency (base-year $):	$0
Initial Cost Financed (base-year $):	$0
Annual Rate of Increase:	2.3%

Expected Asset Life:	15 years 0 months
Residual Value Factor:	0%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Routine Recurring OM&R: OM&R Cost

Amount:	$5,600
Annual Rate of Increase:	2.3%

Usage Indices

From Date	Duration	Factor
June 1, 2002	Remaining	100%

Alternative: Lighting Retrofit

Recurring Contract: Annual Contract Payment

Amount: $62,000

Escalation Rates

From Date	Duration	Escalation
June 1, 2002	Remaining	0%

Usage Indices

From Date	Duration	Factor
June 1, 2002	10 years 0 months	100%
June 1, 2012	Remaining	0%

Energy: Electricity

Annual Consumption:	206,911.0 kWh
Price per Unit:	$0.04600
Demand Charge:	$3,311
Utility Rebate:	$0
Location:	Arizona
Rate Schedule:	Commercial
State:	Arizona

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	Remaining	100%

Component: New System

Comment: Install new lighting/daylighting system financed through UC contract

Initial Investment

Initial Cost Paid By Agency (base-year $):	$0
Initial Cost Financed (base-year $):	$390,480
Annual Rate of Increase:	2.3%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	25%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
0 years 0 months	June 1, 2002	100%

Routine Recurring OM&R: Post-Contract OM Costs

Amount: $3,000

Annual Rate of Increase: 2.3%

Usage Indices

From Date	Duration	Factor
June 1, 2002	10 years 0 months	0%
June 1, 2012	Remaining	100%

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Existing
Alternative: Lighting Retrofit

General Information

File Name:	C:\Program Files\BLCC5\projects\2002 Workshop\Exercises\Exercise G4.xml
Date of Study:	Mon Jun 03 16:51:25 EDT 2002
Project Name:	Exercise G4
Project Location:	Arizona
Analysis Type:	Federal Analysis, Financed Project
Analyst:	ASR
Comment	Replace existing lighting system with new system financed through a utility contract.
Base Date:	June 1, 2002
Study Period:	15 years 0 months(June 1, 2002 through May 31, 2017)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs Paid By Agency:			
Capital Requirements as of Base Date	$0	$0	$0
Future Costs:			
Recurring and Non-Recurring Contract Costs	$0	$465,748	-$465,748
Energy Consumption Costs	$492,942	$94,210	$398,732
Energy Demand Charges	$297,986	$32,773	$265,213
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$65,901	$9,971	$55,930
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	$0	-$60,866	$60,866
	------------	------------	------------
Subtotal (for Future Cost Items)	$856,829	$541,837	$314,992
	------------	------------	------------
Total PV Life-Cycle Cost	$856,829	$541,837	$314,992

Net Savings from Alternative Compared with Base Case

PV of Operational Savings	$719,875
- PV of Differential Costs	$404,883

Net Savings	$314,992

NOTE: Meaningful SIR, AIRR and Payback can not be computed for Financed Projects.

Comparison of Contract Payments and Savings from Alternative

(undiscounted)

Year Beginning	Savings in Contract Costs	Savings in Energy Costs	Savings in Total Operational Costs	Savings in Total Costs
Jun 2002	-$62,000	$63,851	$69,580	$7,580
Jun 2003	-$62,000	$62,557	$68,417	$6,417
Jun 2004	-$62,000	$61,508	$67,503	$5,503
Jun 2005	-$62,000	$61,675	$67,807	$5,807
Jun 2006	-$62,000	$62,771	$69,045	$7,045
Jun 2007	-$62,000	$64,394	$70,812	$8,812
Jun 2008	-$62,000	$66,030	$72,596	$10,596
Jun 2009	-$62,000	$67,512	$74,229	$12,229
Jun 2010	-$62,000	$68,933	$75,804	$13,804
Jun 2011	-$62,000	$68,688	$75,717	$13,717
Jun 2012	$0	$69,639	$72,978	$72,978
Jun 2013	$0	$71,005	$74,421	$74,421
Jun 2014	$0	$72,576	$76,070	$76,070
Jun 2015	$0	$74,380	$77,954	$77,954
Jun 2016	$0	$76,155	$79,811	$217,106

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	1,082,633.0 kWh	206,911.0 kWh	875,722.0 kWh	13,134,031.8 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	3,694.1 MBtu	706.0 MBtu	2,988.1 MBtu	44,815.2 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO_2	881,777.18 kg	168,523.77 kg	713,253.41 kg	10,697,336.55 kg
SO_2	1,080.53 kg	206.51 kg	874.02 kg	13,108.51 kg
NO_x	2,880.63 kg	550.54 kg	2,330.09 kg	34,946.56 kg
Total:				
CO_2	881,777.18 kg	168,523.77 kg	713,253.41 kg	10,697,336.55 kg
SO_2	1,080.53 kg	206.51 kg	874.02 kg	13,108.51 kg
NO_x	2,880.63 kg	550.54 kg	2,330.09 kg	34,946.56 kg

Solution to Exercise G5

```
************************************************************************
* N I S T   B L C C:  I N P U T   D A T A   L I S T I N G (ver. 4.9-02 ) *
************************************************************************

FILE NAME: G5-1
FILE LAST MODIFIED ON 06-04-2002/08:49:00
PROJECT NAME: Exercise G5
PROJECT ALTERNATIVE: buy
COMMENT: (NONE)

GENERAL DATA:
-------------
ANALYSIS TYPE: Federal Analysis--Projects Subject to OMB A-94
BASE DATE FOR LCC ANALYSIS: JUN 2002
STUDY PERIOD: 20 YEARS, 0 MONTHS
SERVICE DATE:   JUN 2002
DISCOUNT AND INTEREST RATES ARE Real (exclusive of general inflation)
DISCOUNT RATE:  3.5%
End-of-year discounting convention
Escalation rates do not include general inflation

CAPITAL ASSET COST DATA:
------------------------
INITIAL COST (BASE YEAR $)          5000000
EXPECTED ASSET LIFE (YRS/MTHS)         50/0
RESALE VALUE FACTOR                  50.00%
AVG PRICE ESC RATE(SERVICE PD.)       0.00%
NUMBER OF REPLACEMENTS                    0

NO REPLACEMENTS


OPERATING, MAINTENANCE, AND REPAIR COST DATA:
---------------------------------------------
ANNUAL RECUR OM&R COST ($): 200000
ESCALATION RATE FOR OM&R:     0.00%

No non-annually-recurring OM&R costs reported.

ENERGY-RELATED DATA:
-----------------
NUMBER OF ENERGY TYPES = 0
```

```
***********************************************************************
* N I S T   B L C C:  I N P U T   D A T A   L I S T I N G (ver. 4.9-02 ) *
***********************************************************************

FILE NAME: G5-2
FILE LAST MODIFIED ON 06-04-2002/08:50:00
PROJECT NAME: Exercise G5
PROJECT ALTERNATIVE: lease
COMMENT: (NONE)

GENERAL DATA:
-------------
ANALYSIS TYPE: Federal Analysis--Projects Subject to OMB A-94
BASE DATE FOR LCC ANALYSIS: JUN 2002
STUDY PERIOD: 20 YEARS, 0 MONTHS
SERVICE DATE:   JUN 2002
DISCOUNT AND INTEREST RATES ARE Real (exclusive of general inflation)
DISCOUNT RATE:  3.5%
End-of-year discounting convention
Escalation rates do not include general inflation

CAPITAL ASSET COST DATA:
------------------------
INITIAL COST (BASE YEAR $)              0
EXPECTED ASSET LIFE (YRS/MTHS)       50/0
RESALE VALUE FACTOR                  0.00%
AVG PRICE ESC RATE(SERVICE PD.)      0.00%
NUMBER OF REPLACEMENTS                  0

NO REPLACEMENTS


OPERATING, MAINTENANCE, AND REPAIR COST DATA:
--------------------------------------------
ANNUAL RECUR OM&R COST ($): 500000
ESCALATION RATE FOR OM&R:     0.00%

No non-annually-recurring OM&R costs reported.

ENERGY-RELATED DATA:
-----------------
NUMBER OF ENERGY TYPES = 0
```

BLCC Summary for Project: Exercise G5
Alternative: buy

Filename: G5-1.DAT   Date of Analysis: 06-04-2002/08:52:10
Analysis Type: Federal Analysis--Projects Subject to OMB A-94
Study Period: 20.00 Years (JUN 2002 through MAY 2022)
Discount Rate: 3.50%

	Present Value	Annual Value
Initial Cost (as of Service Date)	$5,000,000	$351,806
Annually Recurring OM&R Costs	$2,842,479	$200,000
Less: Remaining Value	($1,256,416)	($88,403)
Total LCC	$6,586,063	$463,403

BLCC Summary for Project: Exercise G5
Alternative: lease

Filename: G5-2.DAT   Date of Analysis: 06-04-2002/08:52:19
Analysis Type: Federal Analysis--Projects Subject to OMB A-94
Study Period: 20.00 Years (JUN 2002 through MAY 2022)
Discount Rate: 3.50%

	Present Value	Annual Value
Initial Cost (as of Service Date)	$0	$0
Annually Recurring OM&R Costs	$7,106,197	$500,000
Less: Remaining Value	($0)	($0)
Total LCC	$7,106,197	$500,000

Solution to Exercise G6

NIST BLCC 5.1-02: Input Data Listing

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise G6.xml
Date of Study:	Mon Dec 23 14:55:13 EST 2002
Analysis Type:	Federal Analysis, Financed Project
Project Name:	Exercise G6
Project Location:	U.S. Average
Analyst:	JS
Comment:	This is a comparison of an ESPC-funded project with an "experience-based" and a "best-case" appropriations-funded project, using average data calculated from the 71 Super ESPC projects awarded through 2001 and data from a group of projects funded from appropriations.
Base Date:	June 1, 2002
Study Period:	20 years 0 months (June 1, 2002 through May 31, 2022)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Discount and Escalation Rates are NOMINAL (inclusive of general inflation)

Alternative: ESPC Project

Comment: This alternative assumes that the project saves $354,000 annually in energy and energy-related costs of which 98% are paid as contractor payments

Recurring Contract: Annual Contract Payment

Amount: $347,000

Escalation Rates

From Date	Duration	Escalation
June 1, 2002	Remaining	1.87%

Usage Indices

From Date	Duration	Factor
June 1, 2002	2 years 3 months	0%
September 1, 2004	16 years 8 months	100%
May 1, 2021	Remaining	0%

Years/Months:	0 years 3 months
Amount:	$30,000
Annual Rate of Increase:	2.3%
Years/Months:	2 years 4 months
Amount:	$236,000

Annual Rate of Increase: 2.3%

Energy: Excess Energy Costs

Annual Consumption:	354,000.0 kWh
Price per Unit:	$1.00000
Demand Charge:	$0
Utility Rebate:	$0
Location:	U.S. Average
Rate Schedule:	Industrial
State:	U.S. Average

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	2 years 3 months	100%
September 1, 2004	Remaining	0%

Escalation Rates

From Date	Duration	Escalation
June 1, 2002	Remaining	1.87%

Component:

Initial Investment

Initial Cost Paid By Agency (base-year $):	$273,000
Initial Cost Financed (base-year $):	$2,990,000
Annual Rate of Increase:	2.3%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	11.2%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
2 years 5 months	November 1, 2004	100%

Routine Recurring OM&R: Post-contract OMR&R Costs

Amount:	$36,400
Annual Rate of Increase:	4%

Usage Indices

From Date	Duration	Factor
June 1, 2002	2 years 3 months	0%
September 1, 2004	16 years 8 months	0%
May 1, 2021	Remaining	100%

Alternative: Experience-based Agency-funded Project

Comment: The schedule and costs for this alternative are based on historical documentation for a group of projects that received funding from appropriations over a 2-year period.

Energy: Excess Energy Costs

Annual Consumption:	354,000.0 kWh
Price per Unit:	$1.00000
Demand Charge:	$0
Utility Rebate:	$0
Location:	U.S. Average
Rate Schedule:	Industrial
State:	U.S. Average

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	5 years 3 months	100%
September 1, 2007	Remaining	0%

Escalation Rates

From Date	Duration	Escalation
June 1, 2002	Remaining	1.87%

Component:

Initial Investment

Initial Cost Paid By Agency (base-year $):	$3,263,000
Initial Cost Financed (base-year $):	$0
Annual Rate of Increase:	2.3%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	26.2%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
2 years 10 months	April 1, 2005	100%

Routine Recurring OM&R: OMR&R Costs

Amount:	$36,400
Annual Rate of Increase:	4%

Usage Indices

From Date	Duration	Factor
June 1, 2002	5 years 3 months	0%
September 1, 2007	Remaining	100%

Non-Recurring OM&R: IH Pre-feasibility study

Years/Months:	0 years 1 month
Amount:	$2,000
Annual Rate of Increase:	2.3%

Non-Recurring OM&R: Funding request - Feasibility study

Years/Months:	0 years 7 months
Amount:	$600
Annual Rate of Increase:	2.3%

Non-Recurring OM&R: Feasibility study

Years/Months:	0 years 10 months
Amount:	$815,750
Annual Rate of Increase:	2.3%

Non-Recurring OM&R: Funding request - Design/Construction

Years/Months:	2 years 7 months
Amount:	$600
Annual Rate of Increase:	2.3%

Alternative: Best case Agency-funded Project

Comment: In this alternative the development schedule corresponds to the schedule of the average Super ESPC project.

Energy: Excess Energy Costs

Annual Consumption:	354,000.0 kWh
Price per Unit:	$1.00000
Demand Charge:	$0
Utility Rebate:	$0
Location:	U.S. Average
Rate Schedule:	Industrial
State:	U.S. Average

Usage Indices

From Date	Duration	Usage Index
June 1, 2002	2 years 3 months	100%
September 1, 2004	Remaining	0%

Escalation Rates

From Date	Duration	Escalation
June 1, 2002	Remaining	1.87%

Component:
Initial Investment

Initial Cost Paid By Agency (base-year $):	$3,263,000
Initial Cost Financed (base-year $):	$0
Annual Rate of Increase:	2.3%
Expected Asset Life:	20 years 0 months
Residual Value Factor:	11.2%

Cost-Phasing

Cost Adjustment Factor: 2.3%

Years/Months (from Date)	Date	Portion
0 years 9 months	March 1, 2003	100%

Routine Recurring OM&R: OMR&R Costs

Amount:	$36,400
Annual Rate of Increase:	4%

Usage Indices

From Date	Duration	Factor
June 1, 2002	2 years 3 months	0%
September 1, 2004	Remaining	100%

Non-Recurring OM&R: Feasibility study

Years/Months:	0 years 1 month
Amount:	$127,257
Annual Rate of Increase:	2.3%

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Experience-based Agency-funded Project
Alternative: ESPC Project

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise G6.xml
Date of Study:	Mon Dec 23 14:55:32 EST 2002
Project Name:	Exercise G6
Project Location:	U.S. Average
Analysis Type:	Federal Analysis, Financed Project
Analyst:	JS
Comment	This is a comparison of an ESPC-funded project with an "experience-based" and a "best-case" appropriations-funded project, using average data calculated from the 71 Super ESPC projects awarded through 2001 and data from a group of projects funded from appropriations.
Base Date:	June 1, 2002
Study Period:	20 years 0 months(June 1, 2002 through May 31, 2022)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs
PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs Paid By Agency:			
Capital Requirements as of Base Date	$2,982,250	$252,807	$2,729,442
Future Costs:			
Recurring and Non-Recurring Contract Costs	$0	$4,189,531	-$4,189,531
Energy Consumption Costs	$1,662,909	$751,096	$911,813
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$1,235,251	$28,860	$1,206,392
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	-$453,961	-$194,555	-$259,406
	------------	------------	------------
Subtotal (for Future Cost Items)	$2,444,199	$4,774,932	-$2,330,733
	------------	------------	------------
Total PV Life-Cycle Cost	$5,426,449	$5,027,739	$398,709

Net Savings from Alternative Compared with Base Case

PV of Operational Savings $2,118,204
- PV of Differential Costs $1,719,495

Net Savings $398,709

NOTE: Meaningful SIR, AIRR and Payback can not be computed for Financed Projects.

Comparison of Contract Payments and Savings from Alternative (undiscounted)

Year Beginning	Savings in Contract Costs	Savings in Energy Costs	Savings in Total Operational Costs	Savings in Total Costs
Jun 2002	-$30,172	$0	$833,950	$803,778
Jun 2003	$0	$0	$0	$0
Jun 2004	-$523,232	$279,895	$280,532	$2,949,039
Jun 2005	-$373,674	$381,212	$381,212	$7,538
Jun 2006	-$380,657	$388,336	$388,336	$7,679
Jun 2007	-$387,790	$99,444	$133,823	-$253,967
Jun 2008	-$395,036	$0	$47,735	-$347,301
Jun 2009	-$402,418	$0	$49,619	-$352,799
Jun 2010	-$409,938	$0	$51,578	-$358,361
Jun 2011	-$417,620	$0	$53,620	-$364,001
Jun 2012	-$425,424	$0	$55,736	-$369,688
Jun 2013	-$433,374	$0	$57,936	-$375,438
Jun 2014	-$441,473	$0	$60,223	-$381,250
Jun 2015	-$449,745	$0	$62,607	-$387,139
Jun 2016	-$458,150	$0	$65,078	-$393,072
Jun 2017	-$466,711	$0	$67,647	-$399,065
Jun 2018	-$475,433	$0	$70,317	-$405,116
Jun 2019	-$484,342	$0	$73,100	-$411,242
Jun 2020	-$451,488	$0	$69,532	-$381,956
Jun 2021	$0	$0	$0	-$771,248

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	92,958.9 kWh	39,888.0 kWh	53,070.9 kWh	1,061,273.1 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	317.2 MBtu	136.1 MBtu	181.1 MBtu	3,621.2 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO_2	90,096.26 kg	38,637.89 kg	51,458.37 kg	1,029,026.51 kg
SO_2	293.86 kg	131.08 kg	162.79 kg	3,255.30 kg
NOx	271.41 kg	116.40 kg	155.02 kg	3,099.90 kg
Total:				
CO_2	90,096.26 kg	38,637.89 kg	51,458.37 kg	1,029,026.51 kg
SO_2	293.86 kg	131.08 kg	162.79 kg	3,255.30 kg
NOx	271.41 kg	116.40 kg	155.02 kg	3,099.90 kg

NIST BLCC 5.1-02: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: ESPC Project
Alternative: Best case Agency-funded Project

General Information

File Name:	C:\Program Files\BLCC5\projects\Exercises\Exercise G6.xml
Date of Study:	Mon Dec 23 14:55:46 EST 2002
Project Name:	Exercise G6
Project Location:	U.S. Average
Analysis Type:	Federal Analysis, Financed Project
Analyst:	JS
Comment	This is a comparison of an ESPC-funded project with an "experience-based" and a "best-case" appropriations-funded project, using average data calculated from the 71 Super ESPC projects awarded through 2001 and data from a group of projects funded from appropriations.
Base Date:	June 1, 2002
Study Period:	20 years 0 months(June 1, 2002 through May 31, 2022)
Discount Rate:	5.6%
Discounting Convention:	End-of-Year

Comparison of Present-Value Costs
PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs Paid By Agency:			
Capital Requirements as of Base Date	$252,807	$3,186,469	-$2,933,661
Future Costs:			
Recurring and Non-Recurring Contract Costs	$4,189,531	$0	$4,189,531
Energy Consumption Costs	$751,096	$751,096	$0
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$28,860	$666,686	-$637,827
Capital Replacements	$0	$0	$0
Residual Value at End of Study Period	-$194,555	-$194,555	$0
	------------	------------	------------
Subtotal (for Future Cost Items)	$4,774,932	$1,223,228	$3,551,704
	------------	------------	------------
Total PV Life-Cycle Cost	$5,027,739	$4,409,697	$618,043

Net Savings from Alternative Compared with Base Case

PV of Operational Savings	-$637,827
- PV of Differential Costs	-$1,255,869

Net Savings	$618,043

NOTE: Meaningful SIR, AIRR and Payback can not be computed for Financed Projects.

Comparison of Contract Payments and Savings from Alternative (undiscounted)

Year Beginning	Savings in Contract Costs	Savings in Energy Costs	Savings in Total Operational Costs	Savings in Total Costs
Jun 2002	$30,172	$0	-$127,495	-$3,416,264
Jun 2003	$0	$0	$0	$0
Jun 2004	$523,232	$0	-$30,578	$781,101
Jun 2005	$373,674	$0	-$42,497	$331,177
Jun 2006	$380,657	$0	-$44,174	$336,483
Jun 2007	$387,790	$0	-$45,922	$341,867
Jun 2008	$395,036	$0	-$47,735	$347,301
Jun 2009	$402,418	$0	-$49,619	$352,799
Jun 2010	$409,938	$0	-$51,578	$358,361
Jun 2011	$417,620	$0	-$53,620	$364,001
Jun 2012	$425,424	$0	-$55,736	$369,688
Jun 2013	$433,374	$0	-$57,936	$375,438
Jun 2014	$441,473	$0	-$60,223	$381,250
Jun 2015	$449,745	$0	-$62,607	$387,139
Jun 2016	$458,150	$0	-$65,078	$393,072
Jun 2017	$466,711	$0	-$67,647	$399,065
Jun 2018	$475,433	$0	-$70,317	$405,116
Jun 2019	$484,342	$0	-$73,100	$411,242
Jun 2020	$451,488	$0	-$69,532	$381,956
Jun 2021	$0	$0	$0	$0

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	39,888.0 kWh	39,888.0 kWh	0.0 kWh	0.0 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	136.1 MBtu	136.1 MBtu	0.0 MBtu	0.0 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO2	38,637.89 kg	38,637.89 kg	0.00 kg	0.00 kg
SO2	131.08 kg	131.08 kg	0.00 kg	0.00 kg
NOx	116.40 kg	116.40 kg	0.00 kg	0.00 kg
Total:				
CO2	38,637.89 kg	38,637.89 kg	0.00 kg	0.00 kg
SO2	131.08 kg	131.08 kg	0.00 kg	0.00 kg
NOx	116.40 kg	116.40 kg	0.00 kg	0.00 kg

Economic Measures of Evaluation and Their Uses

Type of Decision	Appropriate LCC Economic Measures (Evaluation Criterion)				
	LCC	NS	SIR	AIRR	DISCOUNTED PB
Accept/Reject	yes (minimum)	yes (>0)	yes (>1.0)	yes (>discount rate)	conditional* (< or = study period)
Level of Efficiency	yes (minimum)	yes (maximum)	no	no	no
System Selection	yes (minimum)	yes (maximum)	no	no	no
Combination of Interdependent Systems	yes (minimum combined LCC)	yes (maximum combined NS)	no	no	no
Project Priority (Independent Projects)	no	no	yes (descending order)**	yes (descending order)**	no

* Discounted Payback measure is consistent with LCC only if (1) cumulative net savings after payback is reached do not turn negative, and (2) residual values, if any, are included if payback is > or = study period.

** Fund in descending order of SIR or AIRR until budget is exhausted. Group of projects that fits within budget and has greatest overall net savings is best.

Acronyms

AIRR
Adjusted Internal Rate of Return
BOA
Basic Ordering Agreement
Btu
British Thermal Units
DoD
Department of Defense
DOE
Department of Energy
DPB
Discounted Payback
ECM
Energy Conservation Measure
ESCO
Energy Services Company
ESPC
Energy Savings Performance Contract
FEMP
Federal Energy Management Programs
HVAC
Heating, Ventilation and Air Conditioning
GJ
Gigajoule (10^9 joules)
kWh
Kilowatt Hours
LCC
Life-Cycle Costs or Life-Cycle Costing
MBtu
10^6 x Btu
NS
Net Savings
OM&R
Operation, Maintenance, and (Routine) Repairs
OMB
Office of Management and Budget
PB
Payback
P/C/I
Planning/Contructions or Installation Period
SIR
Savings-to-Investment Ratio
SPB
Simple Payback
SPV
Single Present Value (Factor)

TLCC

Total Life-Cycle Costs

UC or UESC

Utility Contract or Utility Energy Services Contract

UPV

Uniform Present Value (Factor)

UPV*

Modified Uniform Present Value (Factor)

USC

Utility Services Contract (for demand-side management, energy management services, or project financing)

Glossary

Adjusted Internal Rate of Return (AIRR)
Annual yield from a project over the Study Period, taking into account investment of interim amounts.

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

Amount Financed
Includes Implementation Costs and usually Financing Procurement Costs to comprise the amount borrowed by the Government agency to implement energy conservation measures.

Annually Recurring Costs
Those costs that are incurred each year in an equal, constant dollar amount throughout the Study Period, or that change from year to year at a known rate.

Annual Value (Annual Worth)
The time-equivalent value of past, present, or future cash flows expressed as an Annually Recurring Uniform amount over the Study Period.

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 Date
The beginning of the first year of the Study Period, generally the date on which the Life-Cycle-Cost analysis is conducted.

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 Price
The price of a good or service as of the Base Date.

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.

Contract Payments
An agreed-upon payment made annually or non-annually by the agency to repay the loan provided by an ESCO or UC for implementing energy savings measures.

Contract Period or Contract Term
The time period proposed by the contractor for repaying the loan provided to the a Government agency to implement energy savings measures. It begins at the contract award date and includes the Installation Period and the Energy Savings Performance Period.

Cost Adjustment Factor
The average annual rate at which the phased-in cost of a capital component is adjusted to its value in any year of the Planning/Construction/Installation Period. The Cost Adjustment Factor can, for example, be a contractual rate (sometimes equal to zero) or a rate determined by the agency.

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.)

Debt Service
The sum of interest payments and principal payments which comprise or are part of the Contract Payment to an ESCO or UC.

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 their equivalent amount 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 their 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 of Money 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, at a common point in time, adjusting for the Time Value of Money.

Disposal Cost

See Residual Value

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 (ECM)

Defined as the installation of new equipment/facilities, modification or alteration of existing government equipment/facilities, or revised operations and maintenance procedures to reduce energy consumption of facilities/energy systems.

Energy Cost

The annual cost of fuel or energy used to operate a building or building system, as billed by the utility or supplier (including Demand Charges, if any). Energy Costs are incurred during the Service Period only. Energy consumed in the construction or installation of a new building or building system is not included in this cost.

Energy Savings Performance Contracts

Contracts authorized by the Energy Policy Act of 1992 (EPACT), which offer alternative financing of energy and water efficiency improvements in federal buildings and allow the Federal Government to retain a portion of the energy savings and all the equipment installed.

Energy Savings Performance Period

The period (typically in years) from the date an ECM is operational and accepted by the Government agency to the end of the Contract Period. The Energy Savings Performance Period may also be referred to as the "service period."

Federal Government

The U.S. Government

Financing Procurement Costs

May be added to Implementation Costs to comprise the total amount financed by an ESCO or UC.

Future Value

The time-equivalent value of past, present, or future Cash Flows expressed as of some future point in time.

Implementation Costs

May include survey costs, feasibility study costs, design expenses, construction costs, which may be paid by agency or included in Contract Payment proposed by ESCO or UC.

Initial 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 or during the Planning/Construction/Installation Period for purposes of making the life-cycle cost analysis.

Inflation

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

Installation Period

The period from the date of contract award to the date all contracted energy conservation measures are operational and accepted by the agency. Installation period may also be referred to as "construction period."

Internal Rate of Return

Annual yield from a project over the Study Period, i.e., 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).

Life-Cycle Cost (LCC)

The total discounted dollar costs of owning, operating, maintaining, and disposing of a building or building system over the Study Period (see Life-Cycle Cost Analysis).

Life-Cycle Cost Analysis (LCCA)

A method of economic evaluation that sums discounted dollar costs of initial investment (less Resale, Retention, or Salvage Value), replacements, operations (including energy and water usage), and maintenance and repair of a building or building system over the Study Period (see Life-Cycle Cost). Also, as used in this program, LCCA is a general approach to economic evaluation encompassing several related economic evaluation measures, including Life-Cycle Cost (LCC), Net Benefits (NB) or Net Savings (NS), Savings-to-Investment Ratio (SIR), and Adjusted Internal Rate of Return (AIRR), all of which take into account long-term dollar impacts of a project.

Liquid Petroleum Gas (LPG)

Propane, butane, ethane, pentane, or natural gasoline.

Market Interest Rate

The nominal loan interest rate (including inflation) applied by the ESCO or UC to the Amount Financed to compute annual Contract Payments.

Measures of Economic Evaluation

The various ways in which project cash flows can be combined and presented to describe a measure of project cost effectiveness. The measures used to evaluate FEMP projects are Life-Cycle Cost (LCC), Net Savings (NS), Savings-to-Investment Ratio (SIR), Adjusted Internal Rate of Return (AIRR). Discounted Payback (DPB) and Simple Payback (SPB) are measures of evaluation not fully consistent with the LCC method but are used as supplementary measures in some federal programs.

Modified Uniform Present Value (Worth) (UPV* or UPW*) Factor

A discount factor used to convert an annual amount escalating at a constant rate to a time-equivalent Present Value. The FEMP UPV* Factor indicates a discount factor from a special set published by the U.S. Department of Energy, Federal Energy Management Program, for computing present value energy costs based on variable energy price projections.

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.

Nominal Discount Rate

The rate of interest (market interest rate) reflecting the time value of money stemming from both inflation and the real earning power of money over time

Nonmutually Exclusive Projects

Projects where the acceptance of one alternative does not preculde the acceptance of the others. Examples are wall insulation and ceiling insulation.

Nonrecurring Costs

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

Nonfuel Operation, Maintenance, and Repair (OM&R) 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.)

Performance Period Expenses

May include management/administration costs, operation and maintenance costs, repair and replacement costs, measurement and verification costs, permits and licenses costs, insurance costs, property taxes, and other costs (e.g., "margin"), which may be paid by agency or included in Contract Payment proposed by ESCO or UC.

Planning/Construction Period

The period beginning with the Base Date and continuing up to the Service Date during which only Initial Investment Costs are incurred.

Post-Contract Period

The period between the end of the Contract Period (Contract Term) and the end of the Study Period.

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 Base Date. Single Present Value Factorsare used to convert single future amounts to Present Values. Uniform Present Value Factors and Modified Present Value Factors are used to convert Annually Recurring amounts to Present Values.

Real Discount Rate

The rate of interest reflecting the portion of the time value of money attributable to the real earning power of money over time and not to general price inflation.

Renewable Energy

Energy obtained from sources that are essentially inexhaustible (unlike, for instance, fossil fuels of which there is a limited supply). Renewable sources of energy include wind energy, geothermal energy, hydroelectric energy, photovoltaic and solar energy, biomass, and waste.

Replacement Costs

Future costs included in the capital budget to replace a building system the Study Period.

Resale Value

See Residual Value

Residual Value

The estimated value, net of any Disposal Costs, of any building or 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 (also called Resale Value or Salvage Value, or Retention Value).

Retention Value

See Residual Value

Retrofit

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

Risk Attitude

The willingness of decision makers to take chances or to gamble on investments of uncertain outcome. Risk attitudes are generally classified as risk-averse, risk-neutral, or risk-taking.

Risk Exposure

The probability of investing in a project whose economic outcome is less favorable than what is economically acceptable.

Salvage Value

See Residual Value

Savings-to-Investment Ratio (SIR)

A ratio computed from a numerator of discounted energy and/or water savings, plus (less) savings (increases) in Nonfuel Operation and Maintenance Costs, and a denominator of increased Investment Costs plus (less) increases (decreased) Replacement Costs, net of Residual Value (all in present-value terms), 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.

Service Date

The point in time during the Study Period when a building or building system is put into use, and operating, maintenance, and repair costs (including energy and water costs) begin to be incurred.

Service Period

The period of time starting with the Service Date and continuing through the end of the Study Period.

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.

Single Present Value (Worth) (SPV or SPW) Factor

The discount factor used to convert single future benefit and cost amounts to Present Value.

Study Period

The length of the time period covered by the economic evaluation. This includes both the Planning/Construction Period and the Service Period.

Sunk Costs

Costs which have been incurred or committed to prior to the Life-Cycle Cost analysis and which therefore should not be considered in making a current project decision since this cannot be changed.

Time-of-Use 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 deflation.

Uniform Present Value (Worth) (UPV or UPW) Factor

The discount factor used to convert uniform annual values to a time-equivalent Present Value.

Useful Life

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

Utility Contracts or Utility Energy Services Contracts

Contracts (Area-Wide Contracts or Basic Ordering Agreements) between a government agency and a utility company, which allow the Federal Government to implement energy and water conservation measures through financing provided by the utility.

COURSE EVALUATION

PURPOSE: It is our objective to present a useful and effective training course. You are the final authority on whether that objective has been met. Your completion of this form, therefore, will play an important part in our future planning. Please do not feel bound to limit your remarks to questions on this form. Your comments on any aspect of the course will be appreciated.

COURSE TITLE		Dates Attended From To			
LOCATION					
RESPONSES (Check the response closest to your opinion)		Strongly Agree	Agree	Disagree	N/A
1. Course Material	a. was well organized				
	b. was complete and suitable				
	c. was readable (printed well)				
2. Audio-Visual Material	a. was related to the course				
	b. was good quality				
	c. was sufficient in number				
3. Course	a. was a reasonable length				
	b. was worth recommending to others				
	c. contributed to my knowledge and skills				
	d. accomplished announced purpose				
4. Instruction	a. Subject was thoroughly covered				
	b. Course expectations, requirements, and objectives were made clear				
	c. Participation was encouraged				
	d. Time in class was spent effectively				
5. Classrooms	a. were comfortable				
	b. included a manageable number of students				
	c. were appropriate for this course				
6. Instructors	a. were prepared for class				
	b. stimulated my interest in subject area				
	c. made course a worthwhile learning experience				

REMARKS:

COURSE EVALUATION (Continued)

7. OVERALL INSTRUCTOR EVALUATION (Check your opinion)

a. Knowledge of the subject ❑ Excellent ❑ Good ❑ Fair ❑ Poor

b. Ability to teach ❑ Excellent ❑ Good ❑ Fair ❑ Poor

8. WOULD YOU ADD OR EMPHASIZE ANY SUBJECT MATTER AREAS IN SUBSEQUENT COURSE SESSIONS?

❑ yes ❑ no If "yes," list these areas and give your reasons:

9. WOULD YOU DELETE OR DE-EMPHASIZE ANY SUBJECT-MATTER AREAS?

❑ yes ❑ no If "yes," list these areas and give your reasons:

10. AS A RESULT OF YOUR PARTICIPATION IN THIS COURSE, WHAT ADDITIONAL RELATED TRAINING SHOULD BE MADE AVAILABLE?

11. OTHER COMMENTS. PLEASE MAKE ANY COMMENTS RELATIVE TO THIS COURSE, EITHER GENERAL OR SPECIFIC.

SIGNATURE AND TITLE (optional)	ORGANIZATION	DATE