King County LCCA Guide

This user guide is designed to help King County Project Managers evaluate green building design options. The guide explains life cycle costs and benefits, and presents the essential steps and resources to analyze and select cost effective green building strategies using the King County LCCA Calculator.

What is LCCA?

Life Cycle Cost Analysis (LCCA) is an economic methodology for selecting the most cost-effective design alternative over a particular time frame. The methodology is beneficial as it addresses not only typical owner concerns of design effectiveness and construction cost, but also reflects future costs associated with maintenance, operation and replacement. LCCA looks at the value of a building or capital project over time, overcoming "first cost" limitations.

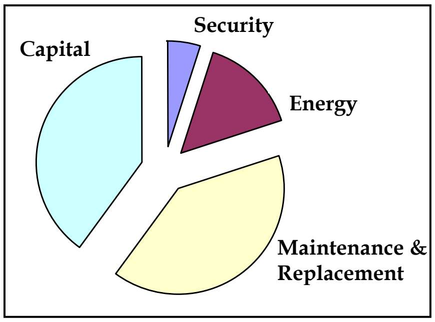


Figure 1: Total Building Costs

For a long-term building owner like King County, future costs are typically much greater than the initial capital costs. **Figure 1** illustrates a cost breakdown for a typical building. The graph shows that capital costs can account for less than half of the total building costs to the owner. The remaining costs consist of maintenance and replacement, energy, and security. Therefore, it is valuable to take into account future costs as well as present costs when making capital budget decisions.

The methodology can be applied to a wide variety of decisions, including accepting or rejecting options, design and sizing, location, replacement, lease or buy options, system interdependence, budget allocation, and priority or ranking methodologies.

LCCA is traditionally used to assess direct costs of a building such as energy costs, building renewal and replacement, and operation & maintenance (O&M) costs. LCCA can also be applied to indirect costs such as staff salaries, staff productivity, lost construction time, fire insurance, lost revenues due to downtime, and other costs that are not directly related to the cost of the building. While these indirect costs are often more difficult to estimate, they are significant and should be considered in the decision-making process.

Figure 2 shows how different building design alternatives are compared using LCCA. The X axis represents possible configurations with differing O&M costs and differing initial capital costs.

If LCCA is not used, the only consideration for deciding among the alternatives is the initial capital cost. In that case, alternatives with the lowest initial capital cost would be preferred.

However, when LCCA is applied to the decision-making process, operating and maintenance costs and long-term savings are also considered. Looking at the total life-cycle cost, the most economic choice is one towards the middle of the chart (i.e. the lowest combined costs for capital and O&M).

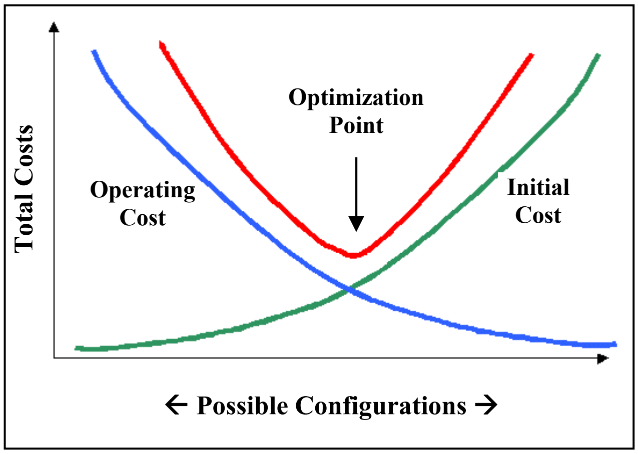


Figure 2: LCCA and Cost-effective Alternatives

LCCA Terms & Definitions

The list below explains the terms and definitions used in a life cycle cost analysis.

Benefit to Cost Ratio (BCR): The BCR of an alternative expresses the relationship between the positive cash flows achieved and the increased investment cost over the base case. A BCR >1 (or >100%) means that the savings obtained are greater than the incremental investments and hence the alternative is more cost-effective than the base case.

Discount Rates: The Present Value uses a Discount Rate to discount future costs to present day value. Though there are two types of discount rates – Real Discount Rates and Nominal Discount Rates. Real Discount Rates do not include inflation; nominal discount rates do. The federal government uses Real Discount Rates; the King County LCCA Tool also uses the Real Discount Rate in its calculation of PV. (Frequently used Discount Rates are discussed under 'Steps to an Effective LCCA' and 'Additional Resources'.)

Life Cycle: The period of time considered in the LCCA, spanning from the time of installation of a building measure to final decommissioning or disposal at the end of the building or equipment's service life. Building systems, such as a roof, will have a life cycle based on manufacturer data; whole buildings or infrastructure projects will have longer life cycles, of 50 years or more.

Net Present Value (NPV): The NPV of an alternative is the summation of all the positive and negative cash flows (initial costs, replacement costs, residual costs, O&M costs, rebates, incentives etc.) that can occur over the time period of analysis and is converted to current dollar value. The alternative or set of alternatives with the highest NPV is the most cost-effective choice.

Present Value (PV): Different alternatives will have different combinations of associated initial and future costs and future savings. Therefore, in order to facilitate comparison between alternatives, the initial and future costs are converted to today's dollars, or Present Value to allow comparison.

Recurring Costs: Recurring costs can occur anytime during the service life of the alternative. This can be a 'One-time' cost or an 'Annual' recurring cost. Replacing a chiller is an example of a 'One-time' recurring cost whereas O&M costs are 'Annual' recurring costs. The time of occurrence of a 'One-time' cost needs to be identified as the number of years into the future the expense is expected to occur.

Residual Value: The residual value of a system or component is its remaining value at the end of the analysis period. Residual values can be based on resale value, salvage value, or scrap value, net of any selling, conversion, or disposal costs. The residual value of a system with remaining useful life in place can be estimated by prorating its initial costs. For example, for a system with an expected useful life of 15 years, which was installed 5 years before the end of the study period, the residual value would be approximately 2/3 of its initial cost.

Return on Investment (ROI): ROI is a measure of the annual percentage yield from a project investment over the study period. An Alternative is economically cost-effective if the ROI is greater than the Discount Rate. The higher the ROI, the higher the NPV.

Simple Payback: Simple payback is the time period required to recover an initial investment in a cost-saving measure and is calculated based on projected savings. However, simple payback uses today's dollar value only, which fails to consider the time-value of money and cash-flow availability. Therefore LCCA typically uses net present value calculations to overcome this issue.

Time Value of Money: The value of money changes due to shifting purchasing power over time (e.g. interest rates, inflation and deflation) and due to earning potential of alternative investments over time.

Using LCCA Methods

For the purposes of King County capital improvement projects, there are essentially two types of life cycle evaluations that routinely warrant consideration. The first type of analysis compares alternate systems for the same component of a building. The second type of study is trying to allocate a budget towards multiple upgrades on different components.

It is helpful to examine an example building in order to understand the distinction between these two types of analysis. The building example is a maintenance facility that is heated and cooled year round.

Alternate Selection

The example building has a budget based on unit heaters and direct expansion (DX) roof air conditioning. An alternate system of combined heating and cooling through an overhead variable air volume (VAV) system is being proposed. Using the King County LCCA Calculator, it is shown that the VAV system has the highest net present value, which makes it the preferred alternate. Other alternate studies show that foam board insulation, indirect lighting, and a rain water harvest system have merit. Heat recovery is not cost effective.

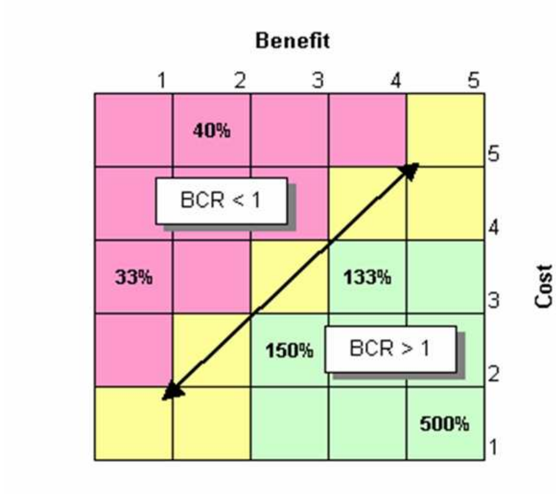
Table 1: Sample Alternatives Summary

Component	First $	NPV	BCR
Rainwater harvest	$12k	$15k	8
Indirect lighting	$5k	$2k	6
Foam board Insulation	$3k	$5k	4
VAV system	$18k	$20k	3
Heat Recovery Unit	$15k	-$2k	0.2

Budget Allocation

The project manager for the example building has $20,000 available to upgrade systems. The funds could be part of an original project budget, or could be pending LCCA study to determine long-term value. How does the project manager choose which alternates to include in the project?

The answer is to select the components using the BCR in descending order until the "investment" budget is reached. In the example this meant that the rain water harvest, indirect lighting and foam board insulation were included in the design.



When comparing LCCs for budget allocation purposes the LCC with the highest BCR ranking might not always have the highest NPV. So when should NPV be used and when should BCR be used?

Use NPV to evaluate groups of mutually exclusive alternatives/LCCs within a particular LCCA.

When the budget for buying alternates is limited and independent upgrades are possible, use the BCR to prioritize, selecting the components that have the highest BCR first and continue in descending order until the budget limit is reached.

Figure 3: Net Present Value versus Benefit to Cost Ratio

Steps to an Effective LCCA

The King County LCCA Calculator

The King County LCCA Calculator is a tool that streamlines the actual economic calculations used in life cycle cost analysis. This lets King County project managers focus on collecting the right data to evaluate and select the most cost-effective of available design alternatives.

The tool generates the life cycle cost of an alternate design that has different costs and benefits from a pre-determined baseline. Each alternate that is being considered requires some input data to be entered in the tool. Once entered, the tool calculates and displays several useful outputs. The project manager then can decide which alternate is selected for the project.

The LCCA Calculator can be used to compare costs of green building features across an entire project, or for individual systems or components. For example, a project manager for a road construction project may use LCCA to discover which paving and storm water management option costs less over a 20-year period. Another project manager might evaluate whether investing more capital dollars for a high-performance HVAC system and better window glass is more cost effective than the code compliant baseline. The goal is to determine which strategy or set of strategies is the most cost-effective and generates the maximum return on investment.

Getting Started

The most important aspect in LCCA is identifying appropriate alternatives and establishing good cost data. Based on these inputs, the KC LCCA Tool is designed to generate separate results for each alternative. The next task is comparing all the results and weighing them against available construction capital to make the most cost effective choice. Use the following steps to generate an effective LCCA. The earlier LCCA is used in the design process, the greater the potential net savings.

Step 1: Identify Alternatives

In this stage, the objectives for the measures are defined. It is important to include the individuals affected by the proposed alternatives (building owners, occupants, design team members, etc.) in the design of the alternates. It is also helpful to develop specific criteria to measure the effectiveness of the proposed alternatives. This could be a required return on investment or payback period.

Alternatives may be put forward by the design team or may be derived from an Eco-Charrette or goal setting meetings. Alternatives also may be derived from owner specific goals based on Division, Department or County-wide legislation and policies.

The types of alternatives considered depend on the creativity of the design and management teams. The alternatives should represent a wide range of solutions to the identified objectives. It is often helpful to use an interdisciplinary team during this stage to draw from a wide range of backgrounds, perspectives, and past experiences.

These alternatives can be single components (Low-E glass vs. Clear glass) or combination of components (high efficiency glazing vs. high performance HVAC.) Try and define at least three viable project alternatives for further study.

Step 2: Define Constant Parameters

The time period of the LCCA study is based on the investor's interests, preferences or organizational policy. Public projects often use longer time periods than private companies or developers, since stewardship of tax-payer resources is an issue.

The base date of analysis is the year the analysis is carried out and all time periods start from this base date. Frequently used periods of analyses are 10-25 years for private sector; public sector owners may use as long as 50 years for their studies. When in doubt, use the service life of the longest lived alternates as the period of analysis. (Note the Federal Energy Management Program's maximum period of analysis is 25 years; the City of Seattle has adopted a 100-year view for their buildings. At the time of this document, there is no King County policy on the time period of analysis.)

The project manager must also identify a discount rate for the studies that is held constant for all alternates. For energy and water related alternatives for federal projects, the Department of Energy establishes a revised Real Discount Rate every year. This is published every year in the Annual supplement to handbook 135, Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis.

For all other alternatives in federal projects use the Office of Management and Budget (OMB) discount rates which are published in Appendix C to the OMB Circular A-94 (see references section for web address). As a general rule of thumb, for private projects use a discount rate of 7-10% and for public projects use a range of 2-6%. Take note that the same discount rate should be used for all alternatives under study.

The King County Budget Office can also offer suggestions on the constant parameters to internal King County capital projects.

Step 3: Identify Costs and Savings

There are typically two types of costs that must be estimated: non-recurring and recurring. Non-recurring costs appear as a lump sum cost in the present or at a fixed point in the future. An example of a non-recurring cost is the capital expenditure for a new high-efficiency chiller unit.

Recurring costs are paid out periodically over the lifetime of the facility. An example of a recurring cost is a capital cost that is spread out over periodic payments. Repair or maintenance costs that occur on a regular basis are also considered to be recurring costs. All costs are identified as negative cash flow in the King County LCCA Calculator.

Savings are expressed as positive cash flow, regardless of whether they occur one time only (e.g. a utility rebate), or if they occur on a regular recurring basis (e.g. a reduced annual energy bill). This logic can be extended to soft costs such as worker productivity or reduced sick time. To enter this type of cost data you will need a head count, salary data, and some estimates of the improvements that the alternates provide.

Step 4: Generate LCCs for Each Alternative

Evaluate all project alternatives in a given category, using the same time period and the same discount rate.

Step 5: Perform a LCCA Comparison

Compare the net present value of each alternative and select the alternative or alternatives with the highest net present value. Compare the benefit to cost ratio of the best alternatives in each category to select the most cost-effective options that will fit into the project budget.

LCCA Example

Step 1: In this example an energy efficient chiller (20 yr life) and improved glazing have been identified as the alternatives for comparison.

Step 2: The discount rates and period of analysis for the two LCCAs have been identified as follows based on the FEMP guidelines and lifecycle of the alternative under consideration.

Parameters	Discount Rates	Period of Analysis
Chiller LCCA	5%	25 years
Glazing Option LCCA	5%	40 years

Step 3: For the Chiller LCCA, the first costs of the chiller and associated cash flows (energy savings, chiller replacement and residual cost, refrigerant change-out) are listed below.

Variable	Conventional Chiller	Energy Efficient Chiller
Cost	$100,000	$175,000
Refrigerant change out	-	$5,000
Energy savings per year	$0	$12,000

Similarly, for the Glazing option LCCA the first costs and the associated energy savings have been identified as tabulated below

Variable	Double Clear	Double Tinted	Double Low-E
Cost per window	$100	$150	$185
Energy Savings/ square foot	0	7.5 cents	9.1 cents

Step 4: LCCs are generated for each alternative based on the costs and parameters identified. (Refer to Table 2, 3 & 4 – LCC Alternatives generated using KC LCCA Calculator)

Step 5: For the Chiller LCCA, the Energy Efficient Chiller alternative has a Net Present Value (NPV) of $75,140 as against the conventional Chiller which would have a NPV of zero. Thus the energy Efficient Chiller is the more cost-effective alternative.

For the Glazing option LCCA, the Double Clear glass will have a NPV=0 while the Double-tinted and Double Low-e have a Net PV of $41,477 and $44,773 respectively. Comparing the NPV's of the three alternatives the Double Low-e alternative is the most cost-effective option as it has the highest NPV.

Measure Description	First Cost of Measure	Type of Measure	Cash Flow	Date of Future Cost	Present Value	Net Present Value	Sum of Gains	Sum of Costs
Energy Efficient Chiller	$ (75,000)	One Time	$ -	0	$ -	$ (75,000)	$ -	$ (75,000)
Energy Efficient Chiller Replacement	$ -	One Time	$ (75,000)	20	$ (28,267)	$ (28,267)	$ -	$ (28,267)
Chiller Replacement Residual	$ -	One Time	$ 56,250	25	$ 16,611	$ 16,611	$ 16,611	$ -
Refrigerant Change out	$ -	One Time	$ (5,000)	10	$ (3,070)	$ (3,070)	$ -	$ (3,070)
Refrigerant Change out	$ -	One Time	$ (5,000)	20	$ (1,884)	$ (1,884)	$ -	$ (1,884)
Refrigerant Change out Residual	$ -	One Time	$ 2,500	25	$ 738	$ 738	$ 738	$ -
Energy Savings	$ -	Annual	$ 12,000	0	$ 169,127	$ 169,127	$ 169,127	$ -
Total Net Present Value						$ 78,256	$ 186,476	$ (108,221)

5.0%	Assumed discount rate.	ROI	72%
25 yrs	Life cycle period of analysis	BCR	172%

Table 2: Energy Efficient Chiller LCC

Measure Description	First Cost of Measure	Type of Measure	Cash Flow	Date of Future Cost	Present Value	Net Present Value	Sum of Gains	Sum of Costs
Double Tinted Glass	$ (10,000)	One Time	$ -	0	$ -	$ (10,000)	$ -	$ (10,000)
Energy Savings	$ -	Annual	$ 3,000	0	$ 51,477	$ 51,477	$ 51,477	$ -
Total Net Present Value						$ 41,477	$ 51,477	$ (10,000)

5.0%	Assumed discount rate.	ROI	415%
40 yrs	Life cycle period of analysis	BCR	515%

Table 3: Double Tinted Glazing Option LCC

Measure Description	First Cost of Measure	Type of Measure	Cash Flow	Date of Future Cost	Present Value	Net Present Value	Sum of Gains	Sum of Costs
Double Low-e Glass	$ (17,000)	One Time	$ -	0	$ -	$ (17,000)	$ -	$ (17,000)
Energy Savings	$ -	Annual	$ 3,600	0	$ 61,773	$ 61,773	$ 61,773	$ -
Total Net Present Value						$ 44,773	$ 61,773	$ (17,000)

5.0%	Assumed discount rate.	ROI	263%
40 yrs	Life cycle period of analysis	BCR	363%

Table 4: Double Low-e Glazing Option LCC

Cost Data

The following examples of possible alternatives describe the level of detail needed for the associated costs and benefits. The costs and benefits shown here are illustrative and should be verified against actual market rates at the time of use. The internet can be a source of general cost data, however the best data is from designer and contractor estimates, or previous job data.

Green Roofs collect, reduce and delay storm water, while also protecting the roof membrane from solar damage and adding thermal mass for cooling.

Variable	Conventional	Green Roof
Period of Analysis	40 years	40 years
Roof membrane cost per square foot	$9-$12	$9-12
Green roof (filter fabric, soil, plants, increased structural support) extra cost per square foot (in addition to roof membrane)	$0	$3-$6 extensive (2″-6″ deep) $6 - $20 intensive (6″ and deeper)
Irrigation System cost per square foot	$0	$2-$4
Roof membrane life	15 years	none
Maintenance	$0	$2 (only first 2 years)
Cost of membrane replacement	$3	$0
Reduction in drainage cost	0	Based on utility rates
Energy Savings	0	Based on utility rates

Under Floor Air Distribution systems provide better mixing of air supplies, increase outside air to occupants, enhance thermal comfort and reduce energy costs through extended economizer operation.

Variable	Conventional	UFAD
First cost per sq.ft	$6	$9
Energy savings	25 kWh/sf/yr	19 kWh/sf/yr
Productivity gains	$0	$5.35 sf/yr

Resilient flooring from natural materials is durable, requires low maintenance and improves indoor air quality.

Variable	VCT	Rubber Flooring
First cost per square foot	$4.53	$10.20
Disposal Cost	$10,000	$6,667
Annual maintenance costs (stripping + chemical cost)	$30,000	$14,000
Replacement period	10	15

Daylighting with high performance glazing and lighting controls reduces glare, improves visual acuity, cuts energy use and connects occupants with nature, improving their productivity.

Variable *	Daylighting Improvement
First cost for glazing improvement per sq.ft	$0.50
First cost for dimming fixtures per unit	$50
First cost for photocell sensors (4 sensors)	$1,348
Reduced instantaneous load	0.54 w/sq.ft
Energy savings (annual)	2.53 kWh/ sq.ft
Productivity gains (annual)	$1.35/ sq.ft

* Data taken from sample project; results will vary.

References

For more information on LCCA, resources and other tools, refer to the list below.

- **Whole Building Design Guide LCCA,** Fuller, Sieglinde K, National Institute of Standards and Technology (NIST) (http://www.wbdg.org/design/lcca.php): For a breakdown of the calculations in LCCA.

- **Life Cycle Costing Manual** for the Federal Energy Management Program, U.S. Department of Commerce, NIST Handbook 135, 1995 Edition. Fuller, Sieglinde K. and Stephen R. Peterson (http://www.eere.energy.gov/femp/information/download_blcc.cfm): This manual provides additional information on present value, discount rate and other elements of LCCA. Also, refer to Table 4-1 Cost Sources for more cost references, such as Means Building Construction Cost Data and the National Construction Estimator Building Cost Manual.

- **Annual supplement to handbook 135, Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis** (http://www.eere.energy.gov/femp/information/download_blcc.cfm#annual_supplement): Lists federal discount rates.

- **Appendix C to Circular A - 94 issued by Office of Management and Budget** (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html): Includes the federal discount rates for measures not associated with energy and water.

- **ASTM standards on Building Economics**, ASTM Subcommittee E06.81 on Building Economics, The American Society for Testing and Materials, (1990).

- **Mechanical and Electrical Equipment for Buildings**, 9th Edition, B.Stein and J Reynolds, John Wiley and sons, Inc. (1999).

- **Assessment Technology section** (ats.ornl.gov), Oak Ridge National Laboratory, Life sciences Division: An online resource center for LCA including a list of LCA consulting companies.

Acknowledgments

This Guide was prepared by Paldino and Company, Inc. on behalf of King County, March 2006.

End of Document