Chapter 1 Introduction to LCC

When we mean to build, we first survey the plot, then draw the model; and when we see the figure of the house, then must we rate the cost of the erection; which if we find outweighs ability, what do we then but draw anew the model in fewer offices, or at least desist to build at all?

William Shakespeare
Henry IV, Part 2, I. iii, 1598

A number of recent trends have emerged as issues of concern for the design professional, including: facility obsolescence, environmental sustainability, operational staff effectiveness (re-engineering), total quality management (TQM), and value engineering (VE). Life cycle costing (LCC) permits the economic assessment of alternatives being considered in response to these issues.

Recent Trends That Support the Need For Life Cycle Costing

Facility Obsolescence

Building or facility obsolescence (especially premature) results from such factors as changing facility users and their new demands; new materials, technology, and procedures of construction and operation; new air pollutants; and new laws and regulations. Each factor requires design professionals to consider innovative alternatives that accommodate change in order to minimize premature obsolescence. Response to a fourth dimension—time—is critical to overall project success. LCC is particularly useful for designers in assessing the life cycle consequences of alternatives being considered in order to minimize facility obsolescence. As Admiral Donald Iselin (former commander of the Naval Facilities Engineering Command) pointed out in his book, *The Fourth Dimension in Building: Strategies for Minimizing Obsolescence,* "We cannot afford to build in ways that become obsolete quickly in a changing world."

Environmental Sustainability

Ensuring environmental sustainability involves seeking materials and methods of construction that will not harm the environment or use excess natural resources. Reusing asphalt pavement and existing buildings, and energy conservation techniques such as daylighting are examples of seeking alternatives that are friendly to the earth. Unfortunately, many of these alternatives carry a high initial price tag that must be factored into the LCC considerations in selecting the best choice for a given owner or user.

Operational Effectiveness (Including Re-engineering)

Operational staff effectiveness is particularly important in buildings such as hospitals and correctional facilities where the staffing costs typically exceed the capital cost in as little as three years. Design professionals must seek ways to organize space in order to minimize staff travel distance and otherwise create efficient work flows to enhance work productivity. Another consideration is re-engineering the management organization of the business departments in order to maximize staff interaction. Above all, design professionals, through effective space layout, can assist owners in minimizing the number of staff members required.

Total Quality Management

The potential for improvements in product quality through effective use of total quality management has forced every business to change its management philosophies. Key TQM concepts such as customer-focused, process-driven, people-oriented, management-led, and continuously improved operations, have revolutionized the way businesses approach their work. Design professionals are now required to rethink their approach to design in order to become more TQM-based. This requirement causes the design professional to address owner challenges of international competition, costs of operation and maintenance, and overall business profitability. The use of life cycle costing helps evaluate options for solving these problems.

Value Engineering

Value engineering has been an effective management tool for seeking the best value for the money in facilities design for more than 40 years. VE continues to be mandated by the U.S. federal government and many state, county, and city agencies. It is also used in many businesses because of the savings it achieves for the owner—often 5–10% of the construction cost. Life cycle costing is a tool that is used in VE to help evaluate various alternatives for the purpose of selecting the optimum solutions. VE can result in another 5–10% savings in follow-on costs of ownership. The authors routinely use LCC in their VE studies.

Owners' Rising Expectations

Rising expectations about the services and amenities that a facility should provide are the result of changing users or owners and the differences in their requirements from those the facility was initially intended to fulfill.

The technologies of modern facilities, including hospitals, research laboratories, educational facilities, and manufacturing facilities, have changed substantially in recent decades, and are continuing to change. These changes have also led to rising expectations in buildings. Accommodating those expectations is costly, but failing to accommodate change is more costly because obsolete facilities impose a heavy burden on their owners and users.

The obsolescence burdens carried by owners result in significantly higher life cycle costs for their facilities because of lost productivity of people, increased operating costs to overcome the mismatch of needs and facility capability, increased worker absenteeism, health care costs related to on-the-job-stress, and reduced ability to attract and retain employees. Obsolescence should be considered within the context of a facility's entire life cycle, from initial planning through operations and maintenance.

LCC Assistance for Recent Trends

Life cycle costing can assist the designer in assessing the economic consequences of continuing to use an existing building, system, or component, in comparison with the expense of substituting an alternative that may offer better staffing efficiency, improved performance, new technology, or changing organizational structure. Facilities must accommodate anticipated new communications, building automation, and energy-saving technology. Consideration must be given to changing patterns of space use. For example, in hospitals, same-day surgery has drastically altered the demand for surgical and supporting laboratory facilities. New technologies—such as positron emission tomography (PET)—have added to hospitals' new, large, and heavy equipment that cannot be easily housed in or moved into older buildings. A good example of social and political cause for obsolescence is the Americans with Disabilities Act of 1990. This law requires that new and remodeled buildings be fully accessible and safe for people with disabilities. A more recent social and political cause is the need for increased security as a result terrorism, and green building requirements for new construction in some states and municipalities.

Strategies for addressing these recent trends include identifying changes that may foster obsolescence, performing pre-design analysis, responding to future requirements through innovative and flexible design solutions, and modifying current approaches during construction, and operation and maintenance.

Before they begin to design, architects and engineers should screen published literature in order to spot emerging issues. For example, the Environmental Protection Agency (EPA) provides professional forums to alert designers of emerging environmental issues. The American Institute of Architects (AIA) has an environmental committee that focuses on the environmental implications of various building materials on facilities.

During pre-design, post-occupancy evaluations are helpful in gathering information regarding the best and worst building features, potential cost-saving modifications, and operational effectiveness of the facility that may be used as ideas for improved life cycle cost-effectiveness and minimized obsolescence. Consideration of integrated building systems may be an effective tool for achieving flexibility. The Veterans Administration (now the Department of Veterans Affairs) has developed an integrated hospital building system (VAHBS) for managing obsolescence and minimizing the remodeling costs of its hospitals. The U.S. Postal Service has developed a "kit-of-parts" to respond to a diverse range of functional needs. Open-plan office building designs and modular furniture respond to the search for increased ability to avoid or delay obsolescence. Design approaches for other facility types can be found through the creative imagination of design architects and engineers and the use of life cycle costing to assess the design alternatives. Such ideas as larger bay sizes, raised flooring, use of interstitial ceiling space, increased floor-to-floor heights, modularity of mechanical and electrical systems, and increased shell space permit operation flexibility for future, as yet unknown, owner and user needs.

During construction, attention should be given to achieving the quality envisioned in the design. Failure to do so will result in a more rapid decline in facility performance and operational effectiveness, increased energy use, and an earlier onset of obsolescence. For those items that are particularly sensitive to new technology, such as electronic control components, medical equipment, and data transmission and networking devices, delaying specification and procurement until immediately prior to installation can help avoid obsolescence. Separate "fit-out" construction packages and owner-furnished equipment (independent from the prime construction contract) will help reduce obsolescence and improve the life cycle cost of the facility.

Management actions during the maintenance and operation stage of the life cycle are particularly important to avoiding or delaying facility obsolescence. No less important is continuing to seek ways of improving staffing operational effectiveness. Good maintenance practices have an effect similar to that of quality assurance during construction; they enhance the likelihood that performance will indeed conform to design intent. This responsibility for good practices rests primarily with the facility manager and maintenance staff. Training of maintenance staff, preparation and updating of maintenance manuals, and use of appropriate materials in maintenance activities contribute to avoiding the costs of obsolescence. Use of new computerized facility management systems that support condition monitoring, documentation management, and maintenance scheduling can be linked with other building systems.

Figure 1.1 summarizes trends and related LCC concerns, including delaying facility obsolescence, environmental sustainability, improving operational effectiveness through re-engineering, and practicing TQM and VE as they relate to LCC concerns including energy, maintenance, flexibility, staffing, and capital cost. This chapter is intended to help design professionals assess the alternatives to address these concerns.

LCC for Design Professionals

Life cycle costing for design professionals can be defined as the economic assessment of competing design alternatives, considering all significant costs of ownership over the economic life of each alternative, and expressed in equivalent dollars. P.A. Stone, a British economist, applies the terminology *cost in use* and suggests that the technique is concerned with "the choice of means to a given end with the problem of obtaining the best value for money for the resources spent."[1] In 1972 the U.S. Department of Health, Education, and Welfare summarized life cycle analysis as the systematic consideration of "cost, time, and quality."[2] Life cycle costing most certainly addresses these, as well as several other issues related to decision processes, analytic methods, databases, and component performance.

Federal, state, and institutional owners have each issued LCC directives to the designers of their facilities. In 1977, the U.S. federal government established a goal of reducing energy consumption by 45% for all federally owned new buildings over their prior 1975 counterparts. The U.S.

RECENT TRENDS: / LCC CONCERNS:	Total Quality Management (TQM)	Obsolescence	Environmental Sustainability	Operational Effectiveness	Value Engineering
Initial Project Cost					■
Energy/Fuel Costs			■		■
Maintenance & Repair		■			■
Alterations & Replacements		■	■		■
Administrative Costs	■			■	■
Staffing Costs	■			■	■
Safety/Security Systems		■		■	■
Real Estate Taxes					■
Water & Sewer Costs			■		■
Fire Insurance Costs					■
Flexible Furniture Systems	■		■	■	■
Air/Water Quality		■	■		
Healthful Environment		■	■		
Sustainable Materials			■		
New Business Technology	■	■		■	■
Communication Systems	■	■		■	■
Automation Equipment	■	■		■	■
Site Environment			■		
Occupant Comfort/Control	■	■	■	■	
Business Profitability	■	■	■	■	■
Bay Size/Floor Height		■		■	■

Figure 1.1: **Recent Trends and Their LCC Concerns**

Congress, in November 1978, established the National Energy Conservation Policy Act, which mandates that all new federal buildings be *life cycle cost-effective* as determined by LCC methods prescribed by the legislation. Existing buildings were to be reviewed to improve their energy efficiency in general, and to minimize their life cycle cost. Nebraska passed legislation in 1978 requiring a life cycle cost analysis for every state facility with a project cost of more than $50,000. Alaska, Florida, Massachusetts, Wisconsin, Texas, North Carolina, New Mexico, Washington, Maryland, Wyoming, Colorado, Illinois, and Idaho, among others, have since established similar legislation. The federal government's General Services Administration (GSA) has developed elaborate procedures for predicting a facility's total life cycle cost. Cities including Atlanta, Phoenix, and Chicago, also require life cycle cost analysis studies from designers of municipal facilities.

Owner Demands

Owners are feeling the international economic squeeze, as well as social and economic pressures, and are reacting to it. Keen international market competition is forcing owners to be extremely cost-effective and environmentally responsive. These factors, coupled with economic incentives to minimize facility obsolescence, *mean that owners are looking for design professionals with enhanced economic skills.* They want facilities with the lowest possible initial project cost, as well as minimized annual energy consumption, maintenance cost, replacement cost, and staffing costs; together with the longest serviceable building life attainable within the other parameters, the highest possible quality, the best appearance, and the least taxes. How can proper decisions be made with all these parameters to consider? How has the profession historically made these decisions? Many design professionals are not completely fulfilling their responsibility to their clients to adequately consider all these factors in the design process. Also, owners have not been forceful enough in requiring these services, nor have they shown much willingness to pay for them. *Owners must provide the required fees and data and be prepared to become involved in the trade-off life cycle cost decisions necessary for final design selections.*

To ensure the best value for least life cycle cost, design professionals must use a clearly defined methodology and have the tools necessary to perform the economic analysis. Of the typical client demands, all are measurable to some extent in dollars except quality and aesthetics, and even these can be evaluated given the functions required of the facility and a proper methodology. (Chapter 7, "Conducting an LCCA Study," outlines an approach for considering these non-monetary criteria in the selection process.)

Design and LCC Considerations

Design professionals must respond to owners' needs and demands. The designer today requires a methodology to analyze the initial project cost, energy consumption, maintenance cost, replacement cost, financing, staffing cost, and so on—in short, a tool to look at *total cost*. This approach is necessary to determine if owners can afford not only the initial costs, but also the follow-on costs. How many design professionals typically provide the owner with both an estimate of the initial project cost and the annual follow-on costs? What training and expertise does the design professional have to address these client needs?

There is a hierarchy of objectives or goal priorities, from the design professional's point of view, to be solved in any design. These can be related to Maslow's needs-priority model[3] (Figure 1.2), which illustrates certain *basic physiological needs* that the designer must first satisfy for the client. These basic needs include such things as program and user requirements and cost and time constraints of the project. Once these have been fulfilled, the designer concentrates on the client's security and safety needs. The requirements of documented building codes and regulations are reviewed and compared with the initial layout. Next, the designer must establish a design that has *social belonging*. In other words, will the community appreciate and understand the design, and will the solution receive peer designer acceptance?

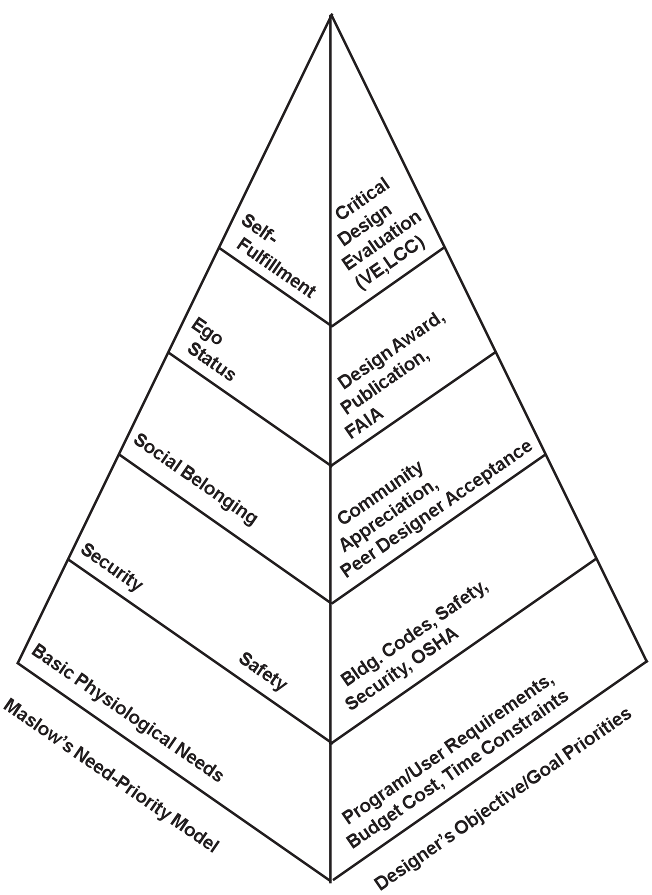

Figure 1.2: **Priority Pyramid**

These needs having been satisfied, the next block on the priority model relates to *professional status or ego*. For an architect, this might be a design award or election to the College of Fellows with the right to use the designation FAIA (Fellow of the American Institute of Architects). For an engineer, it might be a fellowship in an engineering society or recognition through publications and awards. However, there is one more need—that of *self-fulfillment*. That design professionals are beginning to recognize this is shown in their efforts to perform post-occupancy evaluations of their designs.

Can the design stand the test of time? This highest level of the pyramid, from the designer's point of view, can be described as the *critical design-evaluation phase*. To achieve success in this category, such factors as LCC, value engineering, and post-occupancy evaluation need to be considered. How many design professionals are prepared to address these elements, which many of today's facility owners are requiring? In planning of a number of proposed large facilities, owners want to know not only what it will cost to build these facilities, but also what will it cost to maintain and operate them. What are the annual operation and maintenance budgets for the facilities now being designed? *Getting involved in LCC is the first step toward finding the answers.*

Figure 1.3 represents the breakdown of the significant life cycle costs for a typical hospital. It is interesting to note the distribution: initial (capital) costs, 6%; fuel and utilities, 6%; maintenance and contracted costs, 12%; medical supplies and food, 7%; drugs and pharmaceutical, 5%; and staffing costs, 64%. This illustrates the importance of finding design solutions that minimize hospital staffing costs. When staffing costs are not included, the largest block of ownership cost is normally the initial cost. Therefore, the first requirement is to have a standard costing procedure and accounting method to properly define and collect initial costs. In addition, there must be a procedure to define and assemble costs for maintenance and other annual expenses. These accounting procedures must be compatible with the standard costing system for initial costs. The effect of time on the value of money must also be considered, since today's dollar is not equal to a dollar spent in the future. Money invested in any form earns, or has the capacity to earn, interest. *(This concept is discussed at length in Chapter 2, "Life Cycle Costing Fundamentals.")*

What are some of the reasons owners have not always received optimum decisions from their agents? And, in particular, why has there been less-than-optimum decision-making in some of the LCC analyses performed to date? The major reasons are lack of management and owner commitment, lack of innovative ideas, lack of life cycle cost information, recurring circumstances, honest wrong beliefs, and habits and attitudes. If owners do not provide designers the opportunity or incentive to perform LCC, it will seldom be done effectively. *Owners must require specific tasks using the methodology of LCC and be willing to provide additional fees to cover the efforts required from the design professional.*

Who is providing designers with new ideas and better information to ensure optimum decisions? The majority of new ideas come from manufacturers and suppliers. Yet many owners and designers actually discourage vendors' participation in the design process, to the point of not allowing them in the door. At a recent value engineering and LCC workshop held at an engineers' club, club rules did not allow vendors to participate. In addition, very few design firms have a person or a department appointed to assist manufacturers' representatives with new ideas. Seldom do firms conduct in-house seminars concerning the latest uses of new products. Moreover, little effort is spent to seek out top professionals from outside to bring in new ideas and more information. *Yet, if decisions are to be optimized and alternatives properly assessed, designers must continually seek out innovations and new product information.*

Design professionals must overcome recurring circumstances, such as lack of time and lack of redesign funding, that almost always are present and cause poor decisions and unnecessary costs. Since these circumstances seem to follow a standard pattern, designers should either plan ahead, knowing that the chance of their recurrence is great, or offset their impact by generating new solutions on existing projects for later application to follow-on designs.

Designers have to look for, question, challenge, and change honest wrong beliefs that tend to creep into any organization. Many designers are making decisions today that are based on what they think are the best

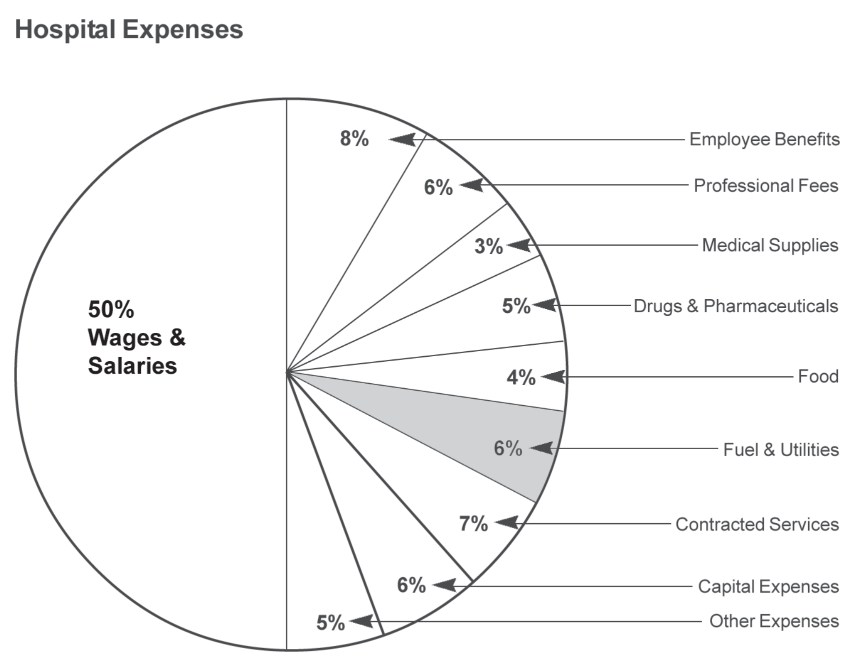

Figure 1.3: **Life Cycle Cost of Ownership, Typical Hospital**

alternatives. These alternatives may not, in fact, be the best ones. For example, many electrical engineers believe that only circuit breakers should be used for main switchgear. On the other hand, there is another generation of engineers who are switch- and fuse-oriented. Whose decision is optimal for a given project? One or the other has some honest wrong beliefs. Where are the quality assurance procedures in facility design similar to those used in the manufacturing process?

Designers must review the habits and attitudes in their organizations to see which ones must be changed to improve decision making. A prime concern is trying to achieve a positive approach to problem-solving. A positive approach enhances optimum decisions, while a negative approach contributes to poor solutions. It can be guaranteed that at the end of each year, the designers with positive attitudes toward new ideas will have made better decisions than designers who express only reasons why an idea will not work. *Remember, positive attitudes achieve positive results!*

What Is Life Cycle Costing?

What is life cycle costing? Basically, LCC is an economic assessment of an item, area, system, or facility that considers all the significant costs of ownership over its economic life, expressed in terms of equivalent dollars. LCC is a technique that satisfies the requirements of owners for adequate analyses of total costs.

A key element in LCC is an economic assessment using equivalent dollars. For example, assume one person has $1,000 on hand, another has $1,000 promised 10 years from now, and a third is collecting $100 a month for 10 months. Each has assets of $1,000. However, are the assets equivalent in terms of today's purchasing power? The answer is not simple because the assets are spread across different points in time. To determine whose assets are worth more, a baseline time reference must first be established. All monies are then brought back to the baseline, using proper economic procedures to develop equivalent costs. Design professionals normally choose between competing design alternatives. So, for design professionals, *life cycle costing is an economic assessment of design alternatives, considering all the significant costs of ownership over an economic life expressed in equivalent dollars*. LCC may also be used to assess the consequences of decisions already made, as well as to estimate the annual operation and maintenance (O&M) costs for budgeting purposes.

For designers to perform a life cycle cost analysis, the owner must provide them with information regarding such things as the facility's economic life, the anticipated return on investment, and financing costs, as well as non-monetary requirements.

From owner to owner, this information will vary greatly. As an example, assume an owner is planning to build a speculative apartment house. The federal government has set up an investment tax credit for this type of facility. However, it requires retention of property by the owner for a minimum of ten years. The owner, in hiring a consultant to perform LCC, would set a ten-year economic life, and would also state the minimum acceptable rate of return for the project to be economically attractive.

Suppose, on the other hand, the owner is a telephone company that will own and operate the facility from 40–100 years. In this case, the owner would require a permanent type of construction, normally with a 40-year economic life. These examples represent the extremes, but they illustrate that the economic information for LCC will vary from one owner to the next.

The LCC definition states that all "significant cost of ownership" should be included. Figure 1.4 illustrates the types of costs that may be considered significant by the designer and owner for an LCC study. These costs are organized so that they may be structured easily into an automated approach as experience is gained in the procedures. For clarification, a brief discussion regarding these blocks of costs follows.

Initial costs include the owner's costs associated with initial development of a facility, such as project costs (fees, real estate, site, and so on) and construction costs. *Financing costs* include the costs of any debt associated with the facility's capital costs. The category of *operation (including energy)* costs is used to keep track of such items as fuel and salaries required to operate the facility. *Maintenance costs* include the regular custodial care and repair, annual maintenance contracts, and salaries of facility staff performing maintenance tasks. Usually, replacement items less than $5,000 in value or having a life of less than 5 years are also included in maintenance costs.

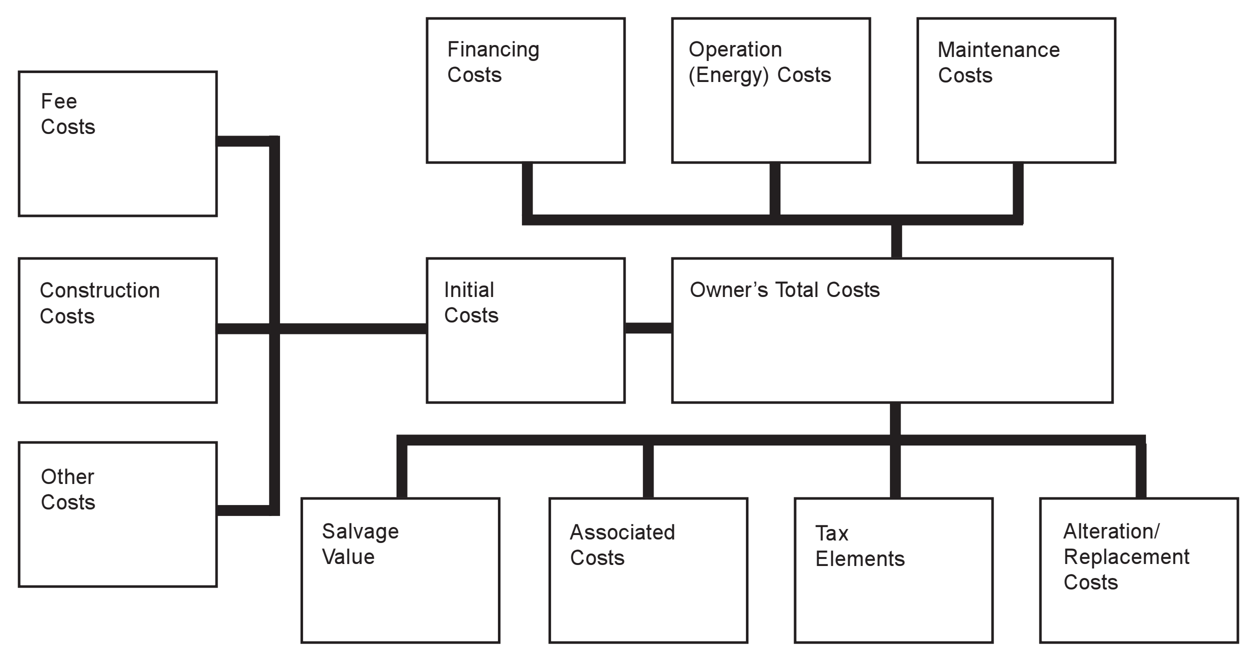

Figure 1.4: **Life Cycle Cost Elements**