OFFICE OF THE STATE ARCHITECT
ENERGY & ENVIRONMENT PROGRAM
POLICIES AND PROCEDURES

BUILDING LIFE CYCLE COST POLICY

Statutory Authority

Colorado Revised State Statutes:

24-30-1301-1311	State Buildings, Department of Personnel and Administration
24-30-2001-2003	Utility Cost Savings Measures
24-82-601-602	State-Owned Facilities – Energy Conservation
24-82-901-902	Outdoor Lighting Fixtures

The State has determined that state-owned real property have a significant impact on the state's consumption of energy. Thus, it is important that energy conservation practices are employed in the design of state-owned real property. Therefore, all state agencies and state institutions of higher education are required to analyze the Building Life-Cycle Cost (BLCC) of all real property constructed or renovated, over its economic life, in addition to the initial construction or renovation cost.

The general assembly authorizes and directs state agencies and state institutions of higher education to employ design and construction methods for real property under their jurisdiction ensuring that Building Life-Cycle Cost analyses and energy conservation practices are employed in new or renovated real property.

The Building Life-Cycle Cost analysis must include but not be limited to such elements as:

a) The coordination, orientation, and positioning of the facility on its physical site;
b) The amount and type of fenestration employed in the facility;
c) Thermal performance and efficiency characteristics of materials incorporated into the facility design;
d) The variable occupancy and operating conditions of the facility, including illumination levels;
e) Architectural features which affect energy consumption; and
f) A study period of 30 years for comparison of alternatives.

The Building Life-Cycle Cost analysis performed for real property with a facility of twenty thousand or more gross square feet with significant energy demands must provide but not limited to the following information:

a) The initial estimated cost of each energy-consuming system being compared and evaluated;
b) The estimated annual operating cost of all utility requirements, including consideration of possible escalating costs of energy. The office may rely on any national or locally appropriate fuel escalating methodology approved by the office of the state architect in performing Building Life-Cycle Cost analyses.
c) The estimated annual cost of maintaining each energy-consuming system;
d) The average estimated replacement cost for each system expressed in annual terms for the economic life of the facility;
e) The use of biofuel to provide supplemental or exclusive heating, power, or both for the facility. For a renovation of such a facility, the cost analysis regarding the use of biofuel must consider any stranded utility costs; and
f) An energy consumption analysis of such real property's heating, ventilating, and air conditioning system, lighting system, and all other energy-consuming systems. The energy consumption analysis of the operation of energy-consuming systems in real property should include but not be limited to:
    i. The comparison of two or more system alternatives;
    ii. The simulation or engineering evaluation of each system over the entire range of operations of the real property for a year's operating period; and
    iii. The engineering evaluation of the energy consumption of component equipment in each system considering the operation of such components at other than full or rated outputs.

As used in this section:

a) "Biofuel" means nontoxic plant matter consisting of agricultural or silvicultural crops or their byproducts, urban wood waste, mill residue, slash, or brush.
b) "Energy consumption analysis" means the evaluation of all energy-consuming systems and components by demand and type of energy, including the internal energy load imposed on real property by its occupants, equipment, and components and the external energy load imposed on the real property by climatic conditions.

The Building Life-Cycle Cost analysis shall be certified by a licensed architect or professional engineer, or by both architect and engineer, particularly qualified by training and experience for the type of work involved.

In order to protect the integrity of historic buildings, no provision of section this policy should be interpreted to require such analysis with respect to any real property eligible for, nominated to, or entered in the national register of historic places, designated by statute, or included in an established list of places compiled by the state historical society.

Selection of the optimum system or combination of systems to be incorporated into the design of real property must be based on the Building Life-Cycle Cost analysis over the economic life of real property; unless a request for an alternative system is made and approved by the office prior to beginning construction.

OVERVIEW OF LIFE-CYCLE COSTING

The state construction program involves large initial expenditures for construction of facilities that obligate ongoing future expenditures to operate and maintain. Because of the owning and operating costs, it is imperative that project decisions strike a balance between the initial and future costs and provide facilities which are designed and constructed to be as cost effective as possible. BLCC involves the selection and evaluation of alternatives that meet program, performance, and budget constraints. It is important that BLCC be an integral part of the building project design process from the very beginning of the project. The earlier BLCC is applied to a project the greater the potential for positive impact on total life-cycle costs.

Several Life-Cycle Costing (BLCC) techniques are available for evaluating cost effectiveness such as the benefit/cost ratio, the internal rate of return, the total life-cycle cost, the annual worth, and the discounted payback period methods. The Total Life-Cycle Cost (TLCC) method is the technique recommended for comparison of alternatives on real estate, new building, and maintenance projects. The Discounted Energy Payback (DEP) method is recommended for the analysis of energy conservation investments and energy performance contract projects.

The TLCC method converts or discounts all relevant costs and benefits occurring throughout the life of an alternative to an equivalent total present value at the base point. This includes initial project costs, and future owning and operating costs. Because these costs or benefits, occurring at different times, have different values due to the purchasing and earning power of money, they cannot be directly compared. The conversion to present value involves adjusting the value of these future costs and benefits for both the purchasing power of money (reflected by the general inflation rate) and the earning power of money (reflected by a real discount rate) with respect to time, so they are comparable. Alternatives must meet program needs and any variations or differences in the level or quality of service between alternatives are expressed in dollars. The alternative with the least total life-cycle cost is the most desirable. If a design has both a lower initial cost and lower future costs relative to an alternative, a BLCC analysis is not needed to show that the former is the economically preferable choice.

APPLICATION TO STATE REAL PROPERTY PROJECTS

The BLCC methods and procedures can be used to evaluate a wide range of situations encountered in the development of state real property projects. The comparison of building design concepts and the selection of systems and components to achieve the most cost-effective building can be analyzed. BLCC evaluation of major repairs versus replacement options to minimize ongoing maintenance and operation costs may also be compared. Although the method of analysis used will depend upon the type of problem, the same general analysis procedures should be followed to assure better overall results.

In either the capital budget/planning stage by the agency or the concept/design stage by the A/E, the alternatives selected for analysis depend upon the magnitude and duration of the agency's needs, the budget limitations, and the number of significantly different, but feasible alternatives available. The number of alternatives can only be determined based on the program and the conditions and considerations for each project. The following table summarizes the application of BLCC to state real property planning stages.

Life Cycle Cost Application to State Real Property

Planning	Definition - Application	Level of Detail
Operation Master Plan	The information necessary for a review of alternatives to meet programmatic needs is collected.	Operational and Maintenance costs are based on budgets and historical data.

Facilities Master Plan	Review of site selection, buy/build/lease analysis, and long-term maintenance planning to meet the agency's programmatic needs.	Projections of initial and future owning and operating costs are based on average GSF costs from similar prior projects.
Facility Program Plan	The step where the agency identifies and evaluates concepts and major building systems and components to determine the most cost-effective solution. The results of the BLCC are summarized in the FPP to support all project requests.	Initial cost is based on estimated costs of alternative building systems and components. Future owning and operating costs are based on calculated quantities and loads and anticipated material, labor and utility costs.
Capital Requests	Those systems and equipment or materials with significant impact on the maintenance and operating costs are identified. BLCC is performed to determine a cost-effective design.	System and equipment costs are based on quotes or actual costs. Owning and operating costs are based on performance characteristics, hours of operation, measured quantities and loads, and prevailing material, labor, and utility costs.

Application to new building or substantial renovation projects

If the alternative selected in the planning stage involves new construction or remodeling, an A/E is engaged for the concept/design stage of project development. The initial step for the A/E, working with the state facilities delegate, is to develop an BLCC analysis plan outlining the various alternatives and considerations for the project. The BLCC plan is important because it organizes the BLCC analysis and describes the proposed application of BLCC to the project. It is recognized that subsequent changes to the BLCC plan may occur as project development progresses and more information becomes available.

The intent of this policy is to direct the agency and their A/E to use the TLCC method of analysis to evaluate both the general building concepts and specific building systems and components. The recommended approach is to start with the identification and analysis of the general concepts, including such alternatives as (1) a simple pre-engineered system building versus a unique custom design; (2) building orientation and shape with respect to the site, such as horizontal versus high rise; (3) building configuration with respect to staffing requirements and program needs; and (4) a building meeting the HPCP requirements. The concepts considered should reflect the combined judgement of the A/E and the agency.

Following the adoption of a general concept, the evaluation progresses to the specific building systems followed by the system components and sub-systems. This step can involve many possible combinations and choices of building systems and components. However, since the majority of the Building Life-Cycle Cost is dependent upon a few major systems and components, the evaluation can usually be limited to those items with a significant impact on the initial, maintenance, and utility costs, and those items with a short useful life or a high replacement cost. Some building systems such as foundation and structure are evaluated based on initial cost only because they do not have future cost considerations. The evaluation of other systems such as the exterior closure, roofing, interior layout and construction, heating, ventilating and air conditioning, electrical and lighting, etc., generally involve a combination of initial, maintenance, utility, and replacement costs.

Initial cost versus maintenance cost comparisons of components might include wall cladding materials, roofing materials, windows and interior finishes. Utility considerations might include the evaluation of alternate envelope insulation thickness, window types, window/wall ratios, more sophisticated mechanical control systems, heat recovery equipment, more efficient lighting fixtures, etc. Initial cost versus maintenance and useful life comparisons might include pumps, compressors, and other similar mechanical or electrical materials and equipment. An experienced designer should be able to easily develop an analysis plan and identify two or three alternatives for each building system and component involved.

The analysis can be simplified by calculating the total Building Life-Cycle Cost for a base line concept. Comparisons with alternatives are then made by identifying the differences in initial and owning and operating costs, calculating the associated life cycle cost difference, and adding or subtracting from the base line amount. The most cost-effective alternative provides the lowest total life-cycle cost. The evaluation of building systems and components can be continued in a similar pattern by identifying the differences in performance and cost, selecting the best alternative, and adjusting the total life cycle cost accordingly. Note that the analysis of alternative systems and components must be in logical order to reflect any interaction. For example, decisions on the heating system should reflect prior decisions on building exterior components and lighting.

Utility costs generally have the most significant impact on life-cycle costs. Likewise, the most cost-effective building is one in which consideration has been given to internal heat generation, solar heat gain, envelope heat gain or loss, and ventilation heat gain or loss such that the net gains or losses are as close to neutral as possible. For example, it may be practical to capture the heat generated by lighting or from processing equipment to provide space heating. The relationship between gains and losses is important to the selection of alternatives for improving the energy performance of a facility.

The overall objective is to provide the most cost-effective combination of concepts, systems, and components that will satisfy the functional program requirements and stay within the budgetary restraints for the project. While this may be a demanding task, if it is planned and implemented as part of the design process it can be easily accomplished. It is expected that over the life of a facility, the ownership and operating costs will far exceed the initial cost, so it is important that for each project the cost factors are identified and, depending upon the functional program requirements, appropriate alternatives are identified and properly evaluated.