Guidance on Life-Cycle Cost Analysis

Required by Executive Order 13123

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prepared for

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Executive Summary

Section 401 of Executive Order 13123 requires that "Agencies shall use life-cycle cost analysis in making decisions about investments in products, services, construction, and other projects to lower the Federal Government's costs and to reduce energy and water consumption…"

The purpose of this guidance is to "clarify how agencies determine the life-cycle cost for investments required by the Order, including how to compare different energy and fuel options and assess the current tools" (Section 502(d)); and "assist agencies in ensuring that all project cost estimates, bids, and agency budget requests for design, construction and renovation of facilities are based on life-cycle costs." (Section 505(a))

Definition of Life-Cycle Costs

Section 707 of Executive Order 13123 defines life-cycle costs as "…the sum of present values of investment costs, capital costs, installation costs, energy costs, operating costs, maintenance costs, and disposal costs over the life-time of the project, product, or measure."

Life-cycle cost analysis (LCCA) is an economic method of project evaluation in which all costs arising from owning, operating, maintaining, and disposing of a project are considered important to the decision. LCCA is well suited to the economic evaluation of design alternatives that satisfy a required performance level but may have differing investment, operating, maintenance, or repair costs, and possibly different life spans. It is particularly relevant to the evaluation of investments where high initial costs are traded for reduced future cost obligations.

Scope of Guidance

This guidance summarizes the life-cycle cost (LCC) requirements of Executive Order 13123. Decision-makers should be aware that the use of LCCA is required by law and Executive Order and that relevant LCC procedures and tools are well developed and have been supported by the Department of Energy's Federal Energy Management Program (FEMP) and other agencies for over 20 years. This guidance provides a discussion of LCCA that combines generic present-value analysis with the LCCA regulatory criteria (10 CFR 436A) promulgated by FEMP. These criteria apply specifically to energy and water conservation and renewable energy projects in federal buildings.

Products, Services, and Other Projects Covered by Executive Order 13123

The projects, products, services, construction, and other projects mentioned in Executive Order 13123 that are to be evaluated using LCCA, include but are not limited to the following (all are subject to LCC criteria in 10 CFR 436A):

- Energy and water conservation, and renewable energy projects in Federal buildings, industrial facilities, and laboratories;
- Energy savings performance contracts and utility contracts and other alternative financing contracting mechanisms;
- Bundling of energy efficiency products with renewable energy products and retirement of inefficient equipment on an accelerated basis;
- ENERGY STAR and other energy-efficient products, strategies, and tools; including sustainable building design, model lease provisions, industrial facility efficiency improvements, and off-grid generation.
- Electricity use; and,
- Mobile equipment.

Evaluation of Energy Savings Performance Contracts and Utility Energy Services Contracts

The general principles of LCCA also apply to the evaluation of projects considered for alternative financing through an Energy Savings Performance Contract (ESPC) or a Utility Energy Services Contract (UESC). LCCA can be used to compare the costs of the existing equipment over a given time period with the costs over the same time period of an energy conservation measure (ECM) proposed by an energy service company. The costs of performing a feasibility study, setting up and administering the contract, and financing the project through the energy service company (ESCO) or utility can all be included in the LCCA. LCCA allows the analyst to compare the life-cycle costs of financed ECMs with those of agency-funded ECMs, the latter implemented either immediately or in a future year. Assumptions and requirements regarding financing-related input data, study periods, and inflation treatment need to be considered.

Bundling of Energy Efficiency Projects

Section 401 of Executive Order 13123 states that "Where appropriate, agencies shall consider the life-cycle costs of combinations of projects, particularly to encourage bundling of energy efficiency projects with renewable energy projects. Agencies shall also retire inefficient equipment on an accelerated basis where replacement results in lower life-cycle costs."

Although bundling strictly cost-effective projects with projects that do not maximize net savings is not in accordance with economic theory, Executive Order 13123 recommends that energy conservation measures (ECMs) be bundled in order to optimize energy-saving and/or environmental benefits of a project. Renewable energy measures and other measures that save large amounts of energy, improve energy-related infrastructure, reduce air pollution, or reduce greenhouse gas emissions may be bundled with other ECMs as long as the overall project is life-cycle cost effective. All items in the bundle must be complementary, i.e., an integral part of the project, and no single ECM should be significantly cost-ineffective. Furthermore, energy managers should take an integrated systems approach when defining the scope of a building retrofit or other energy-related project. In many cases, a decision about one ECM will directly affect the scope or type of other ECMs; due to interdependence some ECMs might become cost-ineffective if bundled .

Life-Cycle Cost for Energy-Using Products

When purchasing energy-using products, agencies should perform an LCCA to assure that they are making a cost-effective selection. Pursuant to FAR Section 23.704, agencies can purchase cost-effective energy-efficient products even if the first cost is higher than that of a less efficient product.

Basis for LCCA Guidance

This guidance does not supersede agency practices that are prescribed by or pursuant to law, Executive Order, or other relevant documents. It is meant to assist agencies in conducting life-cycle cost analyses of investments in products, services, construction, and other projects. The methodology is explained in the context of energy and water conservation and renewable energy projects in federal buildings according to 10 CFR 436A, but it is applicable to any products, services, and other projects where future operational savings are traded off against higher initial investment costs.

The LCC methodology and procedures of 10 CFR 436A are consistent with American Society for Testing and Materials (ASTM) Standards on Building Economics, in particular ASTM Standard Practices E 917, E 964, E 1057, E 1074, and E1121, and Standard Guides E 1185 and E 1369. The supporting NIST LCC computer software (BLCC) can generally be used to analyze any type of project where costs can be categorized as:

- initial investment costs,
- operation and maintenance costs,
- energy costs and water costs,
- capital replacement costs,
- residual values, and
- financing costs.

Reference Materials

The FEMP LCC rules in 10 CFR 436A are explained in NIST Handbook 135 *Life-Cycle Costing Manual for the Federal Energy Management Program* and its annual supplement, *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis: Annual Supplement to NIST Handbook 135* (ASHB 135*).*

Appendix A of this guidance refers the reader to additional Government documents that provide guidance on meeting the LCCA requirements of Executive Order 13123:

- *Facilities Standards for the Public Buildings Service*. This GSA document provides general guidance on LCCA for buildings and building systems.

- *Whole Building Design Guide.* This web site provides information on integrated ‘whole-building,’ techniques and technologies on sustainable building design.
- *Criteria/Standards for Economic Analysis/Life-Cycle Costing for MILCON Design*. This DOD Tri-Services Memorandum of Agreement provides guidance on LCCA for military construction design.

Authority

This LCC guidance is issued under the authority of Executive Order 13123, June 3, 1999. The use of life-cycle costing to evaluate energy and water conservation, and renewable energy projects in the Federal Government arises from the requirements of the National Energy Conservation Policy Act (NECPA) of 1978 (PL 95-619), as amended; the Energy Policy Act of 1992 (PL 102-486); and subsequent legislation and Executive Orders. The LCC rules and regulations, codified in 10 CFR 436, Subpart A, *Life-Cycle Cost Methodology and Procedures*, were published by DOE in 45 FR 5820 on January 23, 1980, and amended in 1990 and 1996 (FR, Vol. 55, No. 224, November 20, 1990; FR, Vol. 61, No. 123, June 25, 1996).

List of Acronyms

AIRR
Adjusted Internal Rate of Return
ASHB 135
Annual Supplement to Handbook 135
ASTM
American Society for Testing and Materials International
BOMA
Building Owners & Managers Association International
CCB
Construction Criteria Base
DoD
Department of Defense
DOE
Department of Energy
DPB
Discounted Payback
ECM
Energy Conservation Measure
EERE
Energy Efficiency and Renewable Energy
EPA
Environmental Protection Agency
ESCO
Energy Services Company
ESPC
Energy Savings Performance Contract
FEMP
Federal Energy Management Programs
GSA
General Services Administration
HVAC
Heating, Ventilation and Air Conditioning
LCC
Life-Cycle Costs or Life-Cycle Costing
LCCA
Life-Cycle Cost Analysis
LEED
Leadership in Energy and Environmental Design
MOA
Memorandum of Agreement
NAVFAC
Naval Facilities Engineering Command
NIBS
National Institute of Building Sciences
NIST

National Institute of Standards and Technology

NS

Net Savings

OM&R

Operation, Maintenance, and (Routine) Repairs

OMB

Office of Management and Budget

PB

Payback

P/C/I

Planning/Construction or Installation Period

SBIC

Sustainable Buildings Industry Council

SIR

Savings-to-Investment Ratio

SPB

Simple Payback

SPV

Single Present Value (Factor)

TPES

Tri-Services Parametric Estimating System

UC

Utility Contract

UESC

Utility Energy Services Contract

UPV

Uniform Present Value (Factor)

UPV*

Modified Uniform Present Value (Factor)

1. General Principles of Life-Cycle Cost Method

(a) Definition

Life-cycle cost analysis (LCCA) is a method for evaluating all relevant costs over time of a project, product, or measure. The LCC method takes into account first costs, including capital investment costs, purchase, and installation costs; future costs, including energy costs, operating costs, maintenance costs, capital replacement costs, financing costs; and any resale, salvage, or disposal cost, over the life-time of the project, product, or measure.

(b) Time adjustments

Adjustments to place all dollar values expended or received over time on a comparable basis are necessary for the valid assessment of a project's life-cycle costs and benefits. Time adjustment is necessary because a dollar today does not have equivalent value to a dollar in the future. There are two reasons for this disparity in value. First, money has real earning potential over time among alternative investment opportunities, and future revenues or savings always carry some risk. Thus an investor will require a premium or extra return for postponing to the future the spending of that dollar. Second, in an inflationary economy, purchasing power of money erodes over time. Thus a person would demand more than a dollar at some future time to obtain equivalent purchasing power to a dollar held today.

The process of converting streams of benefits and costs over time in the future back to an equivalent "present value" is called discounting. A discount rate is used in special formulas to convert future values. When future values are expressed in current (nominal) dollars, where inflation is included in the future values, a market (nominal) discount rate is used. It takes into account both inflation and the earning potential of money over time. When future values are expressed in constant (real) dollars, where general price inflation has been stripped out, a real discount rate is used. It takes into account only the earning potential of money over time. Both approaches yield identical results as long as you use real discount rates in discounting constant-dollar future amounts and market discount rates in discounting current-dollar future amounts.

Choices among energy-savings projects can be made by estimating for each alternative project a stream of life-cycle costs, calculating their present values and choosing the alternative (including "do nothing") that yields the minimum present-value life-cycle cost (PVLCC or Lowest LCC). Another measure of evaluation is Net Savings (NS) arrived at by computing net present value (NPV) savings achieved by an alternative relative to a "base case," and selecting the alternative with the maximum Net Savings. When performed correctly, both methods will lead to the same project selection.

(c) Life-Cycle Cost formula

To find the total LCC of a project, sum the present values of each kind of cost and subtract the present values of any positive cash flows such as a resale value. Thus, the following formula applies:

Life-cycle cost = first cost + maintenance and repair + energy + water + replacement - salvage value,

where all dollar amounts are converted to present values by discounting.

(d) Applications of Life-Cycle Cost Analysis

Projects may be compared by computing the LCC for each project, using the formula above and seeing which is lower. The alternative with the lowest LCC is the one chosen for implementation, other things being equal.

The LCC method can be applied to many different kinds of decisions when the focus is on determining the least-cost alternative for achieving a given level of performance. For example, it can be used to compare the long-run costs of two building designs; to determine the expected savings of retrofitting a building for energy or water conservation, whether financed or agency-funded; to determine the least expensive way of reaching a targeted energy use for a building; or to determine the optimal size of a building system.

In addition to the LCC formula shown above, there are other methods for combining present values to measure a project's economic performance over time, such as Net Savings, Savings-to-Investment Ratio, Adjusted Internal Rate of Return or Discounted Payback.

(e) Note on Discounted Payback and Simple Payback

Discounted Payback (DPB) and Simple Payback (SPB) measure the time required to recover initial investment costs. The payback period of a project is expressed as the number of years just sufficient for initial investment costs to be offset by cumulative annual savings.

DPB is the preferred method of computing the payback period for a project because it requires that cash flows occurring each year be discounted to present value to adjust for the effect of inflation and the opportunity cost of money. The SPB does not use discounted cash flows and therefore ignores the time value of money, making it a less accurate measure than the DPB.

In practice, the DPB or SPB is used to measure the time period required for accumulated savings to offset *initial* investment costs. Any costs or savings incurred during the remainder of the project life cycle are ignored. The DPB and the SPB are therefore not appropriate measures of life cycle cost effectiveness and should be used only as screening tools for qualifying projects for further economic evaluation.

(f) Uncertainty assessment

Estimates of costs are typically uncertain because of imprecision in the underlying data and modeling assumptions. If there is substantial uncertainty it is useful to analyze and report its effects. There are numerous methods for analyzing uncertainty and risk. The technique to be used depends on the degree of uncertainty and the size of the project (see ASTM Standard Guide E 1369). Deterministic analysis, such as *sensitivity analysis* and *breakeven analysis* can be performed within the LCCA method without requiring additional computational aids. *Probability distributions* of economic measures may require more or less complex simulation techniques but may be warranted by the magnitude of some projects. If additional analysis casts considerable doubt on the LCCA, an agency should consider obtaining more reliable data or eliminating the alternative.

(g) Considering emissions reductions from energy-conserving alternative

The BLCC computer program, which supports LCCA for energy and water conservation in federal buildings, has the capability of estimating annual and life-cycle CO_2, SO_2, and NO_x emissions coincident with the energy use of the building or building system being evaluated. Emissions are calculated for electricity, fuel oil, natural gas, LPG, and coal; they are *not* calculated for central steam, chilled water, and "other" energy types that can be included in the BLCC5 input file. The economic cost of these emissions is not estimated, but quantitative estimates of emissions reductions attributable to an energy-saving alternative are included in the LCC report of the program. The emissions factors used in the BLCC5 analysis are based on national average data. They can be modified to reflect local emissions data for electricity and fossil fuels.

2. Federal LCC Criteria

The most critical assumptions of the LCC rules in 10 CFR 426A and OMB Circular A-94 concern the

- Discount rate
- DOE energy price escalation rates
- Use of constant or current dollars
- Study period
- Presumption of cost-effectiveness

(a) Discount rate

DOE/FEMP discount rates for energy and water conservation projects: The Department of Energy determines each year the discount rate to be used in the LCCA of energy conservation, water conservation, and renewable energy projects in federal facilities. According to 10 CFR 436A, *"Subject to a ceiling of 10 percent and a floor of three percent the real discount rate shall be a 12 month average of the composite yields of all outstanding U.S. Treasury bonds neither due nor callable in less than ten years, as most recently reported by the Federal Reserve Board, adjusted to exclude estimated increases in the general level of prices consistent with projections of inflation in the most recent Economic Report of the President's Council of Economic Advisors."*

The *nominal* discount rate is derived identically but is unadjusted for increases in the general level of prices.

The real discount rate and corresponding discount factors are updated annually on April 1 and published in NISTIR 85-3273-XX, *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis*, the Annual Supplement to NIST Handbook 135.

OMB discount rates for non-energy and non-water conservation projects: OMB has specified two basic types of discount rates: (1) a discount rate for cost-effectiveness, lease-purchase, and related analyses; and (2) a discount rate for public investment and regulatory analyses. Only discount rates for the first type of analyses are relevant to this Guidance, since its primary purpose is to support cost-effectiveness studies related to the design and operation of federal facilities.

OMB discount rates for cost-effectiveness and lease-purchase studies are based on interest rates on Treasury Notes and Bonds with maturities ranging from 3 to 30 years. Five maturities (3-, 5-, 7-, 10-, and 30-year) have been specifically identified by OMB, and their *real* interest rates (i.e., adjusted for general price inflation) are used as the discount rates for studies subject to OMB Circular A-94. OMB suggests that the actual discount rate for an economic analysis be interpolated from these maturities and rates, based on the length of the study period used in the analysis.

The *nominal* discount rate is derived identically but is unadjusted for increases in the general level of prices. The nominal discount rate is used for current-dollar analyses, whereas the real discount rate is used for constant-dollar analyses (see definition of constant-dollar and current-dollar analysis in subsection (c) below).

(b) DOE energy price escalation rates

Energy prices change at rates different from the rate of general price inflation. The DOE Energy Information Administration annually projects real energy price escalation rates (excluding inflation) for the next 35 years, by census region, rate type, and fuel type. These real escalation rates and the real DOE discount rate are used to calculate the "modified uniform present value (UPV*) factors" for energy costs in FEMP LCC analyses. The UPV* factors are updated and published annually on April 1 as a set of tables in *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis*, NISTIR 85-3273-XX, the Annual Supplement to Handbook 135. They are also incorporated into the BLCC5 and associated computer programs.

(c) Use of constant dollars

It is recommended that in general all future dollar amounts be estimated in *constant* dollars, with the purchasing power of the dollar fixed as of the base date. This convention eliminates the need to estimate the rate of general price inflation over the study period. If future amounts are estimated in constant dollars, only the annual costs as of the base-date are needed as data inputs into the LCCA. The constant-dollar amounts are then discounted from their date of occurrence to the base date using a *real* discount rate (i.e., a rate that also excludes general price inflation).

The FEMP rule allows the option of estimating LCC in *current* dollars, that is, in dollars that include the rate of general price inflation. The LCCA needs to be performed in current dollars when, for example, tax calculations, budget allocations, or fixed contract payments have to be included in the analysis, that is, whenever there are amounts that have to be evaluated or paid or budgeted as amounts that include the inflation rate. It is also more intuitive to use current-dollar analysis when the analysis includes amounts that change at the rate of inflation as well as amounts that are fixed, such as an annual or monthly contract payment. Thus, an evaluation of ESPCs or UESCs would require current-dollar analysis including the rate of inflation in the dollar amounts, discount rate, escalation rates, and loan interest rate.

(d) Study period

The maximum study period for federal energy and water conservation and renewable energy projects according to 10 CFR 436A is 25 years from the date of occupancy of a building or the date a system is taken into service. Any lead-time for planning, design, construction, or implementation may be added to the 25-year maximum service period. The length of the study period then includes the planning/construction/implementation period and the service period.

Operational and energy costs are calculated beginning with the service date, the date at which the building is occupied and the equipment is taken into service. These annual costs are evaluated over the service period but discounted to the base date, i.e., the beginning of the study period. If there is no planning/construction/implementation period, the base date and service date coincide.

All project alternatives have to be evaluated over the same service period.

For projects that do not primarily conserve energy or water and which are subject to the criteria of OMB Circular A-94 , there is no prescribed limitation of the length of the study period.

(e) Presumption of cost effectiveness according to 10 CFR 436A

1. A project is *presumed cost-effective* if it saves energy or water and if the costs of implementing the energy or water conservation measure are insignificant, and
2. A project is *presumed not cost-effective* if the building is:

   – occupied under a one-year lease without renewal option or with a renewal option that is not likely to be exercised;

- occupied under a lease that includes the cost of utilities in the rent, with no pass-through to the government of energy or water savings; or
- scheduled for demolition or retirement within one year.

3. Evaluation of Energy Savings Performance Contracts and Utility Energy Services Contracts

The general principles of LCCA, as described in this document, also apply to the evaluation of projects that are considered for alternative financing through an Energy Savings Performance Contract (ESPC) or a Utility Energy Services Contract (UESC). LCCA can be used to compare the costs of the existing equipment over a given time period with the costs over the same time period of a project proposed by an Energy Service Company (ESCO) or utility. The costs of performing a feasibility study, setting up and administering the contract, and financing the project through the ESCO or utility can all be included in the LCCA. The BLCC program, in addition to the detailed LCC report showing lowest LCC, also prints out a listing of undiscounted year-to-year cash flows, which allow the analyst to determine whether the total cost savings or energy-related savings of the project are sufficient to cover the proposed contract payments.

LCCA also allows the analyst to compare the life-cycle costs of financed Energy Conservation Measures (ECMs) with those of agency-funded ECMs, the latter implemented either immediately or in a future year.

When evaluating ESPCs or UCs, using the BLCC program, some additional input data and assumptions are needed.

(a) Financing-related input data

- *Investment amounts to be financed:* When an agency has appropriated funds available to "pay down" the acquisition loan, only a percentage of the initial cost of an ESPC or UESC project has to be borrowed and repaid as part of the contract payments.
- *Contract payments:* Typical contract-related costs for ESPCs and UESCs may include debt service, fees for management and administration, measurement and verification, and OM&R costs.
- *Contract term:* The contract term coincides with the performance period of the ESCO and the length of time contract payments are made by the agency.

(b) Assumptions

- ***Base date and service date***: For the purpose of performing an LCCA, the base date is the point in time to which all project-related costs are discounted. The base date is the first day of the study period for the project, usually considered synonymous with the date at which the study is performed. The service date is the date on which the building is occupied or a system is taken into service; operating and maintenance costs (including energy- and water-related costs) are generally incurred after this date, not before.

In the case of a retrofit to an existing building, the base date and service date coincide because the existing equipment continues to consume energy and require maintenance while the energy conservation measures are installed. Energy and non-fuel costs have to be adjusted to account for the changes during the installation period. This case usually applies to projects proposed under ESPCs or UESCs.

- *Current-dollar analysis*: The rate of inflation has to be included when ESPCs or UESCs are evaluated, because (1) the contract payments proposed by the ESCO are determined using a market interest rate, which includes inflation, and (2) during the contract term, fixed contract payments are compared from year to year with undiscounted, current-dollar savings. If the analysis is performed in current dollars, the discount rate and all escalation rates also need to include inflation. The NIST Building Life-Cycle Cost (BLCC) Program, BLCC5, contains a module, "Federal Analysis, Financed Projects," which is dedicated to ESPC and UESC analyses and uses current-dollar analysis as a default.

- *Cost of feasibility studies/"Sunk Costs":* If, in the case of ESPCs or UESCs, the costs of feasibility studies were incurred or committed before the base date of the LCCA, they are "sunk costs" and can be omitted from the LCC computation. By definition, sunk costs cannot be changed by the selection of any project alternative and thus cannot affect its LCC or the LCC of competing alternatives.

4. Bundling of Energy Efficiency Projects

Although bundling less cost-effective projects with projects that are cost-effective does not maximize overall net savings as required by the economic principles of life-cycle costing, bundling of energy efficiency projects is allowed according to ESPC and UESC guidelines. Individual energy conservation measures may be bundled together to optimize energy-saving and/or environmental benefits of a project. In addition, Executive Order 13123 encourages bundling as follows:

> *"…Where appropriate, agencies shall consider the life cycle costs of combinations of projects, particularly to encourage bundling of energy efficiency projects with renewable energy projects. Agencies shall also retire inefficient equipment on an accelerated basis where replacement results in lower life-cycle costs…"* (Section 401, Executive Order 13123)

The Executive Order cites two examples -- renewable energy projects and retirement of obsolete equipment -- when less cost-effective ECMs may be combined in a project with ECMs with larger net savings and implemented as a single, bundled ESPC or UESC project. Similarly, load management efforts and other measures that save great amounts of energy, reduce energy costs, improve energy-related infrastructure, reduce air pollution, or reduce greenhouse gas emissions may also be bundled with other ECMs as long as the overall project is life-cycle cost effective. Individual energy conservation measures must be reasonably related to the overall project as a whole, i.e., must be an integral part of the project; no single ECM should be significantly cost-ineffective.

Energy managers should take an integrated systems approach when defining the scope of a building retrofit or other energy-related project. In many cases, a decision about one ECM will directly affect the scope or type and thus the cost-effectiveness of other ECMs.

5. Life-Cycle Cost for Energy-Using Products

When purchasing energy-using products, agencies should perform an LCCA to assure that they are making a cost-effective selection. Pursuant to FAR Section 23.704, agencies can purchase cost-effective energy-efficient products even if the first cost is higher than a less efficient product.

To assist agencies in calculating the LCC of energy-efficient products, FEMP has developed cost-effectiveness examples for over 50 product types, ranging from household dishwashers to water-cooled electric chillers. The cost-effectiveness examples are presented as part of FEMP's popular one-sheet *Energy Efficiency Recommendations* (an example is included as Appendix C). Each one uses the NIST-prescribed LCC methodology for discounting future costs and savings, which incorporates future energy price trends (as predicted by DOE’s Energy Information Administration). FEMP uses standard industry assumptions for key variables such as annual hours of operation, as well as federal average energy prices, and then calculates the energy cost savings that would accrue from purchasing a “recommended” and “best available” model, compared with one that just meets a legal minimum efficiency (as prescribed by the National Appliance Energy Conservation Act for most residential appliances and equipment, and by ASHRAE Standard 90.1 for many types of commercial equipment). For example, the lifetime energy cost savings (over an estimated 19-year life) for a FEMP-recommended 21 cubic foot refrigerator compared to one that just meets the NAECA standard is $100 (in present value). For the most efficient alternative on the market, the energy savings would be $180. The recommended levels are those prescribed by FEMP for meeting Executive Order 13123's call for agencies to purchase, where cost-effective, Energy Star labeled products, or products in the top 25 % of energy efficiency of their type and size.

This “lifetime energy cost savings” figure gives users a dollar figure to compare with the product’s price premium; if the additional purchase cost of the more efficient item is less than the lifetime savings from energy, the efficient product is economically justified. Additionally, the *Energy Efficiency Recommendations* provide the proper linear adjustments so users can adjust the examples for their own utility rates, hours of operation, or product capacities (FEMP tries to choose common or average capacities, such as 10,000 Btu/hour for room air conditioners, or 500 tons for centrifugal chillers).

FEMP has also developed interactive web-based "cost calculators" so that agency users can easily tailor their own product cost-effectiveness estimates. FEMP provides reasonable default values for cases where, for instance, the user may not have an estimate for the operating hours of his or her facility's air conditioner. However, almost all the relevant variables are modifiable. The calculators are available for several products covered in the *Energy Efficiency Recommendation* series, by first going to the "Energy Efficient Products" web site, at www.eere.energy.gov/femp/technologies/eeproducts.cfm, and then proceeding to the "Energy Cost Calculators." Presently, calculators are available for commercial and residential HVAC equipment and appliances, lighting technologies, water saving technologies, and others. More are being added continuously.

6. Assessment of Building Life-Cycle Cost Computer Programs

(a) NIST Building Life-Cycle Cost (BLCC) Computer Program

BLCC5, developed by the National Institute of Standards and Technology, provides comprehensive economic analysis of proposed capital investments expected to reduce long-term operating costs of buildings or building systems. The multi-platform program calculates lowest life-cycle costs, net savings, savings-to-investment ratio, internal rate of return and payback for any alternative relative to a base case. It complies with American Society for Testing and Materials (ASTM) standards related to building economics and is consistent *with NIST Handbook 135, Life-Cycle Costing Manual for the Federal Energy Management Program*.

The program provides economic analysis for the following project environments:

- **FEMP Analysis, Energy Project:** Energy and water conservation and renewable energy projects falling under Federal Energy Management Program (FEMP) guidelines (10CFR436).
- **Federal Analysis, Financed Project:** Federal projects financed through Energy Savings Performance Contracts (ESPC) or Utility Energy Services Contracts (UESC).
- **OMB Analysis, Non-Energy Project:** Cost-effectiveness, lease-purchase, internal government investments, and asset sales analyses subject to OMB Circular A-94.
- **MILCON Analysis, Energy Project:** Energy and water conservation and renewable energy projects in military construction.
- **MILCON Analysis, ECIP Project:** Energy and water conservation projects under the Department of Defense Energy Conservation Investment Program (ECIP).
- **MILCON Analysis, Non-Energy Project**: for military construction designs that are not primarily intended for energy or water conservation.

(b) BLCC-associated programs (DOS-based)

EERC: Energy Escalation Rate Calculator: The EERC allows the user to calculate an average annual rate of energy price escalation to be applied to contract payments in alternative financing projects when these payments are based on projected energy cost savings. The EERC computes the average, over the contract term (performance period), of the energy price escalation rates projected annually by the DOE Energy Information Administration, by location, industry sector, length of contract period, and proportion of energy savings from each fuel used in the project.

BLCC4: As the predecessor of BLCC5 this program also provides analyses of private-sector projects including financing and tax analyses. The private-sector modules will be transferred to BLCC5 in the future.

EMISS: *A Program for Estimating Local Air Pollution Emission Factors Related to Energy Use in Buildings,* NISTIR 5704, National Institute of Standards and Technology. EMISS is a stand-alone program that generates a file of local air-pollution emission coefficients (CO_2, NO_x , and SO_x) for use with the BLCC program. Emission factors for electricity can be generated by state or geographical region from the EMISS database. Emission factors for fossil fuels used at the site can be generated from estimates of heating value, sulfur content, and end use. 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.

DISCOUNT: *A Program for Discounting Computations in Life-Cycle Cost Analyses,* NISTIR 4513, National Institute of Standards and Technology. The DISCOUNT program computes discount factors and related present values, future values, and periodic payment values of cash flows occurring at specific points. DISCOUNT is especially useful for solving LCC problems that do not require the comprehensive summation and reporting capabilities provided by the BLCC program. DISCOUNT is updated each year on April 1 to incorporate the most recent DOE/EIA energy price escalation rates.

ERATES: *Program for Computing Time-of-Use, Block, and Demand Charges for Electricity Usage,* NISTIR 5186, National Institute of Standards and Technology. ERATES is a computer program for calculating monthly and annual electricity costs under a variety of electric utility rate schedules. Both kWh usage and kW demand can be included in these costs. Most typically these calculations will be used to support engineering-economics studies that assess the cost effectiveness of ECMs or measures to shift electricity use from on-peak to off-peak time periods.

(c) Other computer programs for life-cycle cost analysis
Agencies are free to use other LCCA computer programs as long as they are consistent with the life-cycle cost procedures and methodology of 10 CFR 436A and/or OMB Circular A-94.

7. Other Life-Cycle Costing Resources

(a) NIST Handbook 135: *Life-Cycle Costing Manual for the Federal Energy Management Program, 1995 edition*, National Institute of Standards and Technology. *Handbook 135* is a guide to understanding the LCC methodology and criteria established by the Federal Energy Management Program (FEMP) in 10 CFR 436A for the economic evaluation of energy and water conservation projects and renewable energy projects in all federal buildings. The purpose of *Handbook 135* is to facilitate the implementation of the FEMP rules by explaining the LCC method, defining the measures of economic performance used, describing the assumptions and procedures to follow in performing evaluations, giving examples, and noting NIST computer software available for computation and reporting purposes.

(b) Annual Supplement to NIST Handbook 135: *Energy Indices and Discount Factors for Life-Cycle Cost Analysis, Annual Supplement to NIST Handbook 135 (ASHB 135),* NISTIR 85-3273-XX**:** The ASHB 135, published by NIST and updated annually on April 1, provides energy price indices and discount factor multipliers needed to estimate the present value of energy and other future costs. The data are based on energy price projections developed by the DOE Energy Information Administration. Users of *Handbook 135* will need the most recent version of the ASHB 135 to perform LCC analyses for federal projects. The discount factors listed in the report are incorporated into the BLCC and associated computer programs.

(c) FEMP/NIST LCC Workshops

1. ***Basic LCC Workshop***: The two-day workshop provides a standardized framework for evaluating and comparing the economic performance of energy and water conservation, and renewable energy projects in buildings. It includes class-room instruction, exercises, and computer use of LCC support software.
2. ***Project-Oriented LCC Workshop***: The two-day workshop focuses on practical LCC solutions for energy and water conservation, and renewable energy projects. The workshop is complementary to the Basic LCC workshop taught by NIST and FEMP-Qualified Instructors. Students attending this workshop should have an elementary understanding of the principles of discounted cash flows and LCC analysis.
3. ***DOE/FEMP LCC Telecourse***: The two-hour DOE/FEMP telecourse uses state-of-the-art distance learning technology to demonstrate how to meet federal requirements for life-cycle cost analysis of energy and water conservation, and renewable energy projects. It is an introduction to LCC analysis and is broadcast annually.

4. ***Workshop Registration***: For information about course availability and schedules go to the FEMP web site at http://www.eere.energy.gov/femp/services/training_schedule.cfm. To register for the Basic LCC Workshop or Project-Oriented Workshop, when scheduled, contact Cecilia Mendoza, Ph. 509-375-2518, Fax 509-372-4990, cecilia.mendoza@pnl.gov, or register on-line at http://www.pnl.gov/femp To receive more information on the LCC Telecourse, contact Heather Schoonmaker, Ph. 865-777-9869, trainingsolutions@tds.net.

Note: Locally sponsored sessions of the Basic FEMP LCC Workshop are also available from FEMP-Qualified Instructors. For further information call the FEMP Help Desk at 1-877-EERE-INF (1-877-337-3463).

(d) NIST training videos

An introduction to the FEMP LCC method is provided in the following three video training films. The videos and workbooks are available through the Office of Applied Economics at NIST by calling 301-975-6132.

1. "An Introduction to Life-Cycle Cost Analysis"
2. "Choosing Economic Evaluation Methods"
3. "Uncertainty and Risk"

(e) ASTM Standards on Building Economics

The ASTM compilation on Building Economics provides a comprehensive resource document for evaluating the economic performance of investments in buildings, building systems and other constructed facilities. The ASTM Standards on Building Economics include the following standard practices:

E 917-02 – Measuring Life-Cycle Costs of Buildings and Building Systems
E 964-02 – Measuring Benefit-to-Cost and Savings-to-Investment Ratios for Buildings and Building Systems
E 1057-99 – Measuring Internal Rate of Return and Adjusted Internal Rate of Return for Investments in Buildings and Building Systems
E 1074-93 (1998) – Measuring Net Savings for Investments in Buildings and Building Systems
E 1121-02 – Measuring Payback for Investments in Buildings and Building Systems
E 1699-00 – Performing Value Analysis (VA) for Buildings and Building Systems
E 1765-02 – Applying the Analytical Hierarchy Process (AHP) to Multiattribute Decision Analysis of Investments Related to Buildings and Building Systems
E 1804-02 – Performing and Reporting Cost Analysis During the Design Phase of the Project
E 1946-02 – Measuring Cost Risk of Buildings and Building Systems

(f) Web sites and other contacts

General:

1. FEMP: BLCC5 and associated programs, Handbook 135, Annual Supplement ASHB 135, and Software User Guides, http://www.eere.energy.gov/femp/program/lifecycle.cfm
   Hard copies of Handbook 135, ASHB 135, and BLCC5 CDs are available from the FEMP HELP Desk at 1-877-EERE-INF (1-877-337-3463).

   Web site for energy-using products
   www.eere.energy.gov/femp/technologies/eeproducts.cfm.

2. NIST Office of Applied Economics: support for LCC methodology and BLCC5, sieglinde.fuller@nist.gov, Ph: 301-975-6134, http://www.bfrl.nist.gov/oae/oae.html
3. *Whole Building Design Guide:* guidance on sustainable building design, including guidance on life-cycle cost analysis, http://www.wbdg.org/.

Codes and Standards:

1. 10 CFR 436 Subpart A—*Federal Energy Management Program, Methodology and Procedures for Life-Cycle Cost Analyses*, http://www.access.gpo.gov/nara/cfr/waisidx_00/10cfr436_00.html
2. Circular No. A-94—*Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, http://www.whitehouse.gov/OMB/circulars/a094/a094.html
3. Executive Order 13123—*Greening the Government through Efficient Energy Management*, http://www.eere.energy.gov/femp/pdfs/eo13123.pdf
4. *DOE Guidance on Life-Cycle Cost Analysis Required by Executive Order 13123*, http://www.eere.energy.gov/femp/pdfs/lcc_guide_rev2.pdf
5. *Sustainable Building Technical Manual* (DOE/EPA), http://www.wbdg.org/media/pdf/sbtm.pdf
6. *Facilities Standard for the Public Buildings Service*, *P100* (GSA) – Chapter 1.7 – Life Cycle Costing, http://www.wbdg.org/media/pdf/p100.pdf
7. *P-442 Economic Analysis Handbook (*NAVFAC), http://www.wbdg.org/ccbref/ccbdoc.php?category=nav&docid=63&ref=1
8. *ASTM Standards on Building Economics*, 5th ed., http://www.astm.org/cgi-bin/SoftCart.exe/BOOKSTORE/COMPS/111.htm?L+mystore+kvml2554. ASTM, 2004. ASTM Stock #: BLDGEC99, ISBN# 0-8031-2714-6.
9. Tri-Services Memorandum of Agreement (MOA), *Criteria/Standards for Economic Analyses/Life-Cycle Costing for MILCON Design* (1991), http://www.wbdg.org/media/pdf/moa.pdf

Analysis Tools

1. Energy-10: Cost estimating program available from the Sustainable Buildings Industry Council (SBIC), http://www.sbicouncil.org/store/index.php#ENERGY-10
2. Building Life-Cycle Cost (BLCC5) Program, version 5.2-04: 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.cfm - blcc5

3. Life-Cycle Cost in Design WinLCCID Program: Developed for MILCON analyses by the Construction Engineering Research Laboratory of the U.S. Army Corps of Engineers, http://www.bso.uiuc.edu/WinLCCID. For password contact lawrie@dilbert.me.uiuc.edu.
4. ECONPACK for Windows: An economic analysis tool developed by the U.S. Army Corps of Engineers in support of DOD funding requests, http://www.hnd.usace.army.mil/paxspt/econ.html.

Additional Resources

1. *Building Economics: Theory and Practice* by Rosalie T. Ruegg and Harold E. Marshall. New York: Van Nostrand Reinhold, 1990.
2. *Engineering Economy* by G. J. Thuesen and W. J. Fabrycky. Prentice Hall, 1993. ISBN 0-13-277491-7.
3. *GSA LEED® Cost Study*, *http://www.wbdg.org/media/pdf/gsa_lcs_report.pdf*
4. *Simplified Energy Design Economics* by Harold E. Marshall and Rosalie T. Ruegg. NBS SP 544. Washington, DC: National Bureau of Standards, January 1980.
5. ASTM International: Publishes standards that support LCCA, http://www.astm.org
6. R. S. Means Company: Offers construction cost databases ,http://www.rsmeans.com
7. Sustainable Buildings Industry Council (SBIC): Offers workshops on Designing Low Energy Buildings that include instruction in using Energy-10 software, http://www.sbicouncil.org/
8. DOE/FEMP: Conducts workshops and teleconferences, http://www.eere.energy.gov/femp/services/training.cfm on life-cycle costing which include instruction in using BLCC5.

APPENDIX A

Additional Government Documents Providing Guidance on Life-Cycle Cost Analysis

(Internet links provided in previous section)

a) Office of Management and Budget

For projects that are not primarily concerned with energy or water conservation, Office of Management and Budget (OMB) Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, provides the necessary guidance. The underlying methodologies for the FEMP and OMB rules are identical, except that OMB has different discount rates depending on the type of analysis and the length of the study period and does not limit the length of the study period to 25 years.

b) Department of Defense

A Tri-Services Memorandum of Agreement (MOA) *"Criteria/Standards for Economic Analysis/Life-Cycle Costing for MILCON Design,"* which is updated periodically, provides guidance on LCCA for military construction design. The LCCA rules in this MOA are consistent with 10 CFR 436A and OMB Circular A-94. However, at present the MOA recommends (but does not require) the use of mid-year discounting for all annually recurring costs. It also recommends the lumping together of all initial investment costs at the midpoint of construction for projects that have a beneficial occupancy/service date later than the date of study.

c) General Services Administration

The General Services Administration (GSA) provides general guidance on LCCA for buildings and building systems in their documents *Facilities Standards for the Public Buildings Service*. The documents refers the reader to 10 CFR 436A for further information and instructions on LCCA.

APPENDIX B

Example of LCC Analysis

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

(a) Project Description

The U.S. Coast Guard (USCG) in Honolulu seeks to evaluate the feasibility of utility financing to replace an existing electric resistance water heating system with a solar water heating systems in 280 residences. As part of its regular maintenance schedule, USCG installs new heater tanks at the rate of 28 tanks per year, with the first set of tank renewals being completed one year from the base date. As an alternative, the USCG could replace the existing system with a more energy-efficient solar system that would be installed and financed through an energy services contract with the local utility company. It would be ready for operation in one year. USCG would make a down payment of 25 % of the total initial capital investment of $1,000,000 at the base date and finance the remaining 75 % over a contract term of 10 years. USCG performs a life-cycle cost analysis to determine if the utility proposal is cost effective.

Location:	Honolulu, HI
Base date:	June 2004
Implementation period:	1 year
Length of study period:	21 years
Government discount rate:	4.8 percent (nominal, including inflation)
Discounting convention:	Amounts discounted from end of each year to base date
Analysis type:	Current-dollar analysis (including inflation)
Inflation rate:	1.75 %
Electricity price:	$0.05/kWh, industrial rate

Base Case: Maintain and Repair Existing System

Annual electricity use:	2,975,000 kWh
Initial capital investment:	None
Capital replacement costs:	
Years 6, 11, and 16:	$23,750 for anode replacement

Annually recurring OM&R costs:	$32,220 for tank renewals, beginning one year from base date; no residual values assumed for tanks replaced during the last 9 years of the study period.

Alternative: Replace Existing System with Solar Water Heating System financed through a Utility Energy Services Contract

Contract-related data:

Amount financed:	$750,000 =(75 % of $1,000,000, at 8.5 % interest)
Annual contract payment:	$114,306
Contract term:	10 years
Implementation period:	1 year
Administrative costs:	$1,000 per year during contract term
Oversight costs:	$3,500 to be paid one year from base date; fixed amount

Annual energy usage:	Electricity before implementation: 2,975,000 kWh Electricity after implementation: 560,000 kWh

Component costs:

Initial cost paid by agency:	$250,000 (=25 % of $1,000,000 as down payment)

Capital Replacement costs:

Years 11:	$30,000 for anode replacements
Year 11:	$230,400 for tank replacements
Year 16:	$18,580 for valve replacements; 67 % residual value

Annually recurring OM&R costs:	$10,000 for routine maintenance beginning one year from base date

Non-annually recurring OM&R costs:

Years 11:	$35,000 for repairing controls and insulation

(b)Analysis Results

The LCC analysis shows that financing a solar water system is a cost-effective alternative to keeping the existing system. The *Summary LCC* and *Comparative Analysis* reports below show that the solar water system generates present-value Net Savings of $700,00 over the length of the study period.

The analysis was performed using BLCC5.2-04 for Federal Analysis, Financed Projects. For analysis results, see reports below. Only the *Summary LCC* report and the *Comparative Analysis* report are reproduced here. BLCC5 also outputs *Input Data Listing, Detailed LCC, Cash Flow, and Lowest LCC* reports.

Example of LCC Analysis: BLCC5 Analysis Reports

NIST BLCC 5.2-04: 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\USCG-04.xml
Date of Study:	Tue Nov 02 10:08:24 EST 2004
Analysis Type:	Federal Analysis, Financed Project
Project Name:	USCG
Project Location:	Hawaii
Analyst:	CDE
Comment:	Evaluate feasibility of replacing electric resistance water heating system with solar system financed through a 10-year Utility Energy Services Contract
Base Date:	June 1, 2004
Study Period:	21 years 0 months (June 1, 2004 through May 31, 2025)
Discount Rate:	4.8%
Discounting Convention:	End-of-Year

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

Alternative: Existing System - Electric Resistance
LCC Summary

	Present Value	**Annual Value**
Initial Cost Paid By Agency	$0	$0
Annually Recurring Contract Costs	$0	$0
Non-Annually Recurring Contract Costs	$0	$0
Energy Consumption Costs	$2,190,191	$167,885
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	$465,444	$35,678
Non-Annually Recurring OM&R Costs	$0	$0
Replacement Costs	$51,850	$3,974

Less Remaining Value	-$2,554	-$196
	------------	------------
Total Life-Cycle Cost	$2,704,931	$207,342

Alternative: Solar Water Heating System
LCC Summary

	Present Value	**Annual Value**
Initial Cost Paid By Agency	$250,000	$19,163
Annually Recurring Contract Costs	$858,626	$65,816
Non-Annually Recurring Contract Costs	$3,340	$256
Energy Consumption Costs	$530,205	$40,642
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	$144,458	$11,073
Non-Annually Recurring OM&R Costs	$25,286	$1,938
Replacement Costs	$199,708	$15,308
Less Remaining Value	-$6,692	-$513
	------------	------------
Total Life-Cycle Cost	$2,004,931	$153,684

NIST BLCC 5.2-04: Comparative Analysis

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

Base Case: Existing System - Electric Resistance
Alternative: Solar Water Heating System

General Information

File Name:	C:\Program Files\BLCC5\projects\USCG-04.xml
Date of Study:	Tue Nov 02 10:15:45 EST 2004
Project Name:	USCG
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 a 10-year Utility Energy Services Contract
Base Date:	June 1, 2004
Study Period:	21 years 0 months(June 1, 2004 through May 31, 2025)
Discount Rate:	4.8%
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	$250,000	-$250,000
Future Costs:			
Recurring and Non-Recurring Contract Costs	$0	$861,966	-$861,966
Energy Consumption Costs	$2,190,191	$530,205	$1,659,986
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Recurring and Non-Recurring OM&R Costs	$465,444	$169,744	$295,700
Capital Replacements	$51,850	$199,708	-$147,859
Residual Value at End of Study Period	-$2,554	-$6,692	$4,139
	------------	------------	------------
Subtotal (for Future Cost Items)	$2,704,931	$1,754,931	$950,000

	------------	------------	------------
Total PV Life-Cycle Cost	$2,704,931	$2,004,931	$700,000

Net Savings from Alternative Compared with Base Case

PV of Operational Savings	$1,955,686
- PV of Differential Costs	$1,255,686

Net Savings	$700,000

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

Comparison of Contract Payments and Savings from Alternative

(undiscounted)

	Savings in	**Savings in**	**Savings in**	**Savings in**
Year Beginning	**Contract Costs**	**Energy Costs**	**Total Operational Costs**	**Total Costs**
Jun 2004	$0	$0	$0	-$250,000
Jun 2005	-$118,823	$125,856	$148,859	$30,035
Jun 2006	-$115,341	$128,469	$151,874	$36,533
Jun 2007	-$115,359	$131,779	$155,595	$40,235
Jun 2008	-$115,378	$135,474	$159,706	$44,328
Jun 2009	-$115,397	$136,550	$161,206	$45,809
Jun 2010	-$115,416	$137,222	$162,309	$73,248
Jun 2011	-$115,435	$135,914	$161,440	$46,005
Jun 2012	-$115,455	$132,142	$158,116	$42,661
Jun 2013	-$115,475	$132,794	$159,222	$43,747
Jun 2014	-$115,495	$134,702	$161,592	$46,097
Jun 2015	$0	$136,691	$121,695	-$164,703
Jun 2016	$0	$138,016	$165,855	$165,855
Jun 2017	$0	$140,448	$168,775	$168,775
Jun 2018	$0	$141,622	$170,444	$170,444
Jun 2019	$0	$143,417	$172,744	$172,744
Jun 2020	$0	$145,823	$175,663	$182,487
Jun 2021	$0	$148,081	$178,443	$178,443
Jun 2022	$0	$149,663	$180,557	$180,557
Jun 2023	$0	$152,505	$183,940	$183,940
Jun 2024	$0	$154,926	$186,909	$197,991

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	674,940.0 kWh	2,300,060.0 kWh	48,293,388.1 kWh

Energy Savings Summary (in MBtu)

Energy Type	-----Average Base Case	Annual Alternative	Consumption----- Savings	Life-Cycle Savings
Electricity	10,151.1 MBtu	2,303.0 MBtu	7,848.1 MBtu	164,783.8 MBtu

Emissions Reduction Summary

Energy Type	-----Average Base Case	Annual Alternative	Emissions----- Reduction	Life-Cycle Reduction
Electricity				
CO_2	2,535,309.52 kg	575,238.30 kg	1,960,071.23 kg	41,154,787.80 kg
SO_2	6,800.53 kg	1,535.48 kg	5,265.05 kg	110,547.95 kg
NO_x	7,626.76 kg	1,730.44 kg	5,896.32 kg	123,802.56 kg
Total:				
CO_2	2,535,309.52 kg	575,238.30 kg	1,960,071.23 kg	41,154,787.80 kg
SO_2	6,800.53 kg	1,535.48 kg	5,265.05 kg	110,547.95 kg
NO_x	7,626.76 kg	1,730.44 kg	5,896.32 kg	123,802.56 kg

APPENDIX C
Example of a FEMP Product Energy Efficiency Recommendation

Commercial Unitary Air Conditioner Recommendation		
Product Type[a] and Size	**Recommended**	**Best Available**
< 65 MBtu/h (3 phase)	**12.0 SEER or more[b]**	**14.5 SEER**
65 - 135 MBtu/h	**11.0 EER or more 11.4 IPLV or more**	**11.8 EER 13.0 IPLV**
> 135 - 240 MBtu/h	**10.8 EER or more 11.2 IPLV or more**	**11.5 EER 13.3 IPLV**

[a] *Only air-cooled single package and split system units used in commercial buildings are covered. Water source units are not covered by ENERGY STAR®, but look for efficiency ratings that meet or exceed these levels for air source units.*
[b] *Where operating conditions are often close to rated conditions or in regions where there are high demand costs, look for units with the highest EER ratings that also meet or exceed this SEER.*

EER, or Energy Efficiency Ratio*, is the cooling capacity (in Btu/hour) of the unit divided by its electrical input (in watts) at the Air Conditioning and Refrigeration Institute's (ARI) standard peak rating condition of 95°F.*

SEER (Seasonal Energy Efficiency Ratio) *and* ***IPLV (Integrated Part-Load Value)*** *are similar to EER but weigh performance at different (peak and off-peak) conditions during the cooling season.*