NISTIR 6258

Guide and Criteria for Training FEMP-Qualified Life-Cycle Cost Instructors

Sieglinde K. Fuller

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

Sponsored by:
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U.S. DEPARTMENT OF COMMERCE
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Gary R. Bachula, Acting Under Secretary
for Technology

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AND TECHNOLOGY
Raymond G. Kammer, Director

Abstract

The objective of this guide is to inform applicants of the procedure to become "FEMP-Qualified LCC Instructors." FEMP-Qualified Instructors are entitled to teach life-cycle costing (LCC) workshops similar to those conducted by NIST as part of the Federal Energy Management's (FEMP) training program to promote cost-effective energy and water conservation in federal buildings. The guide gives an overview of the NIST life-cycle costing workshops, describing how they are organized and taught. It explains the technical assistance and instructional materials FEMP-Qualified Instructors will receive from the NIST Office of Applied Economics in support of any workshops they may conduct. The guide also states the requirements that have to be fulfilled by applicants. Finally, the guide describes the core curriculum of the NIST LCC workshop and gives instruction to aid candidates in preparing lectures for the qualifying review conducted by NIST staff.

Keywords

building technology; economic analysis; energy conservation; LCC instruction; life-cycle cost analysis; training guide

Preface

As called for by the National Energy Conservation Policy Act (1978), the National Institute of Standards and Technology (NIST) has provided technical assistance to the Federal Energy Management Program (FEMP) at the U.S. Department of Energy (DOE) in formulating and disseminating life-cycle costing (LCC) methods, handbooks, instructional materials, and software for economic analysis of energy and water conservation, and renewable energy projects in the federal government. As part of this effort NIST conducts two-day workshops on life-cycle costing for energy conservation in buildings. The workshops include training in the use of BLCC (Building Life-Cycle Costing), the NIST computer program that supports the application of life-cycle cost analysis to government projects.

The demand for LCC training by energy managers in federal, state, and local governments has continued to grow. Executive Orders 12759 (1991) and 12902 (1994) mandate a cost-effective reduction in energy consumption by 20 percent by the year 2000 and 30 percent by the year 2005 from 1985 levels. To expand LCC training, FEMP funded NIST to train "FEMP-Qualified Instructors" who will conduct additional LCC courses similar to the NIST basic LCC workshop that has been taught since the mid 1970's throughout the U.S.

This report explains the procedures for becoming a FEMP-Qualified Instructor. For further information on NIST workshops, teleconferences, software, and other LCC-related products please contact:

Office of Applied Economics
National Institute of Standards and Technology
100 Bureau Drive, Stop 8603
Building 226, Room B226
Gaithersburg, MD 20899-8603
Telephone: 301-975-6132
Home page: http://www.bfrl.nist.gov/oae.html

Information about the Federal Energy Management Program can be obtained from:

U.S. Department of Energy
Federal Energy Management Program, M.S. EE-90
1000 Independence Avenue, SW
Washington, DC 20585
Telephone: 1-800-DOE-EREC
Home page: http://www.eren.doe.gov/femp

Acknowledgments

I wish to thank Mr. Theodore Collins of the Federal Energy Management Program for his continued support of the life-cycle-cost project at NIST and for his help in organizing the trainer classes. Special appreciation is extended to Mr. Stephen Petersen who wrote the first draft of this guide. I am also grateful to Dr. Robert Chapman and Ms. Amy Boyles for their careful review and helpful comments and to Ms. Sandy Kelley and Ms. Christine Gorgone for preparing the manuscript for printing.

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1. The NIST LCC Workshop Series

The NIST Life-Cycle Costing (LCC) workshop series consists of four workshops:

1) the basic LCC workshop, which focuses on the life-cycle cost methodology and Federal Energy Management Program (FEMP) criteria;
2) the project-oriented workshop, which emphasizes the use of the BLCC software for complex analyses of energy and water conservation projects;
3) an interactive LCC teleseminar, which is broadcast as part of DOE/FEMP's Energy managers Telecourse Series;
4) the "FEMP-Qualified" LCC course, which is patterned after the National Institute of Standards and Technology (NIST) basic LCC workshop and taught by independent instructors.

Subsections 1.1 and 1.2 describe these four workshops in the context of this training guide for FEMP-Qualified Instructors.

1.1 Basic NIST LCC Workshop

NIST has conducted a two-day life-cycle cost (LCC) workshop under the sponsorship of DOE's Federal Energy Management Program (FEMP) since the mid-1970's. The workshop has been conducted several times each year, usually at least once in the Washington D.C. area and several times in other cities around the United States or at U.S. facilities overseas. The workshop is taught by two instructors from NIST and is generally limited to 40 participants. It includes two computer lab sessions in which the participants receive hands-on training using NIST LCC software. The workshop participants have been encouraged to bring real-world observations and problems into the class, to network with other participants, and to work in teams to solve problem sets. This basic NIST LCC workshop focuses on economic decision-making in the design or retrofit of buildings and building systems, especially with regard to energy conservation and renewable resource projects in federal buildings. The methods taught in the workshop are equally applicable to new and existing buildings, and can be used for both energy and non-energy projects. While the workshop has been primarily oriented toward Federal Energy Managers, the curriculum includes generally recognized methods of economic analysis that are relevant to state and local governments, and private sector participants as well. The workshop has been open on a space available basis to energy professionals from state and local governments, utilities, universities, non-profit institutions, private consultants, and private business. Participants in a typical workshop include about two-thirds federal employees and one-third non-federal employees. The workshop has generally been conducted by NIST under DOE/FEMP sponsorship. DOE/FEMP charges a registration fee to cover the cost of classroom and computer rentals. Site costs have been kept low by working directly with local colleges, universities, or federal training centers. Meals and refreshments are not generally included at the workshops, but local sponsors have on occasion provided these to express appreciation for the opportunity to host the workshop.

Workshop materials, all developed by NIST under contract to FEMP, are provided to the students at no charge. These include a comprehensive student manual, two sets of discount factor tables for use in LCC analyses, NIST Handbook 135 (Life-Cycle Costing Manual for FEMP), LCC computer programs with user guides, and three training videos that can be taken back to work and shared with staff. The student manual includes copies of all the slides used in the NIST workshop, objectives of each workshop module, a comprehensive summary of each module, and a problem set for most modules. The problem sets are generally solved at the end of the module by the participants, working together in informal teams of three or four students.

A one-hour, open-book test is administered at the end of the workshop to participants who attend the workshop in partial fulfillment of the DOE certification requirements for "Trained Energy Manager." The passing grade is 25/40.

1.2 Additional NIST Workshops

1.2.1 Project-Oriented LCC Workshop

NIST has recently developed a two-day "project-oriented" LCC workshop, which is complementary to the basic LCC workshop described above. It focuses on the use of the BLCC software for analyzing complex energy and water conservation projects rather than on the LCC methodology as does the basic NIST workshop. Students taking this class should have an elementary understanding of discounted cash flows and LCC analysis.

1.2.2 Teleconference Seminar for Federal Energy Managers

This 1-1/2 hour workshop was developed by NIST for DOE/FEMP's Energy Managers Telecourse Series. It gives an overview of the LCC methodology and the FEMP criteria for evaluating energy and water conservation projects in federal buildings. It is broadcast once or twice a year as an interactive teleconference from the Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN. (See http://orau.gov/femp for course information or contact Heather Schoonmaker at schoonmh@orau.gov for downlink information).

1.2.3 FEMP-Qualified Instructors LCC Workshops

The demand for LCC training by energy managers in federal, state, and local governments continues to grow. Executive Orders 12759 (1991) and 12902 (1994) require that investments in energy and water conservation be evaluated using LCC criteria; the Energy Policy Act of 1992 requires that federal energy managers be trained in LCC methodology. As a result, FEMP funded NIST to train "FEMP-Qualified LCC Instructors" to conduct LCC courses similar to the NIST basic workshop. Candidates mostly come from a sponsoring institution such as a college, federal agency, or professional institution. These alternative instructors/sponsors will provide the necessary facilities and materials, handle registration, and teach the courses at no cost to the federal

government, using registration fees set by the instructor or sponsoring institution to cover costs. FEMP does not provide funding for these courses, but assists in coordinating their timing and location around the United States, provides information about these courses to federal energy managers and other interested parties, provides names of sponsors/instructors to institutions wishing to host LCC courses, and provides original copies of materials to be used in the courses for local reproduction by the instructor as needed. As of September 1998 there were 23 such FEMP-Qualified Instructors offering basic LCC courses throughout the U.S.

The NIST LCC instructors will provide initial training for prospective instructors immediately following a regularly scheduled NIST LCC workshop. To qualify as an instructor, the candidates will be expected to attend a NIST workshop and to prepare and deliver two lectures related to the core curriculum of the workshop for presentation to the NIST instructors and other candidates, at an arranged training session.

NIST staff will provide consulting assistance to FEMP-Qualified Instructors to answer questions related to the FEMP LCC methodology and criteria and will provide them with updated information as it becomes available. FEMP and NIST will also provide limited quality control services to monitor the content and quality of FEMP LCC courses taught by FEMP-Qualified Instructors.

This guide is intended to serve as an instructor's reference for conducting a two-day, LCC course fully equivalent to the basic NIST LCC workshop. It states the expected candidate skills and experience and the requirements for qualification as an LCC instructor. The guide also establishes the core curriculum and lists course materials and other background material needed to successfully conduct this course.

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2. Criteria for FEMP-Qualified LCC Instructors

Three steps are required to become a FEMP-Qualified Instructor.

(1) Submission of a request to FEMP to become a FEMP-Qualified LCC Instructor.

Written request for instructor qualification should be sent to:

U.S. Department of Energy
Federal Energy Management Program, EE-90
Attn: Mr. Theodore C. Collins, Training Manager
1000 Independence Avenue, S.E.
Washington, D.C. 20585

The request should include a resume with relevant teaching experience on the part of the instructor and information about the sponsoring institution, if any. Teaching experience that will be considered especially relevant includes recent experience teaching engineering economics (and especially life-cycle cost analysis), research or teaching related to building systems (especially with regard to their energy performance), research or teaching in other areas of energy-related systems. If the instructor is working with a sponsoring institution, the institution must verify that the candidate is applying in its name and that it supports the instructor's application to become a FEMP-Qualified LCC instructor. FEMP and NIST will review these applications and select candidates based on their overall qualifications and their geographical location. FEMP encourages instructors to participate from all regions of the country and does not wish to encourage over-representation from any one region.

(2) Attendance at a NIST LCC workshop and special trainer workshop on the following day.

Priority admission to a regularly scheduled NIST LCC workshop of their choice will be given to the instructor candidates. Candidates will be expected to pass the LCC workshop exam at a higher level than other students taking the workshop. At the trainer session immediately following the workshop, additional training-related materials will be given to the instructor candidates and the core curriculum requirements will be discussed.

(3) Successful presentation to a NIST instructor of two lectures based on the NIST/LCC workshop materials

The instructor candidates will be expected to make presentations to the NIST instructor and to the other instructor candidates in order to demonstrate their competency in teaching the most essential elements of the LCC workshop, and to review their presentation skills and materials. The topics to be covered are discussed in section 6 of this guide. Opportunities for these presentations will generally be made immediately following the trainer workshop. The instructor candidates can choose to make these presentations at that time, return to a later trainer workshop, or travel to NIST,

Gaithersburg, MD. Consideration will be given to presentations submitted on video tape, along with an overview of the training materials to be used. The instructor will be deemed "FEMP-Qualified " when successfully completing this third step.

Once qualified, the instructor is expected to notify FEMP of planned workshops, and workshops completed, along with a list of students who have completed the workshop. FEMP maintains a mailing list of workshop attendees in order to provide them with notices of updated materials, criteria, and computer programs related to the FEMP LCC methodology. The instructor must make a good-faith effort to keep abreast of the latest LCC methods and criteria required by FEMP for the analysis of federal energy projects and OMB for non-energy-related federal projects. In order to maintain the status of FEMP-Qualified LCC instructor and be registered as such with FEMP, he or she is expected to teach at least one LCC course per year.

3. FEMP and NIST Support to FEMP-Qualified Instructors

FEMP anticipates that FEMP-Qualified LCC courses can be conducted on a self-sustaining basis, without additional funding from FEMP. That is, student registration fees should be sufficient to cover all costs incurred. The amount of this fee will be determined by the instructor or sponsoring institution, based on the cost of access to classroom and computer lab space for two days, the number of instructors, support staff requirements to handle registration, the cost of reproducing course materials, and the number of participants expected. It is suggested that course attendance be limited to 40 students in order to make the course, and especially the computer lab, a manageable size.

FEMP recommends that two instructors team together to teach this course if it is to be conducted on two consecutive days, as the lectures are quite intense and the computer laboratory requires considerable attention to individual student inquiries. Two students can be expected to work together on a PC, and in some areas students could bring their own PC (possibly at a reduced registration fee). NIST experience has found that college classroom and computer labs are often available at a reasonable cost during semester, spring, and summer break periods.

FEMP expects that supply and demand forces will keep registration fees at a moderate level. Course providers will be aware that DOE charged a fee of $195.00 per student for the FY 98 season. Advertising expenses on the part of the course providers are expected to be minimal since FEMP will provide information about scheduled courses to federal energy managers, contractors, and interested private-sector parties through the FEMP newsletter, FEMP Focus (circulation 7000). Regional DOE offices, if notified of upcoming courses, can be expected to promote courses offered in their region. FEMP will also provide the names of FEMP-Qualified LCC Instructors in their region to federal, state, and local government agencies and their institutions seeking to host a FEMP-Qualified Instructors LCC course.

DOE and NIST will provide the instructors with specific publications and computer programs used in FEMP-Qualified Instructors LCC courses. At a minimum, single copies of these materials will be provided to each instructor for local reproduction. When sufficient stock is available, NIST will provide additional copies of some material that can be distributed directly to the students at no charge. Note that all of the materials distributed by FEMP and NIST, including the computer programs, are in the public domain. They are therefore not subject to copyright protection and can be copied and distributed without permission.

The NIST staff will provide consulting assistance to FEMP-Qualified LCC Instructors as needed to answer questions regarding the LCC methodology and criteria covered in the course, and to discuss background materials that NIST provides to the instructors. NIST staff will also provide limited quality control services to the instructors, especially in terms of reviewing hand-out materials prepared by the instructors and modifications to the student manual and visual materials for the course (if any).

FEMP will prepare and send training certificates to the participants who completed the workshop. A certificate of attendance will be sent to those participants who attended the entire workshop but did not elect to take the final examination or who did not pass the final examination. A certificate of partial fulfillment of the FEMP training requirements for Federal Energy Managers will be sent to those participants who attended the entire workshop and passed the final examination.

4. LCC Course Materials

4.1 Basic Course Materials

The primary reference for the NIST LCC workshop is NISTIR 5165, Life-Cycle Costing Workshop for Energy Conservation in Buildings: Student Manual. This student manual includes copies of all of the slides used in the NIST workshop, objectives of each workshop module, a comprehensive summary of each module, and a problem set for most modules. The problem sets are generally solved by the participants at the end of the module, working together in informal teams of three or four students.

The instructors are encouraged to use the NIST student manual "as is" in teaching FEMP-Qualified LCC courses. However, the student manual can be revised to include examples or class problems that more closely address the local environment in which the course will be conducted or to add visual materials to clarify the instructor's presentation (but not to change the methodology or content of the course). FEMP and NIST request a review copy of any changes to the student manual for quality control purposes.

A set of the NIST workshop slides or the corresponding Power Point files will be lent to the instructors for use in their workshops or for making their own copies.

Other essential course materials that must be provided to each participant in a FEMP-Qualified LCC course include:

(1) NISTIR 85-3273, Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis, the Annual Supplement to NIST Handbook 135. This is updated each year on April 1, and includes the current discount rate and energy price escalation rates to be used in LCC studies of energy-related projects in federal buildings. The current version must be used in teaching a FEMP-Qualified LCC course. Instructors can obtain sufficient quantities of this report by calling the DOE Help Desk at 1-800-DOE-EREC or by downloading the document from the DOE web site at htttp://www.eren.doe.gov/femp--Technical Assistance--Analytical Software Tools.

(2) NISTIR 89-4203, Discount Factor Tables for Life-Cycle Cost Analyses. This document provides generic discount factors for a range of discount rates and price escalation rates, to be used in LCC analyses. This publication is a permanent report; it does not need to be updated periodically to stay current. NIST will provide multiple copies of this report as inventory allows; otherwise instructors must duplicate these at their own expense.

(3) The BLCC, QuickBLCC, and DISCOUNT computer programs. These programs and supporting files are distributed by NIST through DOE (1-800-DOE-EREC) on a set of two, high-density, 3.5 inch diskettes or can be downloaded from the DOE web site. The user's guide for each program is included as a WordPerfect file. (The user's

guide for QuickBLCC is included in the BLCC user's guide, section 6.) These programs are used in the two computer lab sessions of the LCC course.

(4) The NIST EMISS Program and user's guide. EMISS is a stand-alone program that generates a file of local air-pollution emission coefficients (CO_2, NO_x, SOx) for use with the BLCC program. BLCC uses this file of emission factors to estimate reductions in emissions associated with energy conservation projects on both an annual and life-cycle basis. The program is available on diskette from the DOE Help Desk or can be downloaded from the DOE web site.

(5) The NIST ERATES Program and user's guide. ERATES is a stand-alone program that can be used for generating block-rate, time-of-use-rate, and demand-rate schedules for electricity prices. ERATES can compute monthly and annual electricity costs based on those schedules, given hourly kWh usage data or monthly kWh usage/kW demand data. BLCC and QuickBLCC can import ERATES files for electricity cost calculations. The user's guide is included with the ERATES program. The program is available on diskette from the DOE Help Desk or can be downloaded from the DOE web site.

Hard copies of the user's guides for the above programs are not needed for the course but are provided to the students in the NIST workshops. The instructors are expected to make copies of the program disk for distribution to the students or to instruct them on how to download the programs from the DOE web site.

4.2 Optional Course Materials

The following materials are provided to students in most NIST workshops but are not considered essential to the workshop. NIST will provide single copies to the instructors, who should be familiar with their contents. Instructors should advise students of the existence, content, and availability of these materials:

(1) NIST Handbook 135, Life-Cycle Costing Manual for FEMP, 1995 edition. This handbook provides the basic FEMP methodology for conducting LCC analyses of energy-and-water related projects in federal buildings. It is the primary reference for the FEMP LCC methodology. However, it is not used in the workshop. Most federal energy managers already have this handbook or can order it free of charge by calling 1-800-DOE-EREC.

(2) NIST Special Publication 757, Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Building Investments. This provides more depth about the topics of risk and uncertainty covered in the workshop. It should be referenced by the instructor when discussing the subject of risk and uncertainty in LCC analysis.

4.3 Other Materials

The following materials are not generally provided to the students in the NIST LCC workshops but are useful background materials. The instructors should be knowledgeable about these materials and be able to cite them as references in the LCC course. NIST will provide single copies of these materials to the instructors.

(1) OMB Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs. This is the primary reference for establishing an economic decision-making methodology and determining the appropriate discount rate for non-energy-related projects in the Federal Government. Appendix C contains the discount rates for non-energy projects; it is updated annually around March 1.

(2) 10 CFR 436A, "Federal Energy Management and Planning Programs; Life-Cycle Cost Methodology and Procedures." These are the FEMP LCC methods and criteria that must be used when conducting an LCC analysis of energy conservation or renewable resource projects for federal facilities. The most recent version was published in the Federal Register on November 20, 1990. Handbook 135 is based on these rules.

(3) ASTM Standards on Building Economics, Third Edition. This is a compilation of all of the ASTM standards related to building economics, published by ASTM and updated periodically. The FEMP methodology for LCC analysis and related measures of economic performance (e.g., SIR and AIRR) are consistent with these ASTM standards. (Note: unlike all of the other material listed above, the ASTM publication is copyrighted material and cannot be reproduced for general distribution).

(4) NIST Training Videos. There are three NIST Training Videos related to economic analysis of energy conservation projects in buildings. These three videos and accompanying workbooks are in a series entitled "Least-Cost Energy Decisions for Buildings."

Part I. Introduction to Life-Cycle Costing
Part II. Uncertainty and Risk
Part III. Choosing Economic Evaluation Methods

These videos (and companion workbooks) are available from:

Video Transfer, Inc.
5709-B Arundel Drive
Rockville, MD 20852
(301) 881-0270.

The videos and workbooks are in the public domain and can be copied for any use.

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5. Core Curriculum for the LCC Course

The Student Manual for the NIST LCC workshop serves as the primary reference source for the content of a FEMP-Qualified LCC course. This manual is divided into ten lectures, or modules. Two of these modules include a computer laboratory, which begins with an overview lecture on the computer program(s) to be used and a brief discussion of the problem that will be solved in the computer lab. The NIST student manual includes a copy of all of the slides used in the workshop, but does not contain copies of occasional blackboard lecture notes. At the end of each module there are notes, keyed to each of the slides, that explain the significance of each slide. Problems to be solved by the students (usually working in small groups) are also provided at the end of each module.

The instructors are encouraged to use the NIST student manual as is when teaching a FEMP-Qualified LCC course. However, minor modifications to include examples and classroom problems that reflect local conditions or conservation projects are acceptable.

This section provides an overview of the course objectives and the core curriculum that must be included in FEMP-Qualified LCC courses if they are to be considered equivalent to the NIST LCC workshop.

The LCC course objectives are:

(1) To understand and use life-cycle cost analysis methods and related measures of economic performance for evaluating capital investment projects that are expected to reduce future operating-related costs.

(2) To understand the special requirements of the Federal Government for conducting LCC analyses of federal buildings and building systems, especially with regard to energy-related projects.

(3) To be familiar with the BLCC computer program and associated programs (QuickBLCC, DISCOUNT, EMISS, ERATES).

Since the audience often includes participants from the private sector who are interested in LCC analysis of energy-related projects from the private sector perspective, it is important that the general methodology be presented from a generic standpoint as much as possible. That is, use examples that are equally applicable to the public and private sector and make a point to emphasize that the general methodology is generic, while some criteria such as the discount rate and maximum study period are specific to the type of federal project.

The following ten general lecture topics make up the core curriculum for a FEMP-Qualified LCC course. These topics are keyed to modules in the NIST Student Manual. Supplementary notes are included here for instructor reference. The two computer labs are included at the end of the lecture topics, although they do not have to be presented in that order.

5.1 Overview of Economic Analysis Methods for Capital Investment Decisions (Module A)

5.1.1 Types of investment decisions that require economic analysis

a. Selecting among mutually exclusive project alternatives:
   Accept/Reject Projects
   System Energy Efficiency
   System Selection/Design
   Combination of Interdependent Systems

b. Prioritization of independent projects to allocate limited funding

Important: These two decision types (mutually exclusive and prioritization for funding allocation) are fundamentally different, although they are both based on LCC analysis methods. It is important that the student recognize this difference, because the economic analysis methods used to solve these two types of problems are quite different. (Lowest LCC versus ranking by SIR/AIRR.)

5.1.2 What is LCC?

- Definition
- Applications to energy conservation projects in buildings and related facilities
- Limitations on use
- What to do with non-quantifiable benefits and costs

Stress that economics is not the bottom line, just a decision tool.
Bottom line: buildings and building systems should work! (Safe, reliable, promote productivity.)

5.1.3 Steps in an LCC analysis (list slightly revised from workbook)

- Identify acceptable alternatives
- Establish common study parameters and data requirements
- Estimate all costs in today's dollars
- Adjust future costs to present value
- Compute total LCC for each alternative
- Identify alternative with lowest LCC
- Consider unquantifiable costs and benefits
- Consider uncertainty in input values
- Select best alternative
- Compute supplementary measures of economic performance (if necessary)

5.2 Defining the Problem and Getting Appropriate Data (Module B)

5.2.1 Choosing acceptable design alternatives

- Stress importance of good engineering; results can be no better than best alternative identified.

5.2.2 Common data and assumptions needed for the analysis

- Base date
- Service date
- Study Period
- Discount rate
- Constant or current dollars and underlying inflation rate (if current dollars)
- Energy Prices and energy price escalation rates

5.2.3 Cash flow diagrams

- Show both with and without planning/construction period.

5.2.4 Cost data and energy performance data for individual project alternatives

- Types of cost data :

- Investment costs: (FEMP rules include these three categories)
  - Initial investment
  - Capital replacements
  - Residual/resale/salvage/value

- Operating-related costs:
  - Annually recurring Operating/Maintenance/Repair (OM&R) costs
  - Non-annually recurring OM&R costs
  - Energy costs
  - Water costs (will be getting special attention in the future as water conservation is included in FEMP's regulations)

Note: usually we assume that operating-related costs begin with the service date, not with the base date; initial investment costs are incurred before or on the service date, but not afterwards. (In some larger projects, some part of the facility may be put into use before construction is completed on others, but we do not generally get into this detail).

5.2.5 Relevant costs

Do not include sunk costs. Costs that are the same for all alternatives can be left out of the analysis, since they will wash out when comparing the alternatives. Don't spend a lot

of time collecting cost data which will not significantly affect the differences among alternatives.

5.2.6 Timing of cash flows

FEMP rules permit end-of-year discounting or mid-year discounting. The FEMP methodology is based on end-of-year discounting. DoD likes to use mid-year discounting. One-time costs can occur at any time during the year, but if you are doing the analysis by hand it is generally easier to assume that these costs occur at the end of the year.

5.2.7 Sources of cost and performance data

All costs should be specified in today's dollars. This is not implicit in a generic LCC methodology but it is the way we teach it and the way that NIST software (BLCC and QuickBLCC) work. Today's costs are converted to future costs using escalation rates (if any) for the particular cost category.

Energy analysis: Estimate annual energy costs for each alternative, including both energy usage and demand charges, if any. When evaluating energy efficiency-related options, use marginal energy costs (the cost of the last unit used each month). When comparing alternative systems that use different types of energy, use average energy costs or the actual rate structure. Generally a whole-building energy analysis program is needed to estimate the energy usage of the base case and each alternative. Be careful to see that the differences make sense; these differences (the savings) are generally more important than the absolute amounts when it comes to the economic analysis. Use local energy prices and DOE escalation rates (FEMP rule). Pay attention to demand rates and summer/winter rate differentials.

5.2.8 Determining an appropriate study period

- Study period usually reflects life of project or holding period of building
- Study period is usually determined by investor
- Study period must be same for each mutually exclusive alternative (common study period)
- Use replacements and residual values to make project alternatives fit the common study period
- Maximum study period in FEMP study is 25 years (from the beginning of the service period, i.e., not including the planning/construction period)

5.3 Adjusting Cash Amounts to Present Value and Handling Inflation (Module C)

5.3.1 Discounting to adjust for the time-value of money

Compare and contrast the concept of interest with discounting. Discuss the need for converting cash flows occurring at different points in time to time-equivalent values. The

discount rate should be based on opportunity cost, but the expected rate of general inflation, the required real rate of return (net of inflation), and risk attitude are important factors in evaluating the time-value of money. People have different discount rates because they have different perceptions of opportunity costs, risk attitudes, and projections of inflation.

5.3.2 Determining the appropriate discount rate for an LCC analysis

- FEMP rate for energy-related projects are updated each April (Annual Supplement to NIST Handbook 135)
- OMB rates for non-energy projects are updated each year in March (Appendix C to Circular A-94 and Annual Supplement to NIST Handbook 135)

5.3.3 Discounting mechanics

- Show how to compute future amounts and present amounts
- Contrast one-time costs with uniform annual amounts and annual amounts that change at a known rate
- Show both summation and closed-form equations for annual amounts
- UPV and UPV-discounted amount are simply sums of discounted annual amounts

5.3.4 Present value factors and their use

- Single present value factors
- Uniform present value factors
- Modified uniform present value factors (UPV* factors to adjust for price escalation)
- Energy price escalation rates and special FEMP UPV* factors
- Where to get the appropriate factors:
  - Generic discount factor tables: NISTIR 89-4203
  - Annual Supplement to Handbook 135: NISTIR 85-3273-xx

5.3.5 Discounting examples (see student workbook)

5.3.6 How to handle inflation

- Constant versus current dollars in LCC analyses
- Constant dollars must have the base year identified
- Use real rates (discount and escalation) with constant dollars
- Use nominal (market) rates with current dollars
- Show derivation of real discount rates and escalation rates from nominal rates
- Show that both methods will give identical results if computed properly, but constant-dollar analysis does not require estimating average inflation or the change in inflation from year to year

5.4 Computing and comparing LCCs (Module D)

5.4.1 General LCC formula

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

- Specialized formula for energy-related projects in buildings:

LCC = Init Invest + Repl - Resid + OM&R + Energy + Water (all in PV terms)

5.4.2 FEMP criteria for LCC analysis

- FEMP discount rate (changes annually)
- 25 year study period maximum (plus planning/construction period, if any)
- Current, local, energy prices used with DOE projections of energy price escalation rates (unless documented escalation rates are available from the local utility)
- Constant dollars highly recommended but not required
- Don't use differential escalation rates for individual cost items except energy

5.4.3 Provide detailed LCC example(s) with energy conservation example

5.5 Supplementary Economic Measures and Their Use (Module F)

5.5.1 Supplementary economic measures

- Net Savings (NS)
- Savings-to-investment ratio (SIR)
- Adjusted Internal Rate of Return (AIRR)
- Payback (simple and discounted) (PB)

These are all comparative measures of economic performance. Thus they require that a base case be identified for purpose of comparison. Their values will differ for the same project alternative, depending on the base case that is used. In a retrofit situation, the base case is usually the existing state, but in new construction it could be the minimum acceptable level from a whole-building performance standpoint, or the minimum level required by code, or some other level. LCC analysis by itself (when used to evaluate mutually exclusive alternatives) does not require the identification of a base case.

5.6 Selecting Among Mutually Exclusive Project Alternatives (Module G)

In general, show that LCC by itself is the most effective way to solve these types of problems; that SIR, AIRR, or payback do not identify the most economic alternative. If you try to pick the alternative with the highest SIR or AIRR, or shortest payback, you

will generally accept a low level of performance. (The supplementary measures can sometimes be used incrementally, but this is analogous to an accept/reject solution and will not always lead to the correct solution.)

5.6.1 Choosing the most cost effective system efficiency–give example(s)

5.6.2 Choosing the most cost effective system type–give example(s)

5.6.3 Evaluating interdependent systems (simultaneous optimization)

Give examples of interdependence among building systems, e.g., thermal envelope, HVAC systems, and lighting. That is, a change to one system will have effects on the energy costs of another. Combinations of interdependent systems must be evaluated to determine which combination has the lowest LCC. Only practical combinations need to be evaluated. Stress the need to combine the present value (PV) costs of each system and the corresponding PV energy costs for the overall building into a single LCC for each combination evaluated. (Do not break out energy costs by system.) This is somewhat analogous to whole-building energy analysis, where you specify system/component parameters but you get the calculated energy use for the overall building, not for each system/component.

5.7 Allocating Limited Funding Among Competing Projects (Module H)

5.7.1 Using SIR and AIRR to rank independent projects (not mutually exclusive)

Maximize combined net savings but not net savings for individual projects to find best allocation.

Pre-sizing of projects before ranking is generally preferred, but if you have a limited budget and no hope of getting future funding, then include incremental analysis of systems. Discuss shortcomings of this latter approach (locking in at less than optimal levels).

5.8 Dealing with Uncertainty and Risk (Module J)

5.8.1 Deterministic techniques

- Sensitivity analysis
- Break-even analysis
- Conservative cost estimating

5.8.2 Probabilistic techniques (overview only)

- Generally restricted to expensive projects

5.8.3 Risk attitude

Note that the federal government is "risk neutral," thus expected values are usually adequate for decision making.

5.9 NIST BLCC Computer Program and Laboratory (Module E)

Overview and laboratory. See Module E in the NIST Student Manual for overview notes and the problem to be solved in the computer laboratory. Students are encouraged to run the DISCOUNT program after completing the BLCC problem in the laboratory, but no problem is assigned. (The DISCOUNT menu is self-explanatory once the students have learned the use of the various types of discount factors.) Note that the overview of the program is generally given in the classroom, before moving to the computer lab. Demonstration of the program with a computer projection system before going into the lab is recommended. Once in the computer lab, the students are expected to use BLCC at their own pace to solve the class exercise. Two students are usually paired at each computer, and a student who is less computer-literate is encouraged to team up with one that is. Instructors answer individual questions and check the students' results. Students are expected to get the same results as the instructors' prepared results, or understand completely why their results may be different (e.g., they may have used a different energy price escalation rate forecast). It is important that the problem be discussed before starting on the computer.

5.10 BLCC/QuickBLCC Program and Laboratory (Module I)

Overview and computer lab. See Module I (letter I) in the NIST Student Manual for overview notes and the problem to be solved in the computer laboratory. The same observations made in 5.9 about discussing the program and problem before going into the lab apply here as well.

5.11 Conclusion/Summary (no module reference)

Overview of decision types and economic criteria:
Going over the decision matrix shown on the next page is a good way to wrap up the workshop. It is preferable to distribute the handout after presenting the matrix on the board; it forces the students to think as you work through the presentation.

5.12 Examination Upon Completion of Course

A standardized exam has been prepared by the NIST instructors for administration at the end of the two-day FEMP-Qualified LCC course. This is a 40-question, multiple choice, open-book exam. The exam is voluntary on the part of the students, but a passing grade is required to receive credit towards the Energy Manager Certificate. The minimum passing score is 25/40.

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.

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6. Oral Review Requirements for FEMP-Qualified LCC Instructors

As part of the qualification process for instructors, the candidates must present two lectures of approximately forty-five minutes each on specified aspects of the LCC methodology and FEMP LCC criteria. These presentations are to be given at a special training session with the NIST instructors and other candidates in attendance. These two lectures will not be two discrete modules from the NIST LCC workshop student manual, but rather a composite of several of these modules. It is important that the lectures do not last more than forty-five minutes so that there will be adequate time for critique and for other candidates to give their presentations on the same day.

The participants in this exercise must be prepared to give these lectures with overheads or other suitable projection materials. (Overheads can be made with a word processor or by hand). The overhead materials can be taken from the student workbook, created by the trainer, or they can be a combination of the two. The lectures will be critiqued by the NIST instructors and the other participants. The purpose of this exercise is to demonstrate satisfactory knowledge about the subject and to pick up additional suggestions from the NIST instructors, FEMP representatives, and other instructor candidates in attendance.

Lecture 1 should cover the following materials:

- Common data and assumptions needed for an LCC analysis
- Relevant cost data for project alternatives (not sources)
- Energy cost considerations (energy usage calculations, energy costs, DOE escalation rates)
- Discounting as a means of adjusting for the time-value of money
- Determining the appropriate discount rate for an LCC analysis
- Discounting mechanics (SPV, UPV, UPV*)
- Use of precalculated discount factors in an LCC analysis and where to find them

Lecture 2 should cover the following materials:

- How to handle inflation in an LCC analysis
- Computing and comparing LCCs, with example(s)
- Supplementary economic measures and their use (NS, SIR; AIRR optional)
- Selecting among mutually exclusive project alternatives
- Using SIR and AIRR to rank independent projects

Lectures should be consistent with the NIST student manual, but they do not need to have the same level of detail. The purpose of these lectures is not to instruct but to demonstrate familiarity with the subjects. The NIST instructors and FEMP representatives in attendance will be allowed to ask questions during the presentation but there will not be time to go into depth on these subjects during the presentations.

The NIST instructors and FEMP representatives will judge these presentations based on the following criteria:

Demonstrated knowledge of LCC methods and criteria
Demonstrated knowledge of building energy mechanics
Coverage of assigned topics in lectures
Teaching skills and enthusiasm for subject matter
Preparation for the lectures.

After successfully completing the demonstration lectures, candidates will receive a certificate from DOE/FEMP to confirm them as "FEMP-Qualified Instructors."