Guidelines for Utilizing Life Cycle Cost Analysis and Cost-Benefit Analysis

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Table of Contents

Introduction

For years, the architecture/engineering and construction industries have focused on two primary concerns in the creation of buildings. The first, which is of utmost importance to architects and engineers, is the design of a building. Is the building enjoyable to view and occupy? Does the organization of spaces enhance the user's program? The client expects a building design that satisfies their aesthetic and functional goals.

The second concern, which is the primary focus of contractors, is the construction of a building. How will the building be built? How much will the building cost? The client expects a sound building for the estimated construction cost.

These are typically the primary concerns of a client when the idea of constructing a building is addressed, so it is no surprise that architects and contractors focus their efforts towards this end. These are significant concerns; however, they are not the only concerns that should be addressed when planning future construction.

A third concern that is receiving more attention as building owners investigate the economics of facility management is the cost of operations over the life of a building. The combination of economic theory and computer technology allows for a more sophisticated approach to the design and construction of a facility than ever before. Instead of merely looking at the facility in terms of cost to design and build, owners can broaden their perspective to include operations, maintenance, repair, replacement, and disposal costs. The sum of initial and future costs associated with the construction and operation of a building over a designated period of time is called the life cycle cost.

The *National Institute of Standards and Technology (NIST) Handbook 135, 2022 edition*, defines **Life Cycle Cost (LCC)** as "the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or a building system" over a designated period of time. Life Cycle Cost Analysis (LCCA) is an economic evaluation technique that determines the total cost of owning and operating a facility or building system over a period of time.

Life Cycle Cost Analyses can be performed on any size of building or on individual building systems. Many building owners apply the principles of life cycle cost analysis when making decisions regarding construction or improvements to a facility. From the homeowner who opts for vinyl siding in lieu of wood to the federal highway commission that chooses concrete paving over asphalt, both owners should be taking into consideration the future maintenance and replacement costs in their selections. While initial cost is a factor in their decisions, it is not the only factor.

The guidelines incorporated in this handbook have been developed to assist Alaskan school districts, their consultants, and communities in evaluating the life cycle cost of school construction decisions. The guidelines are based on AS 14.11.013, which directs the Department of Education & Early Development (DEED) to review projects to ensure they are in the best interest of the state, and AS 14.11.014, which stipulates the development of criteria intended to achieve cost-effective school construction. In support of these statutes, the standard DEED project agreement contains a clause requiring value engineering, and projects may require a full value analysis report. The project agreement language states:

> *Value Engineering: During the design of the Project, the Recipient, and the Recipient's consultants, shall incorporate value based design efforts with the goal of reducing the cost of the Project without sacrificing value. A formal Value Analysis may be required as specified in Appendix B.*

It cannot be emphasized enough that the district is best served when they involve the department early in design to review and plan for alternative designs. This will not only help to develop cost effective projects but, also assists both the district and the department to document compliance with clause 9.

In response to these legislative directives, the department evaluates all school construction and major maintenance grant requests based on their initial and long-term costs, i.e., their life cycle cost. This handbook establishes the Life Cycle Cost Analysis technique, and a simpler Cost-Benefit Analysis alternative, and criteria by which educational facility construction alternatives are to be evaluated. It is important to note that the usefulness of a LCCA lies not in the determination of a total cost of a project alternative, but in the ability to compare the cost of project alternatives and to determine which alternative provides the best value per dollar spent.

In 2022, the department introduced the *Alaska School Design & Construction Standards*. These Standards achieve two primary objectives: fulfill a statutory mandate to provide cost-effective construction standards and establish consistency for state aid. The *Standards* apply to all new school construction and new additions to existing buildings. Renovation to existing facilities will adhere to the *Standards*, whenever possible, as approved by DEED.

Selected design features and materials described in Part 2 Design Principles and Part 3 System Standards, have been designated with indicators for an LCCA. The indicators are followed by a numerical scale of 1 through 5 that conform to the following levels:

Designation	Cost Savings
LCCA-1	0% to 2%
LCCA-2	2% to <5%
LCCA-3	5% to <8%
LCCA-4	8% to <12%
LCCA-5	12% to 15%

LCCA-1 has the least life cycle to cost benefit, LCCA-5 has the most benefit.

An LCCA, or a cost-benefit analysis alternative, is required to support certain designated elements in the *Standards* prior to approval by DEED for inclusion in a project. The cost savings are what is expected to be achieved in comparison to baseline options. The LCCA level is shown in the Standards where the element is described.

Terminology of Life Cycle Cost Analysis

Life Cycle Cost Analysis is an essential design process for controlling the initial and the future cost of building ownership. LCCA can be implemented prior to design efforts or at any point in the design process. It can also be an effective tool for evaluation of existing building systems. LCCA can be used to evaluate the total cost of a full range of projects, from an entire site complex to a specific building system component. The Department of Education & Early Development has been charged with the responsibility of determining if a school capital project is in the best interest of the State of Alaska. The effective use of LCCA is vital in demonstrating that a school district's project request is not only the best solution for the district, but also for the State of Alaska.

As defined earlier, Life Cycle Cost is the total discounted dollar cost of constructing, owning, operating, maintaining, and disposing of a building or a building system over a defined period of time. Keeping this definition in mind, one can breakdown the LCC equation into the following three variables: the pertinent **costs** of ownership, the period of **time** over which these costs are incurred, and the **discount rate** that is applied to future costs to equate them with present day costs.

Initial & Future Expenses

The first component in an LCC equation is cost. There are two major cost categories by which projects are to be evaluated in a LCCA. They are Initial Expenses and Future Expenses. **Initial Expenses** are all costs incurred prior to occupation of the facility. **Future Expenses** are all costs incurred after occupation of the facility. Appendix A outlines the individual costs that are to be evaluated within the two major cost categories.

Defining the exact costs of each expense category can be somewhat difficult since, at the time of the LCC study, nearly all costs are unknown. However, through the use of reasonable, consistent, and well-documented assumptions, a credible LCCA can be prepared.

It should also be noted that not all of the cost categories are relevant to all projects. The preparer is responsible for inclusion of the pertinent cost categories that will produce a realistic LCC comparison of project alternatives. If costs in a particular cost category are equal in all project alternatives, they can be documented as such and removed from consideration in the LCC comparison.

Residual Value

One future expense that warrants further explanation is that of residual value. **Residual value** is the net worth of a building at the end of the LCCA study period. Unlike other future expenses, an alternative's residual value can be positive or negative, a cost or a value.

Since a LCC is a summation of costs, a negative residual value indicates that there is value associated with the building at the end of the study period. Perhaps the value is a roof that was recently replaced, or it is the building's superstructure that could function for another thirty years. Whatever the reason for the remaining value, it is a tangible asset of building ownership and should be included in the LCCA.

A positive residual value indicates that there are disposal costs associated with the building at the end of the study period. Perhaps, the costs are related to abatement of hazardous material or demolition of the structure. Whatever the cause, these are the costs of building ownership and should be included in the LCCA.

Zero residual value indicates that there is no value or cost associated with the building at the end of the study period. This rare instance occurs if the intended use of the building terminates concurrent with the end of the study period, the owner is unable to sell the building, and the owner is able to abandon the building at no expense.

Study Period

The second component of the LCC equation is time. The **study period** is the period of time over which ownership and operational expenses are to be evaluated. Typically, the study period can range from twenty to forty years, depending on owner's preferences, the stability of the user's program, and the intended overall life of the facility. While the length of the study period is often a reflection of the intended life of a facility, the study period is usually shorter than the intended life of the facility.

The National Institute of Standards and Technology (NIST) breaks the study period into two phases: the planning/construction period and the service period. The planning/construction period is the time period from the start of the study to the date the building becomes operational (the service date). The service period is the time period from the date the building becomes operational to the end of the study.

Due to the uncertainty of construction funding and the short construction season, the planning/construction period can take several years to complete for an Alaskan school project. To remove the uncertainty regarding the appropriate length of the planning/construction period and to simplify the LCC calculation, the department approves of the assumption that all initial costs will be incurred in the base year of the study. Thus, all initial costs will be entered into the LCCA at their full value.

The DEED recommended study period for LCCA is twenty years. This is due to population fluctuations within communities, the ever-changing nature of educational programs, the relative life span of individual building systems, and the reduced economic impact of costs incurred after twenty years.

The department's LCCA spreadsheet is designed for a twenty-year study period. It can be used to evaluate project options for complete school facilities (new construction and renovation projects), as well as evaluate project options related to individual building systems (roof replacement projects, mechanical upgrade projects, etc.).

Real Discount Rate

The third component in the LCC equation is the discount rate. The **discount rate**, as defined by *Life Cycle Costing for Design Professionals, 2nd Edition*, is "the rate of interest reflecting the investor's time value of money." Basically, it is the interest rate that would make an investor indifferent as to whether he received a payment now or a greater payment at some time in the future.

The NIST takes the definition of discount rates a step further by separating them into two types: real discount rates and nominal discount rates. The difference between the two is that the **real discount rate** *excludes* the rate of inflation, and the **nominal discount rate** *includes* the rate of inflation. This is not to say that real discount rates ignore inflation, their use simply eliminates the complexity of accounting for inflation within the present value equation. The use of either discount rate in its corresponding present value calculation derives the same result. For simplicity, this handbook will focus on the use of real discount rates in the calculation of LCC for project alternatives.

Obviously, as the economics of the world around us changes, so does the discount rate. To establish a standard discount rate to be used in LCCA, the department has adopted the U.S. Department of Energy's real discount rate. This rate is updated and published annually in the *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – Annual Supplement to NIST Handbook 135*. The publication can be found at https://www.nist.gov/publications/

Constant-Dollars

Just as discount rates can be defined as either real or nominal, so too can costs. The *NIST Handbook 135, 2022 edition*, defines **constant-dollars** as "dollars of uniform purchasing power tied to a reference year and exclusive of general price inflation or deflation." The NIST defines **current-dollars** as "dollars of nonuniform purchasing power, including general price inflation or deflation, in which actual prices are stated."

When using the real discount rate in present value calculations, costs must be expressed in constant-dollars. Similarly, when using the nominal discount rate in present value calculations, costs must be expressed in current-dollars. In the rare case that the inflation rate is zero, constant-dollars are equal to current-dollars and the real discount rate is equal to the nominal discount rate.

In practice, the use of constant-dollars simplifies LCCA. For example, suppose one wants to evaluate roofing products over a 30-year period. However, one roofing product must be replaced after 20 years. How much will the replacement of the roof cost in 20 years? By using constant dollars, the guesswork of estimating the escalation of labor and material costs is eliminated. The future constant dollar cost (excluding demolition) to install a new roof in 20 years is the same as the initial cost to install the roof. Any change in the value of money over time will be accounted for by the real discount rate.

Present Value

To accurately combine initial expenses with future expenses, the present value of all expenses must first be determined. The *NIST Handbook 135, 2022 edition*, defines **present value** as "the time-equivalent value of past, present or future cash flows as of the beginning of the base year."

The present value calculation uses the discount rate and the time a cost was or will be incurred to establish the present value of the cost in the base year of the study period. Since most initial expenses occur at about the same time, initial expenses are considered to occur during the base year of the study period. Thus, there is no need to calculate the present value of these initial expenses because their present value is equal to their actual cost.

The determination of the present value of future costs is time dependent. The time period is the difference between the time of initial costs and the time of future costs. Initial costs are incurred at the beginning of the study period in Year 0, the base year. Future costs can be incurred anytime between Year 1 and the final year of the study period. The present value calculation is the equalizer that allows the summation of initial and future costs.

Along with time, the discount rate also dictates the present value of future costs. Because the current discount rate is a positive value (inflation), future expenses will have a present value less than their cost at the time they are incurred.

Future costs can be broken down into two categories: one-time costs and recurring costs. **Recurring costs** are costs that occur every year over the span of the study period. Most operating and maintenance costs are recurring costs. **One-time costs** are costs that do not occur every year over the span of the study period. Most replacement costs are one-time costs.

To simplify the LCCA, all recurring costs are expressed as annual expenses incurred at the end of each year and one-time costs are incurred at the end of the year in which they occur. To determine the present value of future one-time costs the following formula is used:

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

Where:

PV = Present Value

A_t = Amount of one-time cost at a time "t"
d = Real Discount Rate
t = Time (expressed as number of years)

To determine the present value of future recurring costs the following formula is used:

$$PV = A_0 \times \frac{(1+d)^t - 1}{d \times (1+d)^t}$$

Where:

PV = Present Value
A_0 = Amount of recurring cost
d = Real Discount Rate
t = Time (expressed as number of years)

Selection of Project Alternatives

Prior to beginning an LCCA, project alternatives need to be established. These alternatives should be distinctly different and viable solutions to the facility issue being addressed. The chosen alternative is to be the most reasonable and cost-effective solution to the project problem. A minimum of three different project alternatives should be incorporated into the LCCA. A brief description of each project alternative and why it was chosen should be included in the LCCA.

Listed below are some possible project options that should be considered while selecting the most viable, reasonable, and cost-effective alternatives. These options are based on statutory language found in AS 14.11 and are included in the instructions to the annual CIP grant applications.

- Renovation and addition to the existing school facility.
- Rental and remodel of an existing local facility.
- Purchase and remodel of an existing local facility.
- Alteration of the attendance area boundary.
- Demolition of existing school and construction of a new school on the same site.
- The use of double shifting or year round school.
- Sale of existing school and construction of a new school on a new site.

Renovation and addition to the existing facility must be considered as at least one of the project alternatives for replacement school projects. A "No Action" alternative is not an acceptable project alternative. Options for the replacement of a building system could include replacement of select items, refurbishment, phasing the replacement in sections or different materials or equipment type.

An LCCA for each of the selected project alternatives is to be generated using the DEED LCCA spreadsheet or other software. The department's spreadsheet is available online at: https://education.alaska.gov/facilities/publications

Completion of the Life Cycle Cost Analysis

A LCCA can be performed in a variety of ways without compromising the results if the assumptions that shape the LCCA employ reasonable and consistent judgement. Given the various methods used to perform a LCCA, the Department of Education & Early Development has outlined the basic steps for preparation of a LCCA below.

This is not intended to be the only way a LCCA should be prepared, but it is meant to clarify the department's expectations. This outline should also enable school districts to judge for themselves the quality of services provided by their consultants.

The LCCA needs only to address cost categories that are pertinent to the scope of the project. However, to insure accurate comparison of alternatives, all LCCA evaluations of the project alternatives must incorporate the same cost categories. The LCCA of each project alternative should include:

- A brief description of the project alternative.
- A brief explanation as to why the project alternative was selected.
- A brief explanation of the assumptions made during the LCCA.
- Conceptual or schematic documentation indicating the design intent of the alternative.
- A site plan showing the integration of the proposed facility on the site and necessary site improvements (for projects involving additions or new construction).
- A detailed LCCA of the project alternative.
- A summary table that compares the total life cycle costs of Initial Investment, Operations, Maintenance & Repair, Replacement, and Residual Value of all the project alternatives.

Initial Investment Costs

The first step in the completion of the LCCA of a project alternative is to define all the initial investment costs of the alternative. **Initial investment costs** are costs that will be incurred prior to the occupation of the facility. All initial costs are to be added to the LCCA total at their full value. Appendix A lists the minimum initial investment cost categories that are to be addressed.

The level of detail of these costs should be commensurate with the level of project detail. Construction costs can be derived by using the DEED Cost Model spreadsheet, construction cost literature, contractor quotes, or professional cost estimating consultants.

Operation Costs

The second step in the completion of the LCCA of a project alternative is to define all the future operation costs of the alternative. The **operation costs** are annual costs, excluding maintenance and repair costs, involved in the operation of the facility. Most of these costs are related to building utilities and custodial services. All operation costs are to be discounted to their present value prior to addition to the LCCA total. Appendix A lists the minimum operation cost categories that are to be addressed in the LCCA.

Operation costs that are not directly related to the building should usually be excluded from the LCCA. An example of a cost that should be excluded is the cost of office materials. While it is an annual operating expense, it has nothing to do with the operation of the building but is instead a function of the building user.

However, should project alternatives generate different requirements of the user, it is appropriate to include these costs. An example of such a situation is the comparison of a year round school alternative with an alternative that uses the traditional nine month school season. It is quite possible that the two alternatives would have different staffing requirements. While staffing is not a building operation cost, it should be included in the LCCA to provide an accurate comparison of the alternatives.

Maintenance & Repair Costs

The third step in the completion of the LCCA of a project alternative is to define all the future maintenance and repair costs of the alternative. For simplicity, maintenance and repair costs have been combined in the department's LCCA spreadsheet. It should be noted that there is a distinct difference between the two costs.

Maintenance costs are scheduled costs associated with the upkeep of the facility. An example of a maintenance cost is the cost of an annual roof inspection and caulking of the building's roof penetrations. This task is a scheduled event that is intended to keep the building in good condition.

Repair costs are unanticipated expenditures that are required to prolong the life of a building system without replacing the system. An example is the repair of a broken window. This is an unscheduled event that does not entail replacement of the entire window unit, merely the replacement of the broken pane.

Some maintenance costs are incurred annually and others less frequently. Repair costs are, by definition, unforeseen so it is impossible to predict when they will occur. For simplicity, maintenance and repair costs should be treated as annual costs. All maintenance and repair costs are to be discounted to their present value prior to addition to the LCCA total. Appendix A lists the minimum maintenance and repair cost categories that are to be addressed in the LCCA.

It is important to note that all options are not 'created equal'. At first glance, maintenance and repair costs could be judged to be equal for all alternatives. However, the department urges districts to delve deeper and ask, "Is it possible that an alternative is more susceptible to damage than others?" Facility location, age of building systems, and variations in exterior envelope area are just a few factors that should be considered when estimating maintenance and repair costs for project alternatives. Credible explanation of the district's evaluation assumptions should be included in the LCCA.

Due to the variation in the Alaskan climate and building conditions, the department recommends using actual historical data and the district's preventative maintenance plan to generate maintenance and repair costs. Since maintenance and repair costs are typically part of the school's operating budget, historical costs for this work should be available. When actual maintenance costs are unavailable, costs can be derived from use of available literature or cost estimating consultants.

Replacement Costs

The fourth step in the completion of the LCCA of a project alternative is to define all the future replacement costs of the alternative. **Replacement costs** are anticipated expenditures to major building system components that are required to maintain the operation of a facility. All replacement costs are to be discounted to their present value prior to addition to the LCCA total. Appendix A lists the minimum replacement cost categories that are to be addressed in the LCCA.

Replacement costs are typically generated by replacement of a building system or component that has reached the end of its useful life. An example of a replacement cost is the replacement of a boiler. A boiler has a life expectancy that is shorter than that of the facility it serves. At some point it will fail and require replacement to keep the facility operational.

Since this handbook assumes the use of the constant-dollar approach to LCCA, the cost to replace a building component in the future will be the same as the current cost of the building component plus demolition costs and any alterations of existing systems required for the new component(s). Replacement costs can be derived from use of the DEED Cost Model spreadsheet, construction cost literature, contractor quotes, historical data, or cost estimating consultants.

Residual Value

The fifth step in the completion of the LCCA of a project alternative is to define the residual value of the alternative. **Residual value**, as defined earlier, is the net worth of a building or building system at the end of the LCCA study period. This is the only cost category in a LCCA where a negative value, one that reduces cost, is acceptable.

The residual value of a facility or building system is especially important when evaluating project alternatives that have different life expectancies. An example is the evaluation of two roofing alternatives, a metal roof versus a composition shingle roof.

The shingle roof has a life span of 20 years whereas the metal roof is expected to last 40 years. In a LCCA over a 30-year study period the shingle roof will have to be replaced, thus incurring replacement costs. The metal roof will not require replacement; thus, no replacement costs will be incurred. The residual value of each option is to be calculated as follows:

Metal Roof Residual Value = (Initial Cost) x (Age of Metal Roof/Metal Roof Life - 1)

Shingle Roof Residual Value = (Initial Cost) x (Age of Shingle Roof/Shingle Roof Life - 1)

The metal roof has a residual value of one quarter its initial cost because at the end of the study period three-quarters of its intended life will have been consumed. The shingle roof has a residual value of half its initial cost because a replacement roof was installed ten years prior. Thus, at the end of the study period, half of the *current* shingle roof's intended life will have been consumed.

The residual value of a project alternative can be established in several different ways depending on the level of detail available. However, project solutions that opt for a new replacement facility in lieu of renovation and addition to the existing facility should establish residual value on a building systems basis.

Finalize LCCA

Once all pertinent costs have been established and discounted to their present value, the costs can be summed to generate the total life cycle cost of the project alternative. After this has been done for all the viable project alternatives, a summary of the results should be prepared. The summary of project alternatives should compare the total life cycle costs of Initial Investment, Operations, Maintenance & Repair, Replacement, and Residual Value of all the project alternatives.

It is anticipated that the project alternative with the lowest overall life cycle cost will be the project alternative presented in the school district's Capital Improvement Project (CIP) request.

Cost-Benefit Analysis Alternative

The above-described LCCA is very beneficial towards making informed choices during design and construction of educational facilities. Alternatively, for simpler comparisons, there is a Cost-Benefit Analysis (CBA). A CBA should be reserved for simpler comparisons where the return on investment is limited to less than or near 10 years. Choosing between a LCCA or a CBA should be discussed with the owner, consultant, and possibly the department.

Discussion of possible alternatives should begin early in the project planning. Alternatives can be incorporated into the project efficiently if researched and costed prior to 65% design development deliverables. This is also a good time to discuss alternatives with the department. Utilizing an on-line system can make discussions easier and more efficient, this can help to show the intention to utilize alternatives and develop a project in the state's best interest.

The example below, considering roof insulation options, could be performed with a CBA if the return on investment were less than 10 years. Savings is calculated as shown and the costs can be from a professional estimate or from bid alternates. With a 10-year study of costs and benefits, the time cost of money is relatively small and can be ignored. The potential pricing inflation can be a secondary consideration. The consideration of future cost of heat (fuel) can either be ignored or considered depending on the confidence of future changes.

Example: Roof Insulation Alternatives

	Base (R-40)	Alt #1 (R-60)	Alt #2 (R-80)
Cost of Construction	$165,700	$171,100	$180,450
Net of Base	0	5,400	14,750
Cost of Heat @ $3.00/gal	$2,454/yr.	$1,635/yr.	$1,227/yr.
Net of Base	0	$819/yr.	$1,227/yr.
ROI (yrs.)		6.6yrs.	12.0yrs.

In this CBA, alternate #1 (R-60) is an easy choice at 6.6 years of payback. Alternate #2 (R-80) is a payback of 12 years. In this scenario, at 12 years, a choice would have to be made whether the CBA is sufficient to make a decision on the alternative selection, or whether a full LCCA should be performed. Both answers could be justified.

Summary

This handbook was created to assist school districts and consultants in the ability to make informed choices in proposed educational facility construction projects. The Department of Education & Early Development is responsible for ensuring that funded projects are in the best interest of the State of Alaska and are cost-effective solutions. The submittal of realistic LCCAs assists in such a determination.

Unfortunately, not all grant applications have convinced the department that the proposed project was the best and most cost-effective solution. Problems encountered with LCCAs have ranged from faulty methodology to the use of "straw man" alternatives. To assist school districts in avoiding the problems that have surfaced in previous LCCAs, the following list of suggestions is provided:

- Evaluate all project alternatives by the same cost categories, over the same study period, using the same discount rate.
- Include only cost categories that are pertinent to the project scope. If one project alternative incurs costs in a specific cost category, that cost category must be included in all other project alternatives even if no costs are incurred.
- Use the constant-dollar approach to LCCA. This is especially important when defining Replacement Costs.
- Include demolition costs of a building component or system when calculating its Replacement Cost.
- Project alternatives that surplus buildings to the State of Alaska are required to include the cost of demolition in their LCCA.
- Project alternatives that surplus buildings to the local community are required to include the cost of hazardous material abatement in their LCCA.
- Define at least three viable project alternatives for further study. The selected alternatives should be distinctly different to cover the spectrum of possible options. A "No Action" or repair alternative is not considered a viable project alternative.
- All project alternatives must be viable options (i.e., no "straw man" alternatives).
- Address why a project alternative is in the best interest of the State of Alaska.

The best method approach is to initiate alternative discussions between the district, consultant, and the department early on in planning and design. A well planned and developed alternative approach to your project will help to insure the best possible results and help to show that the district has met the project requirements during closeout with the department.

Closing

The guidelines incorporated in this handbook are intended to assist Alaska school districts with the evaluation of various educational facility project alternatives using LCCA. The process of performing a LCCA will heighten understanding of the proposed project among designers and district representatives. Often, cost saving ideas are generated that can be applied to more than one alternative. These ideas can direct the final design of a project toward cost-effective construction and enhance the overall value of a project.

The use of LCCA enables projects to be evaluated by their long-term costs rather than just their initial construction cost. This requires facility owners to consider the long-term operations and maintenance costs of a facility design. The emphasis on future facility costs directly benefits school districts. A building design that minimizes future operations and maintenance expenses leaves more money in the school district's operating budget, thus making more funds available for the education of the students.

LCCA is also a means of supporting certain elements of a design in relation to the *Alaska School Design & Construction Standards*. A design that aspires to utilize certain designated elements must employ LCCA to demonstrate that the option provides for cost-effective design.

The Department of Education & Early Development believes the implementation of proper LCCA techniques will promote cost-effective design and construction practices. The long-term savings generated by these efforts will benefit students, teachers, school districts, as well as the State of Alaska.

Samples

Life Cycle Cost Analysis Sample

And

Instructions

Complete these fields in the summary sheet and it will populate the workbook

Insert length of study

Insert discount rate per latest NIST update

District: District Name
School: School Name
Project: Project Name
Project #: Project Number

Study Period: 20
Discount Rate: 3.10%

Life Cycle Costs of Project Alternatives			
	Alternate #1	Alternate #2	Alternate #3
Initial Investment Cost	$0	$0	$0
Operations Cost	$0	$0	$0
Maintenance & Repair Cost	$0	$0	$0
Replacement Cost	$0	$0	$0
Residual Value	$0	$0	$0
Total Life Cycle Cost	**$0**	**$0**	**$0**
GSF of Project	1 GSF	1 GSF	1 GSF
Initial Cost/GSF	$0.00	$0.00	$0.00
LCC/GSF	$0.00	$0.00	$0.00

The summary will auto-fill from the Alternate 1, 2 and 3 worksheets

Insert GSF of this alternate

District:	District Name
School:	School Name
Project:	Project Name
Project #:	Project Number
GSF:	1 GSF

	Quantity	Unit	Unit Cost	Total Cost	Years	Present Value
Initial Expenses						
Initial Investment Cost (one time start-up costs)						
Construction Management	1	LPSM	$0	$0	0	$0
Land Acquisition	1	LPSM	$0	$0	0	$0
Site Investigation	1	LPSM	$0	$0	0	$0
Design Services	1	LPSM	$0	$0	0	$0
Construction	1	LPSM	$0	$0	0	$0
Equipment	1	LPSM	$0	$0	0	$0
Technology	1	LPSM	$0	$0	0	$0
Indirect/Administration	1	LPSM	$0	$0	0	$0
Art	1	LPSM	$0	$0	0	$0
Contingency	1	LPSM	$0	$0	0	$0
Future Expenses						
Operations Cost (annual costs)						
Heating Fuel	1	GALS	$0.00	$0	20	$0
Electricity	1	KWH	$0.00	$0	20	$0
Water and Sewer	1	LPSM	$0	$0	20	$0
Garbage Disposal	1	LPSM	$0	$0	20	$0
Custodial	1	LPSM	$0	$0	20	$0
Grounds	1	LPSM	$0	$0	20	$0
Lease	1	LPSM	$0	$0	20	$0
Insurance	1	LPSM	$0	$0	20	$0
Other	1	LPSM	$0	$0	20	$0
Maintenance & Repair Cost (upkeep costs ... estimate on annual basis)						
Site Improvements	1	LPSM	$0	$0	20	$0
Site Utilities	1	LPSM	$0	$0	20	$0
Foundation/Substructure	1	GSF	$0.00	$0	20	$0
Superstructure	1	GSF	$0.00	$0	20	$0
Exterior Wall Systems	1	EWSF	$0.00	$0	20	$0
Exterior Windows	1	GLSF	$0.00	$0	20	$0
Exterior Doors	1	LEAF	$0.00	$0	20	$0
Roof Systems	1	RFSF	$0.00	$0	20	$0
Interior Partitions	1	PTSF	$0.00	$0	20	$0
Interior Doors	1	LEAF	$0.00	$0	20	$0
Interior Floor Finishes	1	FFSF	$0.00	$0	20	$0
Interior Wall Finishes	1	WFSF	$0.00	$0	20	$0
Interior Ceiling Finishes	1	CFSF	$0.00	$0	20	$0
Interior Specialities	1	GSF	$0.00	$0	20	$0
Conveying Systems	1	LPSM	$0	$0	20	$0
Plumbing Piping	1	GSF	$0.00	$0	20	$0
Plumbing Fixtures	1	FIXT	$0.00	$0	20	$0
Fire Protection Systems	1	GSF	$0.00	$0	20	$0

District:	District Name
School:	School Name
Project:	Project Name
Project #:	Project Number
GSF:	1 GSF

	Quantity	Unit	Unit Cost	Total Cost	Years	Present Value
HVAC Distribution	1	GSF	$0.00	$0	20	$0
HVAC Equipment	1	LPSM	$0	$0	20	$0
HVAC Controls	1	GSF	$0.00	$0	20	$0
Special Mechanical Systems	1	GSF	$0.00	$0	20	$0
Electrical Service/Generation	1	LPSM	$0	$0	20	$0
Electrical Distribution	1	GSF	$0.00	$0	20	$0
Electrical Lighting	1	GSF	$0.00	$0	20	$0
Special Electrical Systems	1	GSF	$0.00	$0	20	$0
Equipment & Furnishings	1	LPSM	$0	$0	20	$0
Other	1	LPSM	$0	$0	20	$0
Other	1	LPSM	$0	$0	20	$0
Replacement Cost (scheduled replacement of building system or component)						
Site Improvements	1	LPSM	$0	$0	1	$0
Site Utilities	1	LPSM	$0	$0	1	$0
Foundation/Substructure	1	GSF	$0.00	$0	1	$0
Superstructure	1	GSF	$0.00	$0	1	$0
Exterior Wall Systems	1	EWSF	$0.00	$0	1	$0
Exterior Windows	1	GLSF	$0.00	$0	1	$0
Exterior Doors	1	LEAF	$0.00	$0	1	$0
Roof Systems	1	RFSF	$0.00	$0	1	$0
Interior Partitions	1	PTSF	$0.00	$0	1	$0
Interior Doors	1	LEAF	$0.00	$0	1	$0
Interior Floor Finishes	1	FFSF	$0.00	$0	1	$0
Interior Wall Finishes	1	WFSF	$0.00	$0	1	$0
Interior Ceiling Finishes	1	CFSF	$0.00	$0	1	$0
Interior Specialities	1	GSF	$0.00	$0	1	$0
Conveying Systems	1	LPSM	$0	$0	1	$0
Plumbing Piping	1	GSF	$0.00	$0	1	$0
Plumbing Fixtures	1	FIXT	$0.00	$0	1	$0
Fire Protection Systems	1	GSF	$0.00	$0	1	$0
HVAC Distribution	1	GSF	$0.00	$0	1	$0
HVAC Equipment	1	LPSM	$0	$0	1	$0
HVAC Controls	1	GSF	$0.00	$0	1	$0
Special Mechanical Systems	1	GSF	$0.00	$0	1	$0
Electrical Service/Generation	1	LPSM	$0	$0	1	$0
Electrical Distribution	1	GSF	$0.00	$0	1	$0
Electrical Lighting	1	GSF	$0.00	$0	1	$0
Special Electrical Systems	1	GSF	$0.00	$0	1	$0
Equipment & Furnishings	1	LPSM	$0	$0	1	$0
Other	1	LPSM	$0	$0	1	$0
Other	1	LPSM	$0	$0	1	$0
Residual Value (value of facility at end of study period)						
Site Improvements	1	LPSM	$0	$0	1	$0
Site Utilities	1	LPSM	$0	$0	1	$0
Foundation/Substructure	1	GSF	$0.00	$0	1	$0
Superstructure	1	GSF	$0.00	$0	1	$0

District:	District Name
School:	School Name
Project:	Project Name
Project #:	Project Number
GSF:	1 GSF

	Quantity	Unit	Unit Cost	Total Cost	Years	Present Value
Exterior Wall Systems	1	EWSF	$0.00	$0	1	$0
Exterior Windows	1	GLSF	$0.00	$0	1	$0
Exterior Doors	1	LEAF	$0.00	$0	1	$0
Roof Systems	1	RFSF	$0.00	$0	1	$0
Interior Partitions	1	PTSF	$0.00	$0	1	$0
Interior Doors	1	LEAF	$0.00	$0	1	$0
Interior Floor Finishes	1	FFSF	$0.00	$0	1	$0
Interior Wall Finishes	1	WFSF	$0.00	$0	1	$0
Interior Ceiling Finishes	1	CFSF	$0.00	$0	1	$0
Interior Specialities	1	GSF	$0.00	$0	1	$0
Conveying Systems	1	LPSM	$0	$0	1	$0
Plumbing Piping	1	GSF	$0.00	$0	1	$0
Plumbing Fixtures	1	FIXT	$0.00	$0	1	$0
Fire Protection Systems	1	GSF	$0.00	$0	1	$0
HVAC Distribution	1	GSF	$0.00	$0	1	$0
HVAC Equipment	1	LPSM	$0	$0	1	$0
HVAC Controls	1	GSF	$0.00	$0	1	$0
Special Mechanical Systems	1	GSF	$0.00	$0	1	$0
Electrical Service/Generation	1	LPSM	$0	$0	1	$0
Electrical Distribution	1	GSF	$0.00	$0	1	$0
Electrical Lighting	1	GSF	$0.00	$0	1	$0
Special Electrical Systems	1	GSF	$0.00	$0	1	$0
Equipment & Furnishings	1	LPSM	$0	$0	1	$0
Other	1	LPSM	$0	$0	1	$0
Other	1	LPSM	$0	$0	1	$0

Total Life Cycle of Alternate #1 **$0**

Life Cycle Cost Analysis – Example

(un-used rows hidden)

LCCA Task

Compare life-cycle costs for three roof insulation R-values to determine the most cost-effective solution over a 40–year life.

Project Assumptions

- Project Location: Fairbanks
- Roof Area: 10,000 SF

	Alternate 1	Alternate 2	Alternate 3
Description	R-40 insulation under 30 yr. EPDM	R-60 insulation under 30 yr. EPDM	R-80 insulation under 30 yr. EPDM
Initial Investment Costs	Cost of insulation and roof from contractor estimate, heating system base -55F design temp $165,700	Cost of insulation and roof from estimate less heating system demand reduction (-10,417btu) $178,600-$7,500	Cost of insulation and roof from estimate less heating system demand reduction (-15,625 btu) $194,800-$14,350
Energy Costs (Operational)	Energy modeling using 13,500 hdd and 75% AFUE for oil fired boiler. 818 gal/yr.	Energy modeling using 13,500 hdd and 75% AFUE for oil fired boiler 545 gal/yr.	Energy modeling using 13,500 hdd and 75% AFUE for oil fired boiler 409 gal/yr.
Maintenance and Repair	Same for all alternates	Same for all alternates	Same for all alternates
Replacement Costs	EPDM at 30 years Insulation - 50 years	EPDM at 30 years Insulation - 50 years	EPDM at 30 years Insulation - 50 years
Discount Rate NIST 2016	3%	3%	3%

District:	ABC School District
School:	ZYX Elementary
Project:	New School (Roof Insulation Options)
Project #:	DR-xx-1xx
Study Period:	40
Discount Rate:	3.00%

Life Cycle Costs of Project Alternatives

	Alternate #1	Alternate #2	Alternate #3
Initial Investment Cost	**$165,700**	**$171,100**	**$180,450**
Operations Cost	**$56,724**	**$37,793**	**$28,362**
Maintenance & Repair Cost	**$0**	**$0**	**$0**
Replacement Cost	**$18,951**	**$18,951**	**$18,951**
Residual Value	**-$13,080**	**-$13,693**	**-$14,919**
Total Life Cycle Cost	**$228,295**	**$214,151**	**$212,844**
GSF of Project	10,000 GSF	10,000 GSF	10,000 GSF
Initial Cost/GSF	$16.57	$17.11	$18.05
LCC/GSF	$22.83	$21.42	$21.28

District:	ABC School District
School:	ZYX Elementary
Project:	New School (Roof Insulation Options)
Project #:	DR-xx-1xx
GSF:	10,000 GSF

	Quantity	Unit	Unit Cost	Total Cost	Years	Present Value
Initial Expenses						
Initial Investment Cost (one time start-up costs)						
Construction	1	LPSM	$165,700	$165,700	0	$165,700
Future Expenses						
Operations Cost (annual costs)						
Heating Fuel	818	GALS	$3.00	$2,454	40	$56,724
Maintenance & Repair Cost (upkeep costs…estimate on annual basis)						
Replacement Cost (scheduled replacement of building system or component)						
Roof Systems	10,000	RFSF	$4.60	$46,000	30	$18,951
Roof Insulation	10,000	RFSF	$6	$60,000	50	$0
Residual Value (value of facility at end of study period)						
Roof Systems	10,000	RFSF	$4.60	$46,000	30	-$9,401
Roof Insulation	10,000	RFSF	$6	$60,000	50	-$3,679
Total Life Cycle of Alternate #1						**$228,295**

District:	ABC School District	
School:	ZYX Elementary	
Project:	New School (Roof Insulation Options)	
Project #:	DR-xx-1xx	
GSF:	10,000 GSF	

	Quantity	Unit	Unit Cost	Total Cost	Years	Present Value
Initial Expenses						
Initial Investment Cost (one time start-up costs)						
Construction	1	LPSM	$171,100	$171,100	0	$171,100
Future Expenses						
Operations Cost (annual costs)						
Heating Fuel	545	GALS	$3.00	$1,635	40	$37,793
Maintenance & Repair Cost (upkeep costs…estimate on annual basis)						
Replacement Cost (scheduled replacement of building system or component)						
Roof Systems	10,000	RFSF	$4.60	$46,000	30	$18,951
Roof Insulation	10,000	RFSF	$7	$70,000	50	$0
Residual Value (value of facility at end of study period)						
Roof Systems	10,000	RFSF	$4.60	$46,000	30	-$9,401
Roof Insulation	10,000	RFSF	$7	$70,000	50	-$4,292
Total Life Cycle of Alternate #2						**$214,151**

District:	ABC School District
School:	ZYX Elementary
Project:	New School (Roof Insulation Options)
Project #:	DR-xx-1xx
GSF:	10,000 GSF

	Quantity	Unit	Unit Cost	Total Cost	Years	Present Value
Initial Expenses						
Initial Investment Cost (one time start-up costs)						
Construction	1	LPSM	$180,450	$180,450	0	$180,450
Future Expenses						
Operations Cost (annual costs)						
Heating Fuel	409	GALS	$3.00	$1,227	40	$28,362
Maintenance & Repair Cost (upkeep costs…estimate on annual basis)						
Replacement Cost (scheduled replacement of building system or component)						
Roof Systems	10,000	RFSF	$4.60	$46,000	30	$18,951
Roof Insulation	10,000	RFSF	$9	$90,000	50	$0
Residual Value (value of facility at end of study period)						
Roof Systems	10,000	RFSF	$4.60	$46,000	30	-$9,401
Roof Insulation	10,000	RFSF	$9	$90,000	50	-$5,518
Total Life Cycle of Alternate #3						**$212,844**

Appendices

Appendix A – Life Cycle Cost Categories

Initial Expenses

Initial Investment Cost (one time start-up costs)
- Construction Management
- Land Acquisition
- Site Investigation
- Design Services
- Commissioning
- Construction
- Equipment
- Technology
- Indirect/Administration
- Art
- Contingency

Future Expenses

Operation Cost (annual costs)
- Heating Fuel
- Electricity
- Water and Sewer
- Garbage Disposal
- Custodial
- Grounds
- Lease
- Insurance

Maintenance and Repair Cost (scheduled & unscheduled upkeep costs)
- Site Improvements
- Site Utilities
- Foundation/Substructure
- Superstructure
- Exterior Wall Systems
- Exterior Windows
- Exterior Doors
- Roof Systems
- Interior Partitions
- Interior Doors
- Interior Floor Finishes
- Interior Wall Finishes
- Interior Ceiling Finishes
- Interior Specialties

Maintenance and Repair Cost (cont.)

Conveyance Systems
Plumbing Piping
Plumbing Fixtures
Fire Protection Systems
HVAC Distribution
HVAC Equipment
HVAC Controls
Special Mechanical Systems
Electrical Service/Generation
Electrical Distribution
Electrical Lighting
Special Electrical Systems
Equipment & Furnishings
Re-commissioning
Special Construction

Replacement Cost (scheduled replacement of building systems or components)

Site Improvements
Site Utilities
Foundation/Substructure
Superstructure
Exterior Wall Systems
Exterior Windows
Exterior Doors
Roof Systems
Interior Partitions
Interior Doors
Interior Floor Finishes
Interior Wall Finishes
Interior Ceiling Finishes
Interior Specialties
Conveyance Systems
Plumbing Piping
Plumbing Fixtures
Fire Protection Systems
HVAC Distribution
HVAC Equipment
HVAC Controls
Special Mechanical Systems
Electrical Service/Generation
Electrical Distribution
Electrical Lighting
Special Electrical Systems
Equipment & Furnishings
Special Construction

Residual Value (value of facility at end of study period)
- Site Improvements
- Site Utilities
- Foundation/Substructure
- Superstructure
- Exterior Wall Systems
- Exterior Windows
- Exterior Doors
- Roof Systems
- Interior Partitions
- Interior Doors
- Interior Floor Finishes
- Interior Wall Finishes
- Interior Ceiling Finishes
- Interior Specialties
- Conveyance Systems
- Plumbing Piping
- Plumbing Fixtures
- Fire Protection Systems
- HVAC Distribution
- HVAC Equipment
- HVAC Controls
- Special Mechanical Systems
- Electrical Service/Generation
- Electrical Distribution
- Electrical Lighting
- Special Electrical Systems
- Equipment & Furnishings
- Special Construction

Appendix B – Quantity Abbreviations

CFSF – Ceiling Finish Square Feet: sum of all interior areas that receive a ceiling finish.

EWSF – Exterior Wall Square Feet: sum of all exterior wall surfaces excluding windows and doors but including exterior soffits.

FIXT – Plumbing Fixtures: sum of all plumbing fixtures that are connected to both supply and waste piping.

FFSF – Floor Finish Square Feet: sum of all interior areas that receive a floor finish.

GALS – Gallons: sum of annual fuel consumed for heating and electrical generation.

GLSF – Glazing Square Feet: square feet of exterior windows.

GSF – Gross Square Feet: sum of the building's interior spaces including wall area and mechanical mezzanines.

KWH – Kilowatt Hour: sum of annual electricity usage.

LPSM – Lump Sum: estimated financial allowance for a work item.

LEAF – Door Leaf: sum of the number of door leaves. Double doors count as two leaves whereas single doors count as one leaf.

PTSF – Partition Square Feet: square feet of interior partitions. Exclude all exterior walls and count only one face of the partition.

RFSF – Roof Square Feet: square feet of roof surface.

WFSF – Wall Finish Square Feet: sum of all interior areas that receive a wall finish, including interior face of exterior walls.

Glossary

Constant-Dollars: Dollars that have uniform purchasing power over time and that are not affected by general price inflation or deflation.

Current-Dollars: Dollars that do not have uniform purchasing power over time and that are affected by general price inflation or deflation.

Discount Rate: The rate of interest that balances an investor's time value of money.

Initial Investment Cost: Any cost of creation of a facility prior to its occupation.

Life Cycle Cost: A sum of all costs of creation, operation, and disposal of a facility over a period of time.

Life Cycle Cost Analysis: A technique used to evaluate the economic consequences over a period of time of mutually exclusive project alternatives.

Maintenance Cost: Any cost of scheduled upkeep of a building, building system, or building component.

Nominal Discount Rate: A discount rate that includes the rate of inflation.

Operating Cost: Any cost of the daily function of a facility.

Present Value: The current value of a past or future sum of money as a function of an investor's time value of money.

Real Discount Rate: A discount rate that excludes the rate of inflation.

Repair Cost: Any cost of unscheduled upkeep of a building system that does not require replacement of the entire system.

Replacement Cost: Any cost of scheduled replacement of a building system or component that has reached the end of its design life.

Residual Value: The value of a building or building system at the end of the study period.

Study Period: The time period over which a Life Cycle Cost Analysis is performed.

Bibliography

Sieglinde K. Fuller and Stephen R. Petersen, *NIST Handbook 135: Life Cycle Costing Manual for the Federal Energy Management Program*, Washington: U.S. Government Printing Office, 2022.

Alphonse Dell'Isola, *Value Engineering: Practical Applications for Design, Construction, Maintenance & Operations*, Kingston MA: R.S. Means Company, Inc., 1997.

Stephen J. Kirk and Alphonse J. Dell'Isola, *Life Cycle Costing for Design Professionals*, McGraw-Hill, Inc., 1995.

Wolter J. Fabrycky and Benjamin S. Blanchard, *Life-Cycle Cost and Economic Analysis*, Englewood Cliffs, NJ: Prentice Hall, 1991.

American Society for Testing and Materials, *Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems*, Philadelphia: ASTM, 1994.