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Life-Cycle Cost Analysis (LCCA)

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INTRODUCTION

Life-cycle cost analysis (LCCA) is a method for assessing the total cost of facility ownership. It takes into account all costs of acquiring, owning, and disposing of a building or building system. LCCA is especially useful when project alternatives that fulfill the same performance requirements, but differ with respect to initial costs and operating costs, have to be compared in order to select the one that maximizes net savings. For example, LCCA will help determine whether the incorporation of a high-performance HVAC(/resources/hvac.php?r=lcca) or glazing system(/resources/windows.php?r=lcca), which may increase initial cost but result in dramatically reduced operating and maintenance costs, is cost-effective or not. LCCA is not useful for budget allocation.

Lowest life-cycle cost (LCC) is the most straightforward and easy-to-interpret measure of economic evaluation. Some other commonly used measures are Net Savings (or Net Benefits), Savings-to-Investment Ratio (or Savings Benefit-to-Cost Ratio), Internal Rate of Return, and Payback Period. They are consistent with the Lowest LCC measure of evaluation if they use the same parameters and length of study period. Building economists, certified value specialists, cost engineers, architects, quantity surveyors, operations researchers, and others might use any or several of these techniques to evaluate a project. The approach to making cost-effective choices for building-related projects can be quite similar whether it is called cost estimating (/design/utilize_management.php), value engineering(/design/use_analysis.php), or economic analysis (/design/use_analysis.php).

DESCRIPTION

A. Life-Cycle Cost Analysis (LCCA) Method

The purpose of an LCCA is to estimate the overall costs of project alternatives and to select the design that ensures the facility will provide the lowest overall cost of ownership consistent with its quality and function (/design/func_oper.php). The LCCA should be performed early in the design process while there is still a chance to refine the design to ensure a reduction in life-cycle costs (LCC).

The first and most challenging task of an LCCA, or any economic evaluation method, is to determine the economic effects of alternative designs of buildings and building systems and to quantify these effects and express them in dollar amounts.
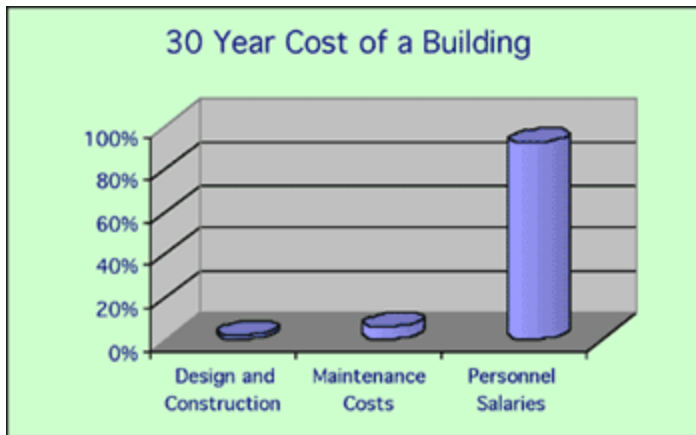
Viewed over a 30 year period, initial building costs account for approximately just 2% of the total, while operations and maintenance costs equal 6%, and personnel costs equal 92%.
Graphic: Sieglinde Fuller
Source: Sustainable Building Technical Manual / Joseph J. Romm, Lean and Clean Management, 1994.

B. Costs

There are numerous costs associated with acquiring, operating, maintaining, and disposing of a building or building system. Building-related costs usually fall into the following categories:

- Initial Costs—Purchase, Acquisition, Construction Costs
- Fuel Costs
- Operation, Maintenance, and Repair Costs
- Replacement Costs
- Residual Values—Resale or Salvage Values or Disposal Costs
- Finance Charges—Loan Interest Payments
- Non-Monetary Benefits or Costs

Only those costs within each category that are relevant to the decision and significant in amount are needed to make a valid investment decision. Costs are relevant when they are different for one alternative compared with another; costs are significant when they are large enough to make a credible difference in the LCC of a project alternative. All costs are entered as base-year amounts in today's dollars; the LCCA method escalates all amounts to their future year of occurrence and discounts them back to the base date to convert them to present values.

Initial costs

Initial costs may include capital investment costs for land acquisition, construction, or renovation and for the equipment needed to operate a facility.

Land acquisition costs need to be included in the initial cost estimate if they differ among design alternatives. This would be the case, for example, when comparing the cost of renovating an existing facility with new construction on purchased land.

Construction costs: Detailed estimates of construction costs are not necessary for preliminary economic analyses of alternative building designs or systems. Such estimates are usually not available until the design is quite advanced and the opportunity for cost-reducing design changes has been missed. LCCA can be repeated throughout the design process if more detailed cost information becomes available. Initially, construction costs are

estimated by reference to historical data from similar facilities. Alternately, they can be determined from government or private-sector cost estimating guides and databases(/design/utilize_management.php). The Tri-Services Parametric Estimating System (TPES) contained in the National Institute of Building Sciences (NIBS) Construction Criteria Base (CCB)(/ccb/) developed models of different facility types by determining the critical cost parameters (i.e., number of floors, area and volume, perimeter length) and relating these values through algebraic formulas to predict costs of a wide range of building systems, subsystems, and assemblies. The TPES models can be adapted to facilities beyond those included in the base modeling system by using SuccessEstimator (/tools/success.php), a software package available from U.S. Cost(http://www.uscost.com/).

Detailed cost estimates are prepared at the submittal stages of design (typically at 30%, 60%, and 90%) based on quantity take-off calculations. These estimates rely on cost databases such as the *Commercial Unit Price Book (C-UPB)* or the *R. S. Means Building Construction Cost Database(http://www.rsmeans.com/)*.

Testing organizations such as ASTM International(http://www.astm.org) and trade organizations have reference data for materials and products they test or represent.

Energy and Water Costs

Operational expenses for energy, water, and other utilities are based on consumption, current rates, and price projections. Because energy, and to some extent water consumption, and building configuration and building envelope are interdependent, energy and water costs are usually assessed for the building as a whole rather than for individual building systems or components.

Energy usage: Energy costs are often difficult to predict accurately in the design phase of a project. Assumptions must be made about use profiles, occupancy rates, and schedules, all of which impact energy consumption. At the initial design stage, data on the amount of energy consumption for a building can come from engineering analysis or from a computer program such as eQuest(http://doe2.com/equest/index.html). ENERGY PLUS (DOE) (/tools/eplus.php), DOE-2.1E(http://simulationresearch.lbl.gov/) and BLAST(/tools/blast.php) require more detailed input not usually available until later in the design process. Other software packages, such as the proprietary programs TRACE (Trane)(/tools/trace.php), ESPRE (EPRI), and HAP (Carrier)(/tools/hap.php) have been developed to assist in mechanical equipment selection and sizing and are often distributed by manufacturers.

When selecting a program, it is important to consider whether you need annual, monthly, or hourly energy consumption figures and whether the program adequately tracks savings in energy consumption when design changes or different efficiency levels are simulated.

Energy prices: Quotes of current energy prices from local suppliers should take into account the rate type, the rate structure, summer and winter differentials, block rates, and demand charges to obtain an estimate as close as possible to the actual energy cost.

Energy price projections: Energy prices are assumed to increase or decrease at a rate different from general price inflation. This differential energy price escalation needs to be taken into account when estimating future energy costs. Energy price projections can be obtained either from the supplier or from energy price escalation rates published annually on April 1 by DOE in *Discount Factors for Life-Cycle Cost Analysis, Annual Supplement to NIST Handbook 135(/ccb/browse_doc.php?d=4233)*.
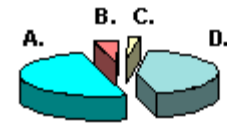
Water Costs: Water costs should be handled much like energy costs. There are usually two types of water costs: water usage costs and water disposal costs. DOE does not publish water price projections.

Operation, Maintenance, and Repair Costs

Non-fuel operating costs, and maintenance and repair (OM&R) costs are often more difficult to estimate than other building expenditures. Operating schedules and standards of maintenance vary from building to building; there is great variation in these costs even for buildings of the same type and age. It is therefore especially important to use engineering judgment when estimating these costs.

HVAC System Cost Over 30 Years

- A. Energy Cost 50.0%
- B. Maintenance Cost 4.7%
- C. Replacement Cost 2.3%
- D. HVAC First Cost 43.0%

(Courtesy of Washington State Department of General Administration)

Supplier quotes and published estimating guides sometimes provide information on maintenance and repair costs. Some of the data estimation guides derive cost data from statistical relationships of historical data (/design/utilize_management.php) (Means(http://www.rsmeans.com/), BOMA (http://www.boma.org)) and report, for example, average owning and operating costs per square foot, by age of building, geographic location, number of stories, and number of square feet in the building. The Whitestone Research *Facility Maintenance and Repair Cost Reference* (https://secure.whitestoneresearch.com/) gives annualized costs for building systems and elements as well as service life estimates for specific building components. The U.S. Army Corps of Engineers, Huntsville Division, provides access to a customized OM&R database for military construction (contact: Terry.L.Patton@HND01.usace.army.mil(mailto:terry.l.patton@HND01.usace.army.mil)).

Replacement Costs

The number and timing of capital replacements of building systems depend on the estimated life of the system and the length of the study period. Use the same sources that provide cost estimates for initial investments to obtain estimates of replacement costs and expected useful lives. A good starting point for estimating future replacement costs is to use their cost as of the base date. The LCCA method will escalate base-year amounts to their future time of occurrence.

Residual Values

The residual value of a system (or component) is its remaining value at the end of the study period, or at the time it is replaced during the study period. Residual values can be based on value in place, resale value, salvage value, or scrap value, net of any selling, conversion, or disposal costs. As a rule of thumb, the residual value of a system with remaining useful life in place can be calculated by linearly prorating its initial costs. For example, for a system with an expected useful life of 15 years, which was installed 5 years before the end of the study period, the residual value would be approximately 2/3 (=(15-10)/15) of its initial cost.

Other Costs

Finance charges and taxes: For federal projects, finance charges are usually not relevant. Finance charges and other payments apply, however, if a project is financed through an Energy Savings Performance Contract (ESPC) (http://www1.eere.energy.gov/femp/financing/espcs.html) or Utility Energy Services Contract (UESC) (http://www1.eere.energy.gov/femp/financing/uescs.html). The finance charges are usually included in the contract payments negotiated with the Energy Service Company (ESCO) or the utility.

Non-monetary benefits or costs: Non-monetary benefits or costs are project-related effects for which there is no objective way of assigning a dollar value. Examples of non-monetary effects may be the benefit derived from a particularly quiet HVAC system or from an expected, but hard-to-quantify productivity(/design/productive.php) gain due to improved lighting. By their nature, these effects are external to the LCCA, but if they are significant they

should be considered in the final investment decision and included in the project documentation. See Cost-Effective—Consider Non-Monetary Benefits(/design/consider_benefits.php).

To formalize the inclusion of non-monetary costs or benefits in your decision making, you can use the analytical hierarchy process (AHP), which is one of a set of multi-attribute decision analysis (MADA) methods that consider non-monetary attributes (qualitative and quantitative) in addition to common economic evaluation measures when evaluating project alternatives. *ASTM E 1765 Standard Practice for Applying Analytical Hierarchy Process (AHP) to Multi-attribute Decision Analysis of Investments Related to Buildings and Building Systems (/references/ihs_l.php?d=astm%20e%201765)* published by ASTM International(http://www.astm.org) presents a procedure for calculating and interpreting AHP scores of a project's total overall desirability when making building-related capital investment decisions. A source of information for estimating productivity costs, for example, is the WBDG Productive Branch(/design/productive.php).

C. Parameters for Present-Value Analysis

Discount Rate

In order to be able to add and compare cash flows that are incurred at different times during the life cycle of a project, they have to be made time-equivalent. To make cash flows time-equivalent, the LCC method converts them to present values by discounting them to a common point in time, usually the base date. The interest rate used for discounting is a rate that reflects an investor's opportunity cost of money over time, meaning that an investor wants to achieve a return at least as high as that of her next best investment. Hence, the discount rate represents the investor's minimum acceptable rate of return.

The discount rate for federal energy and water conservation projects is determined annually by FEMP (http://www1.eere.energy.gov/femp/); for other federal projects, those not primarily concerned with energy or water conservation, the discount rate is determined by OMB(http://www.whitehouse.gov/omb/). These discount rates are real discount rates, not including the general rate of inflation.

Cost Period(s)

Length of study period: The study period begins with the base date, the date to which all cash flows are discounted. The study period includes any planning/construction/implementation period and the service or occupancy period. The study period has to be the same for all alternatives considered.

Service period: The service period begins when the completed building is occupied or when a system is taken into service. This is the period over which operational costs and benefits are evaluated. In FEMP analyses, the service period is limited to 40 years.

Contract period: The contract period in ESPC and UESC projects lies within the study period. It starts when the project is formally accepted, energy savings begin to accrue, and contract payments begin to be due. The contract period generally ends when the loan is paid off.

Discounting Convention

In OMB and FEMP studies, all annually recurring cash flows (e.g., operational costs) are discounted from the end of the year in which they are incurred; in MILCON studies they are discounted from the middle of the year. All single amounts (e.g., replacement costs, residual values) are discounted from their dates of occurrence.

Treatment of Inflation

An LCCA can be performed in constant dollars or current dollars. Constant-dollar analyses exclude the rate of general inflation, and current-dollar analyses include the rate of general inflation in all dollar amounts, discount rates, and price escalation rates. Both types of calculation result in identical present-value life-cycle costs.

Constant-dollar analysis is recommended for all federal projects, except for projects financed by the private sector (ESPC, UESC). The constant-dollar method has the advantage of not requiring an estimate of the rate of inflation for the years in the study period. Alternative financing studies are usually performed in current dollars if the analyst wants to compare contract payments with actual operational or energy cost savings from year to year.

D. Life-Cycle Cost Calculation

After identifying all costs by year and amount and discounting them to present value, they are added to arrive at total life-cycle costs for each alternative:

LCC = I + Repl — Res + E + W + OM&R + O

LCC = Total LCC in present-value (PV) dollars of a given alternative
I = PV investment costs (if incurred at base date, they need not be discounted)
Repl = PV capital replacement costs
Res = PV residual value (resale value, salvage value) less disposal costs
E = PV of energy costs
W = PV of water costs
OM&R = PV of non-fuel operating, maintenance and repair costs
O = PV of other costs (e.g., contract costs for ESPCs or UESCs)

E. Supplementary Measures

Supplementary measures of economic evaluation are Net Savings (NS), Savings-to-Investment Ratio (SIR), Adjusted Internal Rate of Return (AIRR), and Simple Payback (SPB) or Discounted Payback (DPB). They are sometimes needed to meet specific regulatory requirements. For example, the FEMP LCC rules (10 CFR 436A (/references/code_regulations.php?i=116&r=1)) require the use of either the SIR or AIRR for ranking independent projects competing for limited funding. Some federal programs require a Payback Period to be computed as a screening measure in project evaluation. NS, SIR, and AIRR are consistent with the lowest LCC of an alternative if computed and applied correctly, with the same time-adjusted input values and assumptions. Payback measures, either SPB or DPB, are only consistent with LCCA if they are calculated over the entire study period, not only for the years of the payback period.

All supplementary measures are relative measures, i.e., they are computed for an alternative relative to a base case.

NS = Net Savings: operational savings less difference in capital investment costs

SIR = Savings-to-Investment Ratio: ratio of operational savings to difference in capital investment costs
AIRR = Adjusted Internal Rate of Return: annual yield from an alternative over the study period, taking into account reinvestment of interim returns at the discount rate
SPB = Simple Payback: time required for the cumulative savings from an alternative to recover its initial investment cost and other accrued costs, without taking into account the time value of money
DPB = Discounted Payback: time required for the cumulative savings from an alternative to recover its initial investment cost and other accrued costs, taking into account the time value of money

F. Evaluation Criteria

Lowest LCC (for determining cost-effectiveness)
NS > 0 (for determining cost-effectiveness)
SIR > 1 (for ranking projects)
AIRR > discount rate (for ranking projects)
SPB, DPB < than study period (for screening projects)

G. Uncertainty Assessment in Life-Cycle Cost Analysis

Decisions about building-related investments typically involve a great deal of uncertainty about their costs and potential savings. Performing an LCCA greatly increases the likelihood of choosing a project that saves money in the long run. Yet, there may still be some uncertainty associated with the LCC results. LCCAs are usually performed early in the design process when only estimates of costs and savings are available, rather than certain dollar amounts. Uncertainty in input values means that actual outcomes may differ from estimated outcomes.

There are techniques for estimating the cost of choosing the "wrong" project alternative. Deterministic techniques, such as sensitivity analysis or breakeven analysis, are easily done without requiring additional resources or information. They produce a single-point estimate of how uncertain input data affect the analysis outcome. Probabilistic techniques, on the other hand, quantify risk exposure by deriving probabilities of achieving different values of economic worth from probability distributions for input values that are uncertain. However, they have greater informational and technical requirements than do deterministic techniques. Whether one or the other technique is chosen depends on factors such as the size of the project, its importance, and the resources available. Since sensitivity analysis and break-even analysis are two approaches that are simple to perform, they should be part of every LCCA.

Sensitivity Analysis

Sensitivity analysis is the technique recommended for energy and water conservation projects by FEMP. Sensitivity analysis is useful for:

- identifying which of a number of uncertain input values has the greatest impact on a specific measure of economic evaluation,
- determining how variability in the input value affects the range of a measure of economic evaluation, and
- testing different scenarios to answer "what if" questions.

To identify critical parameters, arrive at estimates of upper and lower bounds, or answer "what if" questions, simply change the value of each input up or down, holding all others constant, and recalculate the economic measure to be tested.

Break-even 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 a break-even analysis, benefits and costs are set equal, all variables are specified, and the break-even variable is solved algebraically.

Sensitivity analysis and break-even analysis, and a number of other approaches to risk and uncertainty assessment, both deterministic and probabilistic, are described in detail in *Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Building Investments*, by Harold Marshall, NIST Special Publication 757,

September 1988. (Request a copy of this publication from the Office of Applied Economics at NIST (http://www.bfrl.nist.gov/oae/publications.html)).

H. Design and Analysis Tools

The use of computer programs can considerably reduce the time and effort spent on formulating the LCCA, performing the computations, and documenting the study. Listed below are several LCCA-related software programs:

- Building Life-Cycle Cost (BLCC) Program(/tools/blcc.php)—Economic analysis tool developed by the National Institute of Standards and Technology for the U.S. Department of Energy Federal Energy Management Program (FEMP)(http://www.eere.energy.gov/femp/information/download_blcc.html).
- ECONPACK(/tools/econpack.php) for Windows—An economic analysis tool developed by the U.S. Army Corps of Engineers in support of DOD funding requests.
- SuccessEstimator Estimating and Cost Management System(/tools/success.php)—Cost estimating tool available from U.S. Cost(http://www.uscost.com).

APPLICATION

LCCA can be applied to any capital investment decision in which relatively higher initial costs are traded for reduced future cost obligations. It is particularly suitable for the evaluation of building design alternatives that satisfy a required level of building performance but may have different initial investment costs, different operating and maintenance and repair costs, and possibly different lives. LCCA provides a significantly better assessment of the long-term cost-effectiveness of a project than alternative economic methods that focus only on first costs or on operating-related costs in the short run.

LCCA can be performed at various levels of complexity. Its scope might vary from a "back-of-the-envelope" study to a detailed analysis with thoroughly researched input data, supplementary measures of economic evaluation, complex uncertainty assessment, and extensive documentation. The extensiveness of the effort should be tailored to the needs of the project.

LCCA was among the many design and analysis tools used to transform this turn of the century building located in downtown Tacoma, WA into an energy efficient showcase building. (Courtesy of Washington State Department of General Administration)

RELEVANT CODES AND STANDARDS
- 10 CFR 436 Subpart A—Federal Energy Management and Planning Programs, Methodology and Procedures for Life-Cycle Cost Analyses(/references/code_regulations.php?i=116&r=1)
- Circular No. A-94—Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs (/references/omb_circulars.php?i=70&r=1)
- Energy Policy Act of 2005(/pdfs/epact2005.pdf) (PDF 1.9 MB)
- Executive Order 13423, "Strengthening Federal Environmental, Energy, and Transportation Management"(/ccb/browse_doc.php?d=7707)
- Executive Order 13123—Greening the Government through Efficient Energy Management (/ccb/browse_doc.php?d=342)
  - DOE Guidance on Life-Cycle Cost Analysis Required by Executive Order 13123 (http://www1.eere.energy.gov/femp/pdfs/lcc_guide_05.pdf) (PDF 164 KB)

- *Facilities Standard for the Public Buildings Service, P100* (GSA)—Chapter 1.8—Life-Cycle Costing (/ccb/browse_doc.php?d=5086)
- P-442 Economic Analysis Handbook (NAVFAC)(/ccb/browse_doc.php?d=4180)
- *Standards on Building Economics,(http://www.constructionbook.com/astm-standards-on-building-economics-6th-edition-9780803156951/astm-standard/)* 6th ed. ASTM(http://www.astm.org), ISBN: 978-0-8031-5695-1; stock #BLDGECON07.
- Tri-Services Memorandum of Agreement (MOA) on "Criteria/Standards for Economic Analyses/Life-Cycle Costing for MILCON Design"(/pdfs/moa.pdf) (1991)

LCCA Guidelines for OMB Projects

Office of Management and Budget (OMB) Circular A-94 – *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, October 1992(/references/omb_circulars.php?i=70&r=1), applies to building-related benefit-cost or cost-effectiveness analyses of federal programs or policies that are not primarily concerned with energy or water conservation or renewable energy projects. Appendix C of Circular A-94, updated annually in February, provides the OMB discount rates.

LCCA Guidelines for FEMP Projects

FEMP has published life-cycle costing rules and procedures in its Code of Federal Regulations, 10 CFR 436, Subpart A(/references/code_regulations.php?i=116&r=1). These FEMP rules are consistent with OMB rules. They are to be followed by all federal agencies, unless specifically exempted, in evaluating the cost-effectiveness of potential energy and water conservation projects and renewable energy projects for federally owned and leased buildings. *NIST Handbook 135 Life-Cycle Costing for the Federal Energy Management Program (/ccb/browse_doc.php?d=8097)* explains and amplifies the LCC rules of 10 CFR 436A. The Annual Supplement to Handbook 135, *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis(/ccb/browse_doc.php?d=4233)*, updated annually on April 1, provides the FEMP discount rates. The same publication contains tables of discount factors for time periods up to 30 years, using either the OMB or FEMP discount rate. The FEMP discount factors also include the most recent energy price escalation rates projected by the DOE Energy Information Administration (EIA)(http://www.eia.doe.gov/). The discount factors are embedded in BLCC5(/tools/blcc.php) and other federal LCC computer programs.

LCCA in the Department of Defense (DOD)

The Tri-Services Memorandum of Agreement (MOA) on "Criteria/Standards for Economic Analyses/Life-Cycle Costing for MILCON Design" (1991) provides the guidelines for LCCA for DoD energy and non-energy projects. These guidelines are consistent with FEMP and OMB guidelines. However, the MOA recommends (but does not require) that cash flows are discounted from the middle of each year rather than from the end of each year as are cash flows of FEMP and OMB projects.

ADDITIONAL RESOURCES

WBDG

Design Objectives
Cost-Effective Branch(/design/cost_effective.php), Functional / Operational(/design/func_oper.php), Productive (/design/productive.php), Sustainable(/design/sustainable.php)

Products and Systems

Federal Green Construction Guide for Specifiers(/design/greenspec.php)

Publications

- *Building Economics: Theory and Practice* by Rosalie T. Ruegg and Harold E. Marshall. New York: Van Nostrand Reinhold, 1990.
- *Facility Maintenance and Repair Cost Reference*(https://secure.whitestoneresearch.com/products/view/FAC-MAR-2010-2011) by Whitestone Research. 2010-2011 (15th Edition)
- *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis, Annual Supplement to Handbook 135(/ccb/browse_doc.php?d=4233)* by Amy Rushing, Joshua D. Kneifel and Barbara C. Lippiatt. NISTIR 85-3273-25. Gaithersburg, MD: National Institute of Standards and Technology, May 2010. Also available from the DOE/FEMP Help Desk at 1-877-EERE-INF (1-877-337-3463).
- *Engineering Economy* by G. J. Thuesen and W. J. Fabrycky. Prentice Hall, 1993. ISBN 0-13-277491-7.
- *GSA LEED® Cost Study(/ccb/browse_doc.php?d=90)* GSA, 2004.
- *GSA LEED® Applications Guide(/ccb/browse_doc.php?d=238)* GSA, 2005.
- *Life-Cycle Costing Manual for the Federal Energy Management Program(/ccb/browse_doc.php?d=8097)* by Sieglinde Fuller and S.R. Petersen. NIST Handbook 135. National Institute of Standards and Technology, 1995.
- *Simplified Energy Design Economics* by Harold E. Marshall and Rosalie T. Ruegg. NBS SP 544. Washington, DC: National Bureau of Standards, January 1980.

Others

- ASTM International(http://www.astm.org)—Publishes standards that support LCCA.
- GSA Sustainable Facilities Tool (SFTool)(http://sftool.gov/)—SFTool's immersive virtual environment addresses all your sustainability planning, designing and procurement needs.
- R. S. Means Company(http://www.rsmeans.com)—Offers construction cost databases.
- Sustainable Buildings Industry Council (SBIC)(http://www.nibs.org/?page=sbic)—Offers workshops on Designing Low-Energy Buildings that include instruction in using Energy-10 software.
- U.S. Army Corps of Engineers Life-Cycle Cost Module
- U.S. Cost(http://www.uscost.com)—Conducts training workshops for SuccessEstimator and Tri-Services Parametric Estimating System (TPES) models several times each year.
- U.S. Department of Energy (DOE) Office of Federal Energy Management Programs (FEMP) (http://www1.eere.energy.gov/femp/)—Conducts workshops (http://www1.eere.energy.gov/femp/services/training.html) on a variety of topics related to energy and water conservation.