LIFE CYCLE COST ANALYSIS GUIDELINES 2016

State Fire Marshal's Office
Department of Public Safety
215 East Seventh Street
Des Moines, Iowa 50319
(515) 725-6145
Fax (515) 725-6140

Intentionally left blank

Table of Contents

This booklet was prepared with a grant from the U.S. Department of Energy (DOE). However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s), and do not necessarily reflect the view of the DOE.

Intentionally left blank

INTRODUCTION

Section 470 of the Code of Iowa requires public agencies to conduct a life cycle cost analysis for construction projects in order to optimize energy efficiency at an acceptable life cycle cost. The purpose of this guideline document is to assist architects and engineers in completing this analysis. These guidelines provide a methodology intended to standardize analysis reporting and to facilitate a timely, meaningful, and accurate technical review.

Life cycle cost analysis (LCCA) is an economic method used to evaluate building design alternatives with different levels of energy efficiency. It is a method that can be applied to any capital investment decision in which higher initial costs are exchanged for reduced future operating costs. The design alternative with the lowest life cycle cost is the most cost-effective.

2016 Update Summary

The goal of life cycle cost analysis procedures is to select the building design with the lowest life-cycle cost from a set of alternatives. However this analysis can at times be in conflict with other important project criteria when the evaluations are made on a system-by-system basis as was required previously. The process has been simplified to allow flexibility for designers to respond to the overall life cycle cost of the whole building, as well as additional specific project criteria such as energy improvement beyond code, project first cost, system familiarity, and existing infrastructure.

When the LCCA guidelines were originally developed in the early 1980's, energy codes were not as stringent as they have become since the late 1990's. Today's energy code compliant buildings achieve greater energy efficiency than in the past. In addition, new benchmarks and incentives exist today that are focused primarily on reduction of energy use. Two common incentives are utility company rebate programs and LEED certification. These incentives are based on total building performance, allowing tradeoffs between systems, as opposed to independent system evaluations. The guideline changes are intended to allow design teams to balance multiple competing criteria in determining overall building systems design, while still encouraging the exploration of design alternatives that may benefit the life cycle cost of the overall proposed facility.

Intent of Analysis

The intent of these guidelines is to encourage exploration of meaningful energy efficiency design options that are compatible with the programmatic goals of the project. The design improvements proposed for study should be considered feasible for the project. The analysis is to be used as a tool by the design team and building owner early in the design process to gain usable information with which to make good design decisions. While facilities designed and constructed to code minimum values are allowable, the intent of the life cycle cost analysis process is to evaluate alternate energy efficiency improvement designs against a code minimum baseline to determine the overall life cycle cost impact. Meaningful improvements for study may include, but are not limited to, the following examples:

1) HVAC systems
2) Domestic water heating systems
3) Wall systems
4) Roof systems
5) Glazing systems
6) Lighting systems
7) Daylighting
8) Lighting controls
9) Envelope commissioning
10) Renewable energy systems

When Required

The Code of Iowa defines when an LCCA is required when it states that "… a public agency responsible for the construction or ***renovation*** of a ***facility*** shall… include as a design criterion the requirement that a life cycle cost analysis be conducted for the facility." (emphasis added) (470.2) Pertinent Code (470.1) "Facilities" are defined as follows:

- "*Facility*" means a building having twenty thousand square feet or more of usable floor space that is heated or cooled by a mechanical or electrical system.
- "*Addition*" means new construction equal to or greater than twenty thousand square feet of usable floor space that is heated or cooled by a mechanical or electrical system and is joined to an existing facility.
- "*Renovation*" means a project where alterations, that are not additions, to an existing facility exceed fifty percent of the value of the facility and will affect an energy system."

Timing of a Life-Cycle Cost Analysis

LCCAs must be completed and approved early in the design process before system selection decisions are finalized. Iowa Code states that a "life cycle cost analysis shall be approved… before contracts for the construction or renovation are let." (470.4)

Review and Approval Procedure

The public agency responsible for the new construction or renovation is to submit the LCCA report to the Iowa Department of Public Safety for review. (Contact the Department of Public Safety, Fire Marshal Division, Building Code Bureau for submission instructions at 515/725-6145 or bcinfo@dps.state.ia.us). The purpose of the technical review is to verify compliance with the Code of Iowa and that cost estimates, assumptions, and conclusions are reasonable, meaningful, and accurate.

Upon completion of the Department of Public Safety's review, if there are technical problems or if the department disagrees with any aspects of the report, the department will request clarification or revision of the report. A letter will be sent to the public agency or design professional that submitted the report. Any requested revisions or clarifications will be promptly submitted in writing to the department. This process continues until the report is approved in writing by the Building Code Bureau. The technical review and approval shall be completed before the letting of contracts for the construction or renovation of a facility. (Iowa Code 470.7)

Contact the Building Code Bureau (at 515/725-6145 or bcinfo@dps.state.ia.us) about additional requirements for buildings that are subject to the State Building Code and review by the State Building Code Bureau.

Technical Requirements

Iowa Code states that a public agency or a person preparing a life cycle cost analysis for a public agency shall consider the methods provided for use by the reviewing agency. These guidelines are intended to serve this purpose.

The minimum equipment or measures to be analyzed in an LCCA include:

(1) The building systems affecting the heating, cooling, ventilating, and power consumption of the facility.
(2) Equipment used to heat domestic water.
(3) On-site utility generating equipment, when included in the project.

ANALYSIS PROCEDURE

The goal of the life cycle cost analysis procedure is to confirm that the selected building design has an equal or lower life cycle cost when compared to a code minimum baseline building. The analyst is to evaluate the proposed building design against a baseline code building including the domestic hot water system, lighting system, building envelope, process (plug) loads, and HVAC (heating, ventilation, and air-conditioning) systems. When included in the project, the analyst is to consider the life cycle cost for on-site utility generation.

Each analysis is to be based on a 25 year study period and shall use U.S. Department of Energy Federal Energy Management Program (FEMP) discount factors and indices (refer to the *Resources* section below). When the useful life of a system or system component is less than the study period, the analysis must include the replacement cost and then account for the salvage value at the end of the study period. Salvage value is assumed to be the remaining value at the end of the study period. The salvage value of a system or system component is calculated by linearly prorating its initial cost. Any salvage value is then used to reduce the system's life cycle cost. Appendix B lists equipment service lives to be used in life cycle cost analyses.

The analysis methodology must consider interaction between energy-using systems. When the amount of energy consumed by one system impacts the energy consumed by another, this interaction must be carefully considered in the analysis. The analysis procedure is as follows:

1) Compare two whole building systems including building envelope, interior lighting, water heating, process (plug) loads, heating, cooling, and ventilating. Exterior lighting shall be included at the discretion of the design team. Whole building simulations shall be based on the following two buildings:
    a. Minimally code compliant baseline building – Modeled per ASHRAE 90.1 Appendix G requirements or the ASHRAE 90.1 Energy Cost Budget Method as referenced in the current state energy code.
    b. Alternate proposed design – Modeled per ASHRAE 90.1 Appendix G requirements or the ASHRAE 90.1 Energy Cost Budget Method, following same method as the baseline building as referenced in the current state energy code.
2) The selected building design shall have an equal or lower life cycle cost over a 25 year period when compared with the code minimum building, factoring in the following costs:
    a. Initial cost
    b. Energy cost
    c. Maintenance cost
    d. Replacement cost
    e. Salvage cost
3) When on site utility generation will be included in the project, calculate the life cycle cost of the proposed system(s).

Resources

A particularly useful reference for life cycle costing procedures is the *Life-Cycle Costing Manual for the Federal Energy Management Program*, National Institute for Standards and Technology (NIST) Handbook 135, 1995 Edition. This 10 MB manual can be downloaded on the internet from:

> http://www1.eere.energy.gov/femp/program/lifecycle.html

Alternatively, this manual can be ordered from:

> National Technical Information Service
> 5285 Port Royal Road
> Springfield, Virginia 22161
> (800) 553-6847 or
> (703) 487-4650

In April of each year NIST also publishes an annual supplement to Handbook 135 titled “Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis”. This supplement includes discount factors to be used in life cycle cost analysis calculations. The analyst should use current discount rates, however, only U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) rates are to be used. Do not use Office of Management and Budget (OMB) rates.

Analysts without internet access or analysts unclear on the appropriate rates to use may contact Dave Ruffcorn at (515) 725-6139 or ruffcorn@iowa.gov. The current supplement to Handbook 135 can be downloaded from the previous web address.

The manual and the annual supplement is in Adobe Portable Document Format (PDF) so the Adobe® Acrobat® Reader® software must be used. Acrobat Reader can be downloaded from the internet at:

> https://get.adobe.com/reader/

STANDARD FORMAT FOR LIFE CYCLE COST REPORTS

The format of LCCA reports that are submitted should be similar to the format of the following guidelines. LCCA reports are to be stand-alone documents, meaning that they are to include all information needed for the review, and for future reference.

The order of sections and appendices are:

1. Professional Certification
2. Executive Summary
3. Project Summary Information
4. Assumptions Form
5. Discount Factor Summary Table
6. Life-Cycle Cost Analysis
    A. Baseline and Proposed Building Descriptions
    B. On-Site Electric Generation (if included in the project)
    C. Recommendations
7. Appendices:
    A. ***Life Cycle Cost Analysis Forms***
    B. ***Equipment Service Lives***

Intentionally left blank

Section 1: Professional Certification

The first form required is the Certificate of Responsibility (refer to the following page). The report must be certified by either a registered Architect or a licensed Professional Engineer in Iowa.

Iowa has currently adopted the 2012 International Energy Conservation Code as its energy code for commercial buildings, so this is the base case for each alternative studied. The analyst is to answer the question at the bottom of the form to verify that all design options in the report comply with the energy code.

Certificate of Responsibility

Professional Engineer

SEAL	I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa. (signature)_______________________________________(date) Printed or typed name My license renewal date is December 31, ______. Pages or sheets covered by this seal: ____ ____ ____

Registered Architect

SEAL	I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly Registered Architect under the laws of the state of Iowa. Printed or typed name ______________________________ Signature ____________________________ Date __________ Registration Expires ______________ Date Issued _________ Pages or sheets covered by this seal: ____ ____ ____ ____

Do the designs in this report meet Iowa energy code requirements as adopted from the 2012 International Energy Conservation Code?	**____ Yes ____ No**

Section 2: Executive Summary

The Executive Summary is to include:

- an explanation of the purpose of the report
- a summary of important findings of the report
- a description of important assumptions and special design considerations used in the analysis
- system selection recommendations based on lowest life cycle cost
- *Life-Cycle Cost Analysis Summary* form

The *Life-Cycle Cost Analysis Summary* form must be provided in the Executive Summary (refer to the next page). The *Life-Cycle Cost Analysis Summary* form tabulates the findings of each proposed alternative evaluated in the report and provides the derivation for the annual energy budget for the base case and for the proposed alternatives yielding the lowest life cycle cost. The derivation of the annual energy budget should not double count energy consumption data, such as lighting energy that is often also included in HVAC system energy consumption calculations.

Life Cycle Cost Analysis Summary

Building Area ___________ square feet

System	Description	Electricity (kWh)	Natural Gas (Therms)	Annual mmBtu	Annual Energy Cost ($)	EUI (Btu/sq.ft./year)	Life Cycle Cost ($)	Initial Cost ($)
Baseline								
Proposed								
Utility Generation								
					Base Case Totals			
					Recommended Systems Totals			
					Difference (Base Case minus Recommended)			

Section 3: Project Summary Information

The second form required is the *Project Summary Information* form (refer to the following page). The form is divided into four areas including a project summary, a listing of institution and design professional contact information, and a description of special design considerations or constraints.

The project summary section includes general information about the building as well as specific building design information. Fill in notes pertaining to the following:

- Building Type
- Building Square Footage
- Number of Floors
- Estimated Number of Occupants
- Slab-on-grade?
- Partially below grade?
- Mechanical cooling?
- Renewable resources used?
- On-site electric generation?
- Estimated annual occupancy hours

The next two sections are to provide project contact information (including support staff) involved in the report preparation.

The final section provides space to describe special design considerations requested by the institution or constraints that limit the choice of design alternatives. Design constraints that affect system alternatives selection must be documented here as well as in the report documentation.

Project Summary Information

Project Summary

Project Name ____________________

Institution Name ____________________

City ____________________ State__________ Zip __________

Building Type ____________________ Building Square Footage __________

Number of Floors __________ Estimated Number of Occupants __________

Slab-on-grade? __________ Partially below grade? __________

Mechanical cooling? __________ Renewable resources used? __________

On-site electric generation? __________ Estimated annual occupancy hours __________

Institution Contact

Contact Person ____________________ Title__________

Email ____________________

Address ____________________

City ____________________ State__________ Zip __________

Telephone ____________________ Fax __________

Design Professional Contacts

Architectural Firm ____________________

Architect Name ____________________ Title__________

Support Staff Name ____________________ Title__________

Email ____________________

Address ____________________

City ____________________ State__________ Zip __________

Telephone ____________________ Fax __________

Engineering Firm ____________________

Engineer Name ____________________ Title__________

Support Staff Name ____________________ Title__________

Email ____________________

Address ____________________

City ____________________ State__________ Zip __________

Telephone ____________________ Fax __________

Special Design Considerations ____________________

Scenarios Description*

	Baseline	Proposed
Architectural		
Wall Construction and Overall U-value		
Roof Construction and Overall U-value		
Roof Reflectance		
Window to Wall Area Ratio		
Window Characteristics		
Lighting		
Lighting Controls		
Lighting Power Density		
HVAC		
Air Delivery System		
Heating Equipment		
Cooling Equipment		
Controls		
Service Water Heating		
System Description		
Equipment Efficiency		
On-Site Utility Generation		
Description		

*Add rows as needed to describe the scenarios. Add columns as needed if additional proposed options are studied.

Section 4: Assumptions Form

The *Assumptions Form* provides a central location for documenting assumptions made in the analysis (refer to the next page). Assumptions regarding initial energy rates used in the analysis are to be provided. The energy rates should be entered for both summer and winter, as applicable. In the case of on-site electricity generation, this should also include information about utility buyback rates. The source of the utility cost information must be noted.

Assumptions regarding the estimated annual maintenance costs for the baseline and proposed systems should be documented in the next area. Annual maintenance costs used in the analysis may be based on a percentage of system first cost as noted in the table. Lower percentages may be applicable to central systems; higher percentages may be more applicable to distributed systems. The designer must provide reasoning for the values used. It is also acceptable for the designer to justify and use an alternate maintenance cost structure if it provides additional accuracy in the analysis.

The next area provides a location to document other assumptions made in the analysis. Examples of other assumptions include the quantity of domestic hot water used annually and scheduled occupancy.

The final area on the *Assumptions Form* provides a location to document references used. These references include, but are not limited to, those used to perform calculations and those used to estimate construction costs. Additional pages may be added as necessary to list all of the assumptions and references.

Assumptions Form

Estimated Average Initial Fuel Costs:

	Summer	Winter
Natural Gas ($/Therm)		
Electricity ($/kWh)		
Electricity ($/kW Demand)		
Liquefied Petroleum Gas (LPG) ($/gal)		
Other (Specify)		

Assumptions Relating to Fuel Costs (Identify source of utility cost data)

____
____
____
____
____

Annual Maintenance Costs*

	Baseline	Proposed	Remarks
Lighting			
HVAC			
Service Water Heating			
On-Site Utilities			

* Depending on system type and project, annual maintenance costs between 0.5% to 3% of initial system construction cost may be used. Alternate available cost structures may be used in the analysis if they are a better representation of actual maintenance costs for a particular project than the above range.

Other Assumptions

1. ____
   ____
2. ____
   ____
3. ____
   ____

References

1. ____
____
2. ____
____
3. ____
____

Section 5: Discount Factor Summary

Factors used in the report are to be recorded in the *Discount Factor Summary* form (refer to the next page). As mentioned previously, these factors are from the annual supplement to Handbook 135 *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis* from U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) for Iowa. This document is updated and posted each April.

Discount Factor Summary

Discount Factor Summary

Year	Table References			
	A-1 nonfuel SPV factor	A-2 nonfuel UPV factor	Ba-2 fuel UPV factor (Commercial)	
			Electric	Natural Gas
25*	0.478	17.41	17.67	14.89

* Sample data from ASHB07.pdf (3.0% Discount Rate (DOE))

Section 6: Life-Cycle Cost Analysis

The life cycle cost calculations for each alternative are presented in this section of the report. The forms provided in Appendix A of these guidelines are the preferred reporting method. A set of forms are to be presented for each case. These forms come from Appendix B of the *Life-Cycle Costing Manual for the Federal Energy Management Program*, National Institute for Standards and Technology (NIST) Handbook 135, 1995 Edition. This manual can be ordered or downloaded on the internet as mentioned previously. Directions for the use of each form are presented on the adjoining pages in Appendix B.

Baseline and Proposed Cases

The analysis of each facility option (baseline and proposed cases), and utility generation options (if included) should begin with the baseline case that would be expected to provide the lowest installed cost that still meets the energy code but, due to lower efficiency, usually results in higher operating costs. The proposed option(s) should provide a tradeoff of higher installed cost for lower operating and (potentially) lower life cycle costs. In each case, the system with the lowest life cycle cost must be recommended. Designers may select and trade off improvements in building elements that impact energy consumption to create proposed cases that have a lower life cycle cost than the baseline case. These building elements include envelope, heating systems, cooling systems, domestic hot water systems, lighting systems, and on-site utility generation.

On-Site Utility Generation

When applicable, evaluate design alternatives for on-site utility generation. Potential alternatives include engine generators, micro-turbines, fuel cells, steam turbines, wind turbines, solar arrays (photovoltaic systems), etc.

Recommendations

Briefly note the recommended systems included in the selected case, however, most of this discussion should be provided in the Executive Summary. The set of selected systems should be used to find the detailed energy use prediction on the Life-Cycle Cost Analysis form in the Executive Summary.

Section 7: Appendix

The report appendix is to include supporting information. The contents of the appendix should include sketches of the planned building layout, energy use calculations, and any other pertinent information necessary to document the justification for the recommendations that are made.

Intentionally left blank

GUIDELINE APPENDICES

Intentionally left blank

Appendix A

Life Cycle Cost Analysis Forms

Intentionally left blank

LIFE-CYCLE COST ANALYSIS
PROJECT IDENTIFICATION

PROJECT TITLE ______________________________*FY*_____

*LOCATION*______________________________*DoE REGION*________

*BASE DATE*________________*SERVICE DATE*________________

*DESIGN FEATURE*______________________________

*CONSTRAINTS*______________________________

____

____

TYPE OF STUDY: [**X**] Energy and Water Conservation & Renewable Resources (FEMP) [_] Other (OMB A-94)

BASE CASE AND ALTERNATIVES FOR LCC ANALYSIS

(A) ______________________________

____

(B) ______________________________

____

(C) ______________________________

____

(D) ______________________________

____

(E) ______________________________

____

Analyst________________Phone__________Date of Study________

Project Identification
INSTRUCTIONS

Step 1. PROJECT IDENTIFICATION

- Enter project name and fiscal year.
- Enter location. Enter DOE region (from *Annual Supplement*).
- Enter Base Date and Service Date.
- Enter design feature to be evaluated.
- List constraints. Add page if needed.
- Designate study as energy conservation study or OMB study.

Step 2. BASE CASE AND ALTERNATIVES

- Give title and brief description of base case and alternatives to be analyzed.

Step 3. GENERAL INFORMATION

- Enter name of analyst, telephone number, and date study was completed.

LIFE-CYCLE COST ANALYSIS
INPUT DATA SUMMARY

Project Title____Alt. ID_________

TYPE OF COST OR BENEFIT (1)	(2)	(3)		(4)		(5)	(6)	(7)
One-Time Amounts	$-Amount on BD $\$ \times 10^3$ [_] $\$ \times 10^6$ [_]	Years from		Investment-related?		Data Source	Diff. Esc. Rate	Discount Factor Table
		BD	SD	Yes	No			No.
Annually Recurring Amounts	$-Amount on BD $\$ \times 10^3$ [_] $\$ \times 10^6$ [_]	Number of Payments from		Investment-related?		Data Source	Diff. Esc. Rate	Discount Factor Table
		SD		Yes	No			No.
Water:								
Energy:							Diff. Esc. Rates for ENERGY Projects Embedded in Discount Factors	

BD = Base Date
SD = Service Date

Input Data Summary
INSTRUCTIONS

Step 1. IDENTIFICATION OF ALTERNATIVE

- Enter project title and identification data for alternative from *Project Identification* worksheet.

Step 2. ANALYSIS INPUT DATA

Col. (1) Enter types of costs or benefits as of the Base Date (BD):

One-time amounts:

Examples: Planning/Construction (P/C) or Acquisition Costs
Capital Replacement Costs
Major Repair Costs
Disposal Costs
Resale, Retention, or Salvage Value

Note: P/C or Acquisition Costs may be assumed to occur in a lump sum at the beginning of the study period. All other one-time costs are assumed to occur at any time during the analysis period, the specific time depending on when they are actually expected to occur.

Annually recurring amounts:

Examples: Routine OM&R Costs and Custodial Costs
Energy Costs: Electricity, distillate, residual, etc.
Water Costs

Col. (2) Enter $-amounts as of the Base Date. (Designate as thousands or millions.)

Col. (3) For **one-time amounts**, enter the number of years after the Base Date (BD) and Service Date (SD) for which the costs or benefits occur.
For **annually recurring amounts**, enter the number of annual payments expected over the length of the study period.

Col. (4) Designate as investment-related or non-investment-related.

Col. (5) List data sources on a separate sheet and enter references here.

Col. (6) Enter differential escalation rates(s) for costs other than energy, if applicable.

Col. (7) Enter number of appropriate Discount Factor Table (for region, fuel type, sector, discount rate, differential escalation rate) from *Annual Supplement to Handbook 135*.

LIFE-CYCLE COST ANALYSIS
PRESENT-VALUE CALCULATIONS

Project Title____Alt. ID__________

(1) INVESTMENT-RELATED AMOUNTS	(2) $-Amount on BD $ x 10^3 [ ] $ x 10^6 [ ]	(3) Discount Factor	(4) Present Value (4) = (2)x(3)	(5) PV TOTALS (5) = Summation of (4) by type
				Initial Investment $ ________
				Capital Replacements + $ ________
				Disposal Costs + $ ________
				Salvage/ Resale Value - $ ________
				TOTAL INV.-RELATED COSTS $
OPERATION-RELATED AMOUNTS	$-Amount on BD $ x 10^3 [ ] $ x 10^6 [ ]	Discount Factor	Present Value (4) = (2)x(3)	
				Annual OM&R $ ________
				Non-Annual OM&R + $ ________
				Energy + $ ________
				Water + $ ________
				Other ± $ ________
				TOTAL OPERATION-REL. COSTS $

TOTAL PV LIFE-CYCLE COSTS = $______________

BD = Base Date

Present-Value Calculations
INSTRUCTIONS

Step 1. IDENTIFICATION OF ALTERNATIVES

- Enter project name and identification data for base case or alternative.

Step 2. PRESENT VALUE CALCULATION

Col. (1) Enter costs and benefits by category (investment-related or operation-related).

Col. (2) Enter $-amounts as of the Base Date, from column (2) of *Input Data Summary*.

Col. (3) Enter discount factors from tables identified in column (7) of *Input Data Summary*.

Col. (4) Multiply $-amount (column (2)) by discount factor (column (3)) and enter present value in column (4).

Step 3. LIFE-CYCLE COST CALCULATION

Col. (5)
- Sum all investment-related costs (including resale, retention, or salvage values, if any, that have to be subtracted from costs). Enter in box.
- Sum all operation-related costs and enter in box.
- Add total investment-related costs and total operation-related costs from boxes and enter Total PV Life-Cycle Costs for alternative in bottom part of worksheet.

Appendix B

Equipment Service Lives

Recommended Economic Lifetimes of Various Mechanical Systems

EQUIPMENT ITEM	ECONOMIC LIFE (yrs)
absorption liquid chilling system	20
air compressors	20
air conditioner single package, air-cooled, hermetic	10
air conditioner with remote air-cooled condenser	10
air-cooled single package air conditioner, hermetic	10
air-cooled split system air conditioners	10
air handling units, horizontal and vertical	20-25
air side equipment	20
boilers	20-25
burners	10
central station units	20
centrifugal chillers	20-30
centrifugal compressors, multistage	30
centrifugal compressors, single stage	20
centrifugal liquid chilling systems	20-30
chillers, absorption	20
chillers, reciprocating, up to 150 TR	12
chillers, reciprocating, 150 TR and up	14
coils, heating and cooling	indefinite
comm. air conditioners, remote a.c. condenser	10
comm. water-cooled conditioners, single package	10
compressors, reciprocating v/w, hermetic	12
compressors, reciprocating v/w, open	14
compressor units, vertical single-acting	30
condensers, evaporative, ammonia	20
condensers, evaporative	20
condensers, horizontal shell and tube, ammonia	20
condensers, horizontal shell and tube	20
condensers, remote air-cooled	12
condensing units, reciprocating v/w, hermetic	12
condensing units, reciprocating v/w, open	14
condensing units, vertical single-acting	30
controls, electric and pneumatic	20
cooling coils	indefinite
cooling towers, masonry fill	45
cooling towers, metal fill	15-20
cooling towers, wood fill	15-20
diesel engines	10-12
electric furnaces	10

continued

EQUIPMENT ITEM	ECONOMIC LIFE (yrs)
electric heating, add on	10
electric motors	20-25
evaporative condensers	20
evaporators, ammonia	30
evaporators, pinned coil, ammonia	20
evaporators, spiral pinned, ammonia	20
fans, backward curved (airfoil)	20
fans, coil multiple space conditions	20
fan coil room conditions	20
fans, forward curved	20
fans, utility sets	20
float regulators, high pressure, ammonia	30
float regulators, low pressure, ammonia	30
furnaces, gas fired	10
furnaces, oil fired	10
gasoline engines	10
heat pumps, single package, air-to-air	20*
heat pumps, single package, water-to-air	20*
heat pumps, split system, air-to-air	20*
hermetic year-round air conditioners	14
high pressure receivers	30
high pressure receivers, ammonia	30
horizontal shell and tube liquid chillers, ammonia	30
horizontal shell and tube condensers	30
horizontal shell and tube condensers, ammonia	30
induction room air units	indefinite
liquid chilling systems, centrifugal	20
liquid coolers, horizontal shell and tube	30
low temperature compressor units, recip. v/w, hermetic	12
low temperature compressor units, recip, v/w, open	14
multistage centrifugal compressors	30
multistage turbo compressors	20
multizone central station units	20
multizone rooftop units	10
multiple space fan coil units	20
oil receivers	NA
packaged refrigeration units	12

continued

EQUIPMENT ITEM	ECONOMIC LIFE (yrs)
packaged terminal units	10
photovoltaic panels	25
plug type, refrigeration units	12
produce storage units	12
product coolers	20
product coolers, ammonia	20
pumps, centrifugal	20-25
residential water-cooled conditioners, single package	10
remote air-cooled condenser	12
room air conditioners	8
room units	8
solar thermal panels	15
turbines (steam)	10-30
wind turbine generators	25

Intentionally left blank