

C. Sustainability

1. Introduction

This portion of the Facility Standards includes sustainability guidelines to be followed by the Consultant in the course of a project at the University of Chicago.

Conventional construction and operation of buildings are resource-intensive processes that create a significant amount of waste and contribute to global climate change. The environmental impact of a building is significant, and has implications for the local community and the world beyond our borders. Locally, the University faces environmental and political concerns such as water use and quality, land use, energy consumption, and ongoing operations and maintenance costs. The entire range of impacts should be taken into consideration when designing and constructing buildings.

These guidelines complement the implementation of the University of Chicago's Strategic Sustainability Plan, specifically High Performance Buildings. They will help the University place clear parameters and identify measurable results around what it means to be truly sustainable. The goal is to incorporate principles, materials, and actions into building design, construction and maintenance.

2. Sustainability Process

Each Process Phase is presented below and discusses specific process activities as they pertain to sustainability. The greatest achievement in sustainability occur by maximizing both the environmental and economic return on investments through design, construction and maintenance standards to improve resource conservation and create healthy spaces in a way that's meaningful for the people who study, teach or live in our buildings. Decisions made in one area often affect many other areas.

The guidelines outline an integrated design approach. Each step is identified to establish performance goals and to ensure that decisions are made in a collaborative and informed manner. The maximum benefit for minimum cost are achieved when sustainability is incorporated at project inception

Processes by the University prior to Consultant engagement:

Process Phase	Sustainability Objective
Program Planning/ Project Initiation	Translate academic or departmental initiatives into potential facility needs to determine if a capital construction project is necessary. As part of that effort, a mandatory meeting attended by the FS Project Manager, Office of Sustainability and key stakeholders must be held to discuss potential sustainable approaches.
Program Planning/ Project Initiation	Incorporate the sustainability issues discussed previously into the Request for Proposal (RFP) and Owners Project Requirements (OPR) outlined in the Standards. Understand anticipated costs or savings that may be incurred in order to create a more sustainable building.
Process Phase	Sustainability Objective
Programming	During the Programming phase, the OPR should be further developed to incorporate sustainability goals as they pertain to user needs and design parameters. As the project team develops or verifies the project program, summary schedule, and preliminary budget, the FS Project Manager should arrange a sustainability

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	workshop to review the options and the underlying principles of sustainability as they relate to building design, construction and operation. A sustainability coordinator is to be designated during this meeting.
Programming	Consultant is to begin development of the Basis of Design (BOD) and sustainability checklist (LEED, Living Building Challenge or other, as agreed upon by stakeholders) in response to the OPR and results of the sustainability workshop.
Schematic Design	At the beginning of the Schematic Design (SD) phase, program priorities and associated assumptions should be reevaluated to determine if spaces and functions can be shared or co-located with the sustainability goal of reducing the volume of the building, increasing space efficiency, using fewer raw materials and optimizing energy and water use.
Schematic Design	The largest energy impacts should be identified, prioritized and discussed at design meetings. Energy modeling should be used to evaluate energy efficient design alternatives and refine the project's sustainability goals and energy usage. The results are to be incorporated into the BOD document and sustainability checklist.
Design Development	During the Design Development (DD) phase, the approved schematic design begins to include a level of detail necessary to work out a clear, coordinated description of all aspects of the project. Because the DD phase is one of the last opportunities for the User Group to become involved in the design, it is crucial that sustainability principles from each of this document's categories be fully discussed and implications be understood and integrated as appropriate.
Design Development	Design and construction costs associated with the sustainable elements of the project should be clarified. Sustainable component cost metrics (capital and life cycle) should be developed and cost and/or savings decisions evaluated against performance and life cycle cost considerations. The results are to be refined within the BOD document and sustainability checklist.
Design Development	The project team should ensure that the project schedule allows adequate time for implementing the activities that may lead to a more sustainable project such as commissioning, life cycle analysis and training, among others.
Construction Documents	During the Construction Document (CD) phase, a comprehensive, fully coordinated set of construction documents and specifications are issued to obtain the necessary permits and construct the project. A review of sustainability elements by appropriate Facilities Services and project team stakeholders must be included in the 50% CD review along with any update of the BOD document and sustainability checklist. This review should specifically address materials selection.
Construction	At the start of the Construction phase, a representative from the general contractor, each subcontractor and a designated sustainability coordinator should attend the pre-construction meeting. The sustainability goals and design features of the project should be made clear at this meeting. Review of the project sustainability requirements should occur if applicable. Contractor ideas and opinions should be encouraged during these discussions to allow for innovations and efficiencies.
Closeout	Closeout facilitates the occupancy and turnover of the finished and fully commissioned project to the user group and maintenance department. It is important for building occupants and maintenance personnel to understand how their facility is designed to function, particularly as it relates to specific user

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	behavior, in order for it to operate as designed. The designated sustainability coordinator is to facilitate contributions from all project team members towards the development of a training program to educate personnel about the relevant features of the building and how they are meant to operate, including any user-influenced control strategies.
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3. Guidelines

These guidelines are for use by Facilities Services personnel and Consultants on projects of all scales. Although the University's current Sustainable Building Policy requires implementation of minimum LEED Silver certification standard for larger projects (new buildings over 5\$ million in construction costs), all projects are to follow these guidelines.

The guidelines are organized into the following categories:

- a) Sustainable Sites
- b) Water Efficiency – Wise Water Guidelines
- c) Energy
- d) Materials & Resources
- e) Health, Comfort and Productivity
- f) Education and Training
- g) Innovation

The discussion of each category begins with a set of goals, followed by a list of suggested strategies to be used in achieving those goals. The strategies included are not comprehensive; they are intended to provide ideas, and not exclude any from consideration. The project team should develop additional strategies. The following are suggested reference documents: LEED v4 Reference Guide, Living Building Challenge Rating System or the Sustainable Site Initiative Guidelines, among others. Contact the Office of Sustainability for a more extensive list.

Whole Building Design Approach

Application of a **whole-systems design** approach is crucial for sustainability. Categories and strategies are interdependent; none stand in isolation. Decisions made in one area may affect the performance in another. For example, careful decisions on building shape and window placement that take into account both prevailing wind and sun angles may not only enhance a building's thermal performance but can also improve daylighting. On the other hand, considering one building system alone without regard to others may result in poorer performance in the other systems. Any conflicts among categories should be resolved using an integrated design approach; and careful decisions should be made to select those designs that can trigger multiple savings or other benefits. It is essential that all members of the project team work together and consider all sustainability categories in order to be aware of the influence of their decisions on the overall performance of the building. In addition, not all strategies suggested here are relevant for every project. Considerations and decisions will have to be balanced by the Project Team and strategies that make sense will need to be negotiated.

a) Sustainable Sites

Goals:

- Promote sensitive development that relates well to natural systems and existing infrastructure.
- Maintain and enhance the biodiversity of natural systems and/or existing character of the site.

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- Respond to campus microclimates and natural site conditions.
- Reduce energy use for transportation and site related activities.
- Contribute to the cohesiveness and intelligibility of the existing campus.

Strategies:

Guide Development to Environmentally Appropriate Infill Areas.

As much as possible, select a site that:

- Is characterized as previously developed land.
- Utilizes a floor-area ratio that is at minimum in the range of 0.25 - 0.35 (or equivalent).
- Avoids habitat for any sensitive species.
- Avoids the loss of mature oaks, elms and other trees.

Maintain and Enhance the Biodiversity and Ecology of the Site

Integrate the building with the site in a manner that minimizes the impact on natural resources, while maximizing human comfort and social connections. The development footprint should enhance the existing biodiversity and ecology of the site by strengthening the existing natural site patterns and making connections to the surrounding context. Apply appropriate strategies below:

- Minimize the impacts of the development process to reduce ecological disturbance.
- Design the site to reconnect fragmented landscapes and establish contiguous networks with other natural systems both within the site and adjacent systems beyond its boundaries.
- Minimize the area of the site dedicated to the building, parking, and access roads and attempt to increase the floor-area ratio beyond the campus average.
- Site the building to create traffic patterns that promote non-motorized access.
- Maintain setbacks that effectively utilize the site while respecting surrounding environments.

Optimize Building Placement and Configuration

Place, orient, and configure the building on the site to:

- Optimize daylighting.
- Reduce heat island effects.
- Minimize non-permeable surfaces.
- Optimize stormwater management via onsite retention or reuse
- Maximize alternative transportation options.

Use Microclimate and Environmentally Responsive Site Design Strategies

Design the site and building to respond to microclimate and environmental conditions. Consider and apply the appropriate strategies below:

- Locate trees and shrubs to support passive heating and to complement cooling in outdoor spaces and buildings and to create seasonal heat-sinks and natural ventilation corridors.
- Locate site features (plazas, patios to take advantage of seasonal sun angles and orientation.
- Design the overall site to reduce “heat island” effects. Exploit shading opportunities, and explore the possible use of high albedo materials. Consider pervious surfaces for parking, walkways, plazas, etc. Use permeable paving for roads with infrequent use.

b) Water Efficiencies

Goals of Wise Water-Use Guidelines:

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- Increase the harvesting and recycling of water resources in building and landscape projects
- Reduce the consumption of potable water
- Maintain the aesthetics of the campus landscape and botanic garden
- Minimize impacts to natural resources from the discharge of storm water
- Encourage prudent financial decisions associated with water use
- Calculate life cycle costs of alternative system for payback of investment

Strategies:

Wise Water-Use Guidelines

The University has developed Wise Water-Use Guidelines which are intended to expound upon the commitment to water conservation described in the University's Strategic Sustainability Plan. Implementing them will have a profound and lasting effect on campus aesthetics, conservation efforts, and the University's bottom line.

The environmental costs of water consumption include the release of greenhouse gasses from coal-fired electricity plants. Mismanagement of water resources can also lead to local flooding and the pollution of natural waterways. The University also has an opportunity to reduce some of the fees for treating wastewater by metering consumptive uses like landscape irrigation. Voluntary rating systems, such as LEED and SITES, are available and list potential strategies.

Harvesting and reusing rain water for non-potable needs is an important strategy for reducing the University's reliance on potable water. Depending upon the source of harvested water and its intended use, a number of regulatory issues must be navigated

The guidelines in Volume IV are intended for a broad range of end users. Designers of University projects can find technical assistance in the sections covering "Water Harvesting and Re-use," "Automated Irrigation Systems," and "Sustainable Planting Design for the University Context." Facilities personnel can find recommendations in all of the sections for managing these resources. University administrators should refer to the sections covering "Storm Water Management and Detention Facilities," and "Monitoring and Management" for policy recommendations. Ultimately, most water harvesting and reuse systems developed at the University will need to be reviewed by the City of Chicago's Department of Buildings (DOB).

Erosion Control

- Prevent soil erosion before, during, and after construction by controlling stormwater runoff and wind erosion. Consider silt fencing, sediment traps, ditch checks, construction phasing, stabilization of slopes, and maintaining and enhancing vegetation and groundcover.

Reduce Site Water Consumption

Minimize the need for irrigation. Consider and apply the appropriate strategies below:

- Select drought tolerant plant species, permeable materials, bioswales or other low-tech solutions as a primary option.
- When irrigation is needed, use efficient systems, including drip irrigation, efficient nozzles, moisture sensors, and weather data-based controllers.

Reduce Building Water Consumption

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Design strategies and systems to reduce building water use to exceed the current requirements of US EPA Water Sense. Consider and apply the appropriate strategies below:

- Use infrared faucet sensors, delayed action shut-off or automatic mechanical shut-off valves.
- Use low flow or dual flush toilets that have been tested and rated to function reliably that use a maximum of 1.28 gallons per flush (GPF)
- Use 0.125 or 0.5 GPF urinals.
- Use lavatory faucets with flow restrictors for a maximum rate of 0.5 gallons per minute (GPM), or use metering faucets at 0.25 gallons per cycle.
- Use low-flow showerheads with preferably 1.5 GPM or a maximum of 2.0 GPM
- Use equipment that meet EPA ENERGY STAR® requirements where applicable.

c) Energy

Goals:

- Maximize energy performance of infrastructure and building systems to reduce total consumption and peak energy demand. Pursue renewable energy as a lower priority.
- Reduce green house gas emissions, pollution and climate change caused by energy production.
- Reduce ongoing operations costs associated with utility consumption

Strategies:

Set Energy Use Intensity Targets Prior to Conceptual Design

On appropriate large scale projects, set energy use intensity (EUI) targets, as a requirement the design and construction team must meet prior to approval of any design. Potential targets must be carefully studied and set, typically via a third-party consultant hired by Facilities Services. The design team must substantiate claimed energy performance via an energy model review process. Consult the Office of Sustainability for more detail if considering this approach.

Optimize Building Envelope Thermal Performance

Design building envelope to optimize thermal performance. Consider and apply the following:

- Size openings, select glazing, and utilize shading devices (interior or exterior) to optimize daylighting and glare control while minimizing unwanted heat loss and heat gain.
- Optimize insulation to reduce heating and cooling energy consumption by heat losses and gains through the building envelope.
- Moderate interior temperature extremes by using thermal mass where appropriate.

Provide Daylighting Integrated with Electric Lighting Controls

Ensure that daylighting is designed in coordination with the electric lighting system to reduce energy consumption while maintaining desired lighting characteristics. Consider and apply the appropriate strategies below:

- Shape the architectural plan and section and use appropriate strategies to maximize the amount of useful daylight (e.g., roof monitors, clerestory windows, atriums and courtyards).
- Use shading devices such as overhangs on south elevations, vertical fins on east and west elevations, and/or vegetation to let in natural light but reduce glare and overheating.
- Use light shelves combined with higher, more reflective ceilings to bring natural light deeper into perimeter spaces and control glare and excessive contrast.
- Use photocell-dimming sensors that adjust electric lighting in response to available daylight.

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Provide Efficient Electric Lighting Systems and Controls

Design the lighting systems and components to minimize artificial lighting energy use while still meeting high visual quality. Consider and apply the appropriate strategies below:

- Use fluorescent or LED lamps and luminaires with electronic ballasts.
- Use controls to reduce energy use (e.g., dimmers, occupancy sensors, photocells, time clocks).
- Use low levels of ambient light augmented appropriately by task lighting.

Maximize Mechanical System Performance

Design the building heating, ventilating, and air conditioning (HVAC) system to minimize energy use while maintaining standards for indoor air quality and occupant comfort. Consider and apply the appropriate strategies below:

- When possible, minimize or eliminate air conditioning.
- Use central chilled water system when building in the core campus.
- Use life cycle analysis to determine if central campus steam (less efficient) or building systems (more efficient), such as stand-alone boilers, are appropriate as the building heating source
- Group similar building functions into the same HVAC control zone so those areas can be scheduled separately (e.g. separate around-the-clock areas from classrooms and offices).
- Apply direct/indirect evaporative cooling and/or pre-cooling for conditioned spaces.
- When not using central steam or chilled water, design boilers and chillers using high efficiency equipment, use multiple modular boilers to allow more efficient part-load operation, high efficiency condensing boilers, or gas heater/chillers.
- Modulate outside air according to occupancy, activities, and operations. Use occupancy sensors and variable air volume distribution systems to minimize unnecessary conditioning.
- Use heat recovery systems to reduce heating energy use.
- Use zero CFC-based refrigerants in HVAC and refrigeration equipment. Phase out CFC-based refrigerants for renovation projects.

Use Efficient Equipment and Appliances

Design and/or select any building equipment and appliances to optimize energy efficiency. Consider and apply the appropriate strategies below:

- Use equipment with premium efficiency motors and variable speed drives.
- Select EnergyStar equipment (including transformers) and appliances
- Use efficient equipment to heat and supply service water to the building. When feasible, consider use of tankless water heaters.

Use Energy Sources with a Low Environmental Impact

Consider alternative sources and supply systems to reduce the building's source energy load and minimize green house gas emissions. Consider the building or central campus utility scales.

- Evaluate the feasibility of on-site renewable energy
- Evaluate possibilities for alternative building specific energy supply systems (such as fuel cells).
- Consider energy providers with a higher percentage of renewable energy in its generation mix.
- Investigate financial rebates or incentives offered by the City of Chicago, Com-Ed, or others.

d) Materials & Resources

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Goals:

- Reduce consumption and depletion of material resources, especially nonrenewable resources.
- Minimize the life-cycle impact of materials on the environment.
- Enhance indoor environmental quality.
- Minimize waste generated from construction, renovation, and demolition of buildings.
- Encourage better management of and minimize waste generated during ongoing occupancy.

Strategies:**Use Materials with Low Life-Cycle Cost**

Use a life-cycle methodology to evaluate materials. Choose materials, especially those used in large quantities, with the lowest environmental impact when possible.

Production

In order to conserve embodied energy, which is the total amount of energy needed to create a material from raw extraction to finished life of the product, and reduce the consumption of natural resources, consider the following:

- Salvaged materials (eg reuse furniture, other building materials).
- Remanufactured materials, such as engineered wood products.
- Recycled-content products and materials (post-consumer is preferred over pre-consumer).
- Reusable, recyclable, and biodegradable materials.
- Materials from rapidly renewable sources (e.g., wheat, cotton, cork, bamboo, etc.).
- Wood certified by the Forest Stewardship Council.

Use Locally Manufactured Materials

Obtain materials and products from local sources and manufacturers (within 250 miles of project site), minimizing energy use and pollution associated with transporting from great distances.

Use Durable Materials

Use products or materials (including masonry, steel, glass, and timber products such as beams, columns, floorboards, etc.) that are durable (with a life cycle of at least 50 years), weather well, and last more than one building lifetime (i.e., through a reuse or remodel).

Design for Less Material Use

- Adapt and reuse existing buildings as a primary option.
- Employ design strategies to use fewer materials, including reducing the size of the building or spaces; eliminating unnecessary architectural, finish materials; using modular and standard dimensioning; and using strategies that decrease construction waste.

Design Building for Adaptability

Incorporate interior or exterior design options into the project to facilitate building adaptability. Consider and apply the appropriate strategies below:

- Consider site planning and building configuration for future additions and alterations.
- Plan for maximum standardization or repetition of building elements and details to increase the ease of adapting the structure for future alterations or upgrades.
- Design cladding to accommodate future alterations and upgrades such as shading devices, more efficient glazing, and lighting controls.
- Use materials, systems, and components that can be disassembled for reuse or recycling.

- Use raised floor systems where appropriate for power and telecommunications wiring to accommodate reconfiguration of spaces and information technology support.
- Use modular space planning, partitions, and furnishings.

Design Building for Disassembly

Incorporate interior or exterior design options into the project to facilitate building disassembly. Consider and apply the appropriate strategies below:

- Use structural systems, cladding systems, and wall systems that facilitate disassembly.
- Use structure/shell systems that maintain integrity when demounted or disassembled (e. g., steel, glass, or concrete and panel claddings).
- Use materials, systems, and components that can be disassembled for reuse or recycling.
- Use snap release connectors, friction, or other joints which do not require sealants. Use joints and connections that facilitate disassembly, including bolts, screws, and clips.
- Use homogeneous materials rather than composite materials (such as reinforced plastics and carpets fibers and backing), as they are generally easier to separate and recycle. (An exception is the use of engineered wood products, which are composites)

e) Health, Comfort and Productivity

Goals:

- Provide, monitor and maintain high indoor air quality during demolition, construction and ongoing building operations.
- Provide occupants with operational control of lighting and HVAC systems where practical.
- Produce environments that enhance human comfort, well-being, performance, and productivity by providing healthy spaces.
- Connect building occupants physically or visually to nature

Strategies:

Provide Healthy Ventilation

- Comply with regulations, such as ASHRAE 62.1, that pertain to the design, operation, inspection and maintenance of ventilation systems
- Provide occupants access to operable windows
- Specify materials that control moisture and discourage microbial growth.
- Address moisture control on the site, within the building envelope and inside the building.
- Use appropriate HVAC filters, entry vestibules, floor mats and other appropriate strategies to control dust and pollutants

Use Low Volatile Organic Compounds-emitting Materials

Use low or no Volatile Organic Compound (VOC)-emitting materials (including paints, coatings, adhesives, carpet, ceiling tiles, and furniture systems) to help ensure good indoor air quality.

- Comply with Facilities Standards that focus on the selection and management of new construction materials and renovation activities in order to minimize indoor air quality issues.

- Ensure that all construction materials, interior finishes and major furnishings installed at The University comply with most recent industry standards or regulatory agency VOC emission standards, including specific requirements for carpet systems and paint products.
- Follow material conditioning procedures.
- Follow sequencing procedures (e.g., let wet products dry before installing porous products).
- Reduce dust emissions in occupied buildings through the use of wet methods, etc.
- Submit data for review and approval prior to construction for projects that require:
 - (a) the use of potentially toxic or odor producing products (e.g., roofing, paint, epoxy)
 - (b) projects conducted in close proximity to sensitive areas.

Provide Appropriate Thermal Comfort

- Use operative temperature to address environmental and seasonal considerations for dry bulb and radiant temperature profile, relative humidity and occupants' activities and modes of dress.
- Provide occupants controllability over workspace temperature controls, operable windows and operable window shading devices

Provide Effective Lighting

Illuminance Levels: Use design strategies and features to ensure that the Illuminance Levels and Luminance Ratios comply with these Standards and are appropriate for the users and tasks.

- **Color Temperature:** Use design strategies and features to ensure that color temperature, color rendering, and modeling of light are appropriate for the users, activities and tasks.
- **Glare:** Use design strategies and features (e.g., selection of lighting fixtures, installations, and controls) to avoid glare in ways that support the program, user purposes, and preferences.

Connect Interior Spaces Physically or Visually to Nature

- Provide connection to the outside via doors, operable windows or views in workspaces
- Include natural elements on the interior, such as daylight, water, vegetation, natural ventilation
- Provide indirect connection to nature via natural patterns or other concepts of biophilic design

Provide Appropriate Building Acoustical and Vibration Conditions

- **Vibrations:** Use strategies to control sources of external and internal vibrations.
- **Noise Control:** Use design features and strategies to control sources of noise from mechanical and electrical equipment and from sources exterior to the building. Select wall assemblies with appropriate Sound Transmission Class (STC) ratings based on the conditions of the site, building program and activities. Noise elimination, control, or isolation from equipment should be addressed through acoustic zoning, equipment selection, construction, and appropriately designed ducts, piping, and electrical systems.
- **Soundscapes:** Use design features and strategies to create appropriate sound reverberation levels, background sound levels, sound rendition, and speech interference levels.

f) Education and Training

Goals:

- Buildings foster experiential sustainable education through interactive features and design
- Allow occupants to monitor and understand their daily environmental footprint
- Provide occupants strategies to reduce their consumption of resources
- Through training, ensure staff have adequate knowledge of optimum sustainable operations

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Strategies:**Physical Infrastructure Enables Education**

- Interactive signals tied to building systems cue occupants on energy saving behavior, such as opening windows or closing shades
- Building Automation System (BAS) collects energy and water usage, real-time. A building specific webpage displays this information.
- Utility sub-metering facilitates detailed energy monitoring and allows energy saving competitions and games with results displayed real-time
- Graphic signage details sustainable practices, building features and optimum behaviors
- Project teams are encouraged to seek unique innovation opportunities beyond the ‘typical dashboard in the lobby’, such as interactive art, tactile natural materials, etc.

Training and Engagement Programs

- Project team creates a building specific manual that addresses best practices for students, faculty, staff, visitors, building operators and any other appropriate user groups.
- Via discussion with project stakeholders and communications staff, create an action plan identifying optimum methods to disseminate the best practices defined in the building manual
- Hold educational workshops for building user groups near move-in that clearly define best practices and expectations for sustainably inhabiting the facility
- Create an orientation process for new building users that defines sustainable expectations

g) Innovation**Innovation in Design and Regional Priority**

Project teams are encouraged to use every opportunity to achieve exceptional building performance and incorporate new and innovative sustainable strategies, particularly those that are regional.

4. Life Cycle Cost Analysis

Life Cycle Cost Analysis (LCCA) is used to evaluate the economic performance of a building over its entire life by balancing the initial investment with long-term expense of operation. In order to best understand the implications of a given project, each design alternative is tested using LCCA. Total cost of ownership, from initial construction cost to operations and maintenance is analyzed and the best solution selected based on a holistic understanding gained from LCCA. These LCCA guidelines are meant to help project teams calculate these costs and inform design and construction decisions.

LCCA will be implemented within each project phase. An explanation of how LCCA is to be used is identified in the Process Phase section of this document. Major LCCA activities that are incorporated into the process include Operations & Maintenance Cost Benchmarking and Comparative Analysis.

a) Study Categories

The project team will assess the value of up to 14 possible life cycle cost (LCC) comparisons in six general categories: Energy Systems, Mechanical Systems, Electrical Systems, Building Envelope,

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Siting/Massing and Structural Systems. The 14 comparison areas follow, with examples of options that might be considered in each. These examples are only a starting point; specific systems or options considered will vary with the type, scale and intended use of the building.

Energy Systems:

1. Central plant-connected vs. stand-alone systems (steam & chilled water)
2. Alternative energy systems (e.g., solar photovoltaics, solar thermal, geothermal)
3. Equipment Options for stand-alone systems (e.g., air cooled chillers vs. direct expansion units)

Mechanical Systems:

4. Air distributed systems (e.g., variable volume vs. constant volume, overhead vs. underfloor)
5. Water distribution systems (e.g., various piping systems and pumping options)

Electrical Systems:

6. Indoor lighting sources and controls
7. Outdoor lighting sources and controls
8. Distribution (e.g., transformers, buss ducts, cable trays)

Building Envelope:

9. Skin and insulation options
10. Roofing systems (various materials and insulation methods)
11. Glazing, daylighting and shading options

Siting and Massing:

12. Orientation, floor to floor height and overall building height
13. Landscape, irrigation and hardscape options

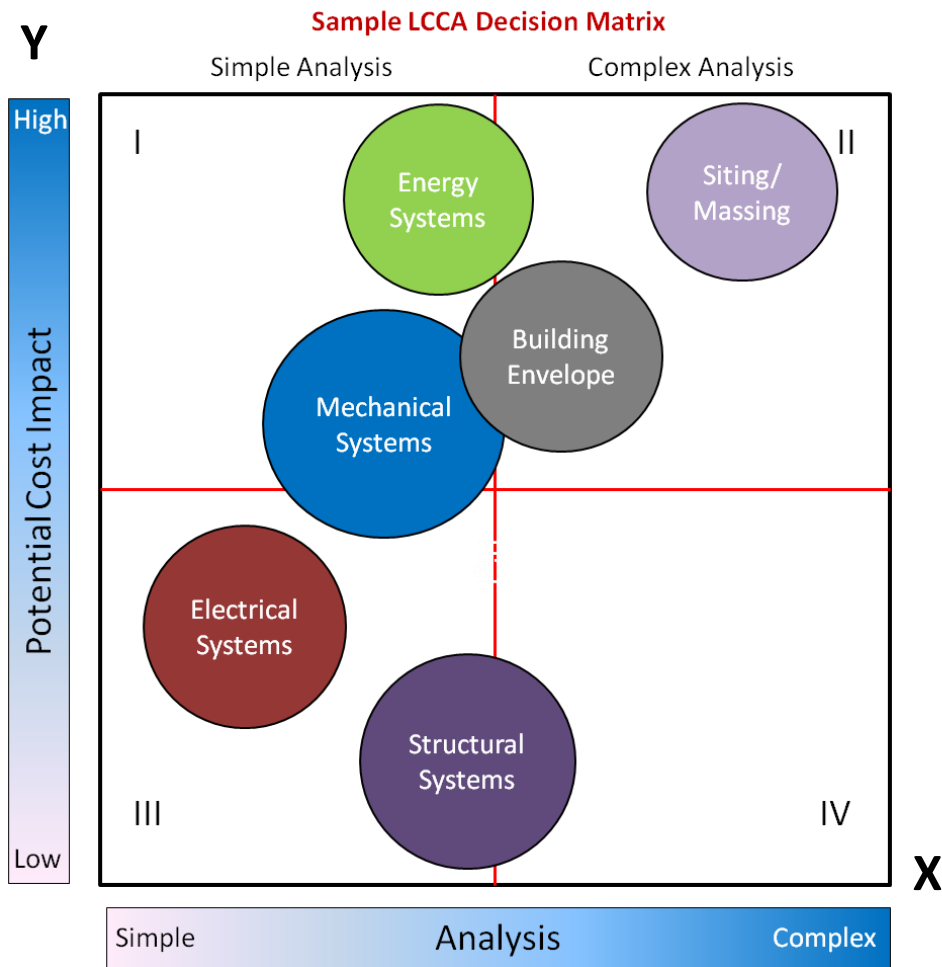
Structural Systems:

14. Systems/materials selection (e.g., wood vs. steel vs. concrete, cast in place vs. pre-cast)

Study Selections

The project team will determine which studies have the highest potential LCC benefit for the project. An LCCA Decision Matrix can assist in this determination. The team should create a customized matrix, using the example below. The Yaxis represents the potential cost impact. The X axis reflects the complexity of the analysis required.

When the six categories and/or 14 analyses are compared on such a matrix, they become easier to prioritize. Those in Quadrant I (simple analyses with high potential cost impact) should have the highest priority. Studies requiring complex analyses but have a high potential impact should be prioritized next (Quadrant II). Simple analyses with low potential impact are next (Quadrant III), followed by complex analyses with low potential impact (Quadrant VI). By taking time to prioritize LCC analyses, the Project Team can focus on those studies most appropriate for the project.



Conducting Comparative Analysis

Each comparative analysis is developed on a project specific basis. The FS Project Manager and Consultant groups will decide together how to determine the details of each analysis. A “base case” will be established. The project team will then draw upon its collective experience to identify alternatives to the base case.

Technical guidelines within this section discuss the format used to record the results of the comparative analyses. While this format is intentionally generic (to accommodate various types of studies), all FS Project Managers must use the same format so that the data collected and analyzed are documented consistently. The results of each team’s studies will be incorporated into an LCCA library for future reference so the University can establish a database of studies as both a reference for future projects.

Selecting Cost-Effective Alternatives

The guidelines for LCCA give project teams the direction and tools to use LCCA to inform project decisions. The team should use LCCA incremental cost and payback findings in concert with other factors such as sustainability and user preferences to determine the final project design elements.

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Alternatives that result in a payback of 5 years or less are required to be incorporated into the project. Alternatives that result in a payback of 6 to 10 years are strongly encouraged. Alternatives resulting in paybacks over 10 years are discretionary.

Documentation and supporting explanations should be included to document considerations.

b) LCCA Process

Operations & Maintenance Cost Benchmarking

During the Program Planning and Project Initiation phases of the project, the FS Project Manager will have developed a “Benchmark Budget” with design and construction cost estimates based upon data from past projects. The Facilities Services O & M group will have also developed O & M benchmarks using historical operations and maintenance data from existing campus buildings for those LCCA components that apply to the project.

Comparative Analysis

During the Programming, Schematic Design and Design Development phases of the project, the project team makes increasingly detailed decisions about the final design for the building, including mechanical, electrical, structural, telecommunications and plumbing systems. During this period, the FS Project Manager will direct the team to conduct a series of analyses comparing the total costs of various building system options. Definitions of LCCA steps to follow when conducting analyses are described below and provide constants (energy and discount rates, etc.) to be used.

LCCA Process Phase Summary

Process Phase	LCCA Objective	Leader
Program Planning/ Project Initiation	<ul style="list-style-type: none"> Assign O & M benchmark 	FS Project Manager/ FS O&M
Programming	<ul style="list-style-type: none"> Develop O & M cost benchmark in addition to project benchmark Hold LCCA work session, in conjunction with the Sustainability Charrette Develop LCCA Decision Matrix 	FS Project Manager
Schematic Design (SD)	<ul style="list-style-type: none"> Review LCCA Decision Matrix Determine which LCCA studies to perform Select cost-effective alternates per LCCA studies Report results of LCCA 	FS Project Manager
Design Development (DD)	<ul style="list-style-type: none"> Review LCCA studies to confirm/verify results given project development 	FS Project Manager
Construction Documents (CD)/Permitting	<ul style="list-style-type: none"> Confirm value engineering decisions from earlier design phases with LCCA results 	FS Project Manager
Construction	<ul style="list-style-type: none"> Outline LCCA elements to contractor Discuss commissioning and testing requirements 	FS Project Manager

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Closeout	<ul style="list-style-type: none"> Conduct training program; perform ten-month evaluation 	FS Project Manager
Operational	<ul style="list-style-type: none"> Validate LCCA study outcomes and assumptions 	FS O & M

Program Planning/Project Initiation (Prior to Consultant Engagement)

The goal of Program Planning is to translate academic or departmental initiatives into potential facility needs to determine if a capital construction project is necessary. The LCCA goal during this phase will be to assign an O&M Benchmark for the long-term costs of the building.

LCCA Tasks	LCCA Deliverables
<ul style="list-style-type: none"> As Part of the Capital Planning process, O & M costs are estimated 	<ul style="list-style-type: none"> None at this stage

Programming (Subsequent to Consultant Engagement)

The overall goal during the Programming phase is to further develop the options outlined through Program Planning and approve one option for further consideration. The LCCA goal will be to reconfirm the O&M Benchmark. As part of the process, the FS Project Manager should update the O&M Benchmark and arrange an LCCA work session to review the Guidelines for LCCA.

LCCA Tasks	LCCA Deliverables
<ul style="list-style-type: none"> FS Project Manager and project team verify the O&M Benchmark FS Project Manager and project team will create a project-specific LCCA Decision Matrix to determine which LCCA studies benefit the project most. FS Project Manager documents cost and scheduling implications of LCCA studies. 	<ul style="list-style-type: none"> Documentation of assumptions for the O&M Benchmark (e.g., if based on historical performance of similar buildings, list of buildings and their O&M costs). Complete project-specific Decision Matrix Completed project schedule and budget, with breakdown of LCCA elements.

Schematic Design

Schematic Design (SD) is a critical phase of project development during which the general scope, initial design, scale and relationships among the components of the project are determined and the greatest level of LCCA effort will take place. The project team will select the comparative analyses to be performed, assess the results and determine which design elements would generate long-term cost savings. The results of the LCCA studies will be reported as a part of the SD submittal, which will clearly state LCCA elements that have (or have not) been incorporated into the project design. The LCCA results will document incremental University investments in building design elements with long-term benefits for the institution. LCCA results will also note elements that would have not been incorporated into the project due to budget constraints. These results will allow the University to reassess the project budget and scope, based on the potential to realize greater returns over time. The FS Project Manager will consider schedule and budget impacts of the LCCA options studied.

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LCCA Tasks	LCCA Deliverables
<ul style="list-style-type: none"> • Review the LCCA Decision Matrix and identify studies • Perform LCCA studies in conformance with the technical guidelines listed in chapter 4.3. • Assess studies and select LCCA elements to be incorporated. • Document LCCA results, budget and schedule implications. 	<ul style="list-style-type: none"> • Final LCCA Decision Matrix with selected studies highlighted. • Completed LCCA comparative studies • Meeting minutes from workshop(s) to discuss LCCA results. • Documentation of LCCA elements, with rationale for inclusion or exclusion. • Updated schedule and budget, with LCCA elements/impacts highlighted

Design Development

During the Design Development (DD) phase, the approved schematic design begins to include a level of detail necessary to work out a clear, coordinated description of all aspects of the project. The project team will review the LCCA elements incorporated to ensure that design conditions have not changed and that the LCCA return-on-investment calculations are still accurate.

LCCA Tasks	LCCA Deliverables
<ul style="list-style-type: none"> • Project team reviews DD documents to ensure current design conforms to previous analysis. 	<ul style="list-style-type: none"> • Documented review of LCCA elements, including design changes or LCCA modifications made during DD phase.

Construction Documents/Permitting

During the Construction Documents (CD) phase, the project team prepares a comprehensive, fully coordinated set of construction documents and specifications to obtain the necessary permits and construct the project.

LCCA Tasks	LCCA Deliverables
<ul style="list-style-type: none"> • At 50% CD, FS Project Manager will ensure that contract documents are consistent with designs evaluated in original LCCA studies. • During bidding, the FS Project Manager will ensure that any Value Engineering (VE) options address the impacts on the LCCA elements 	<ul style="list-style-type: none"> • Documentation of changes made to LCCA elements as a result of VE process.

Construction

The objective of the Construction phase is to safely build the project as represented in the contract documents within the parameters approved by the University. There are no specific LCCA tasks or deliverables during this phase, unless new value engineering arises.

Closeout

Closeout entails the occupancy and turnover of the finished and fully commissioned project to the user group and Facilities Services Operations & Maintenance representative. It is important for

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building occupants and maintenance personnel to understand how their facility is designed to function, particularly as this relates to specific user behavior.

LCCA Tasks	LCCA Deliverables
<p>Project team will:</p> <ul style="list-style-type: none"> • Ensure the Building Manager and FS O & M representative clearly understand specific user requirements associated with LCCA features (e.g., requirements that users control lights manually versus daylighting control systems). • Confirm that O&M manuals are complete and include any specific information related to LCCA elements in the building. • Ensure commissioning and training on systems highlight LCCA expectations for system performance, so that any significant variances can be identified. • During “lessons learned”, evaluate the LCCA process and experience 	<ul style="list-style-type: none"> • Appropriate documents and training for building users and FS O & M representative related to the LCCA features in their building. • Documentation of LCCA “lessons learned” to be included in the eleven-month evaluation.

Operational (post Consultant Engagement)

The Operational phase begins once the initial project construction is complete and the building is handed over to FS O & M. During this period, key assumptions and anticipated outcomes established through LCCA studies need to be validated. As LCCA continues to evolve, the process for this evaluation will become more established and consistent.

LCCA Tasks	LCCA Deliverables
<ul style="list-style-type: none"> • The FS O & M representative will monitor utility consumption and O&M costs. These data are critical to evaluate the effectiveness of the Guidelines for LCCA and facilitate future LCCA work. • Project Manager and the FS O & M representative will conduct tenth-month evaluation to assess performance of LCCA elements. 	<ul style="list-style-type: none"> • Meeting minutes, survey results, etc. from eleventh-month evaluations conducted regarding LCCA elements.

c) Guidelines

The LCCA Procedure

The technical guidelines in this section are intended to establish adequate background and provide clear directions so that team members can implement LCCA studies effectively and consistently.

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Designing for Minimum Life Cycle Costs

LCCA is a method of evaluating the cost-effectiveness of project design decisions. LCCA is comprehensive because it properly accounts for many project cost variables. These include a wide variety of project costs (construction, operations, maintenance, replacements, utilities, etc.). They also encompass the time value of money, including a project-specific discount rate, inflation and cost escalations for a variety of goods and services.

Performing an LCCA study involves:

1. Establishing objectives for the analysis,
2. Determining the criteria for evaluating alternatives,
3. Identifying and developing design alternatives
4. Gathering cost information, and
5. Developing a life cycle cost for each alternative.

1 - Establish Objectives

To be successful, an LCCA study must have clear. LCCA can capture dollar cost variations between alternatives and show which option will have the lowest overall cost. It can only address values quantifiable in dollars. For example, an LCCA study of high-performance glazing can capture the overall cost-effectiveness of different options as compared to a base case. LCCA is not the right tool to evaluate improved occupant satisfaction with the different glazing products.

2 - Determine LCCA Metrics

The two primary metrics to be used and calculated in LCCA are the life cycle costs of each alternative and its payback over a certain study life. That is, consideration should be given to total costs and the time it takes to recover an incremental initial investment incorporating the time value of money. When two alternatives have similar O&M costs over the study life, “first” costs (i.e., construction costs) will most likely drive the decision. This approach is further supported by the consideration of uncertainty (see below under Calculating Life Cycle Costs).

3 - Identify the Base Case and Develop Alternate Designs

The LCCA approach is geared towards evaluating design alternatives. The alternative that captures the “standard” design or minimum requirements for a project is called the “base case”. The design team must develop alternatives to evaluate against the base case. These alternatives must be developed in sufficient detail to derive good cost estimates, which are required to run the life cycle cost calculations and to capture the incremental cost differences of the options.

The intent of these guidelines is not to develop an infinite number of alternates, but rather to capture as much cost benefit as possible given a reasonable amount of effort and investment. The goal should be to develop roughly one to five alternatives for a given building component. The design team should develop the alternatives, using its experience and judgment in selecting relevant building and system component options.

Analysis of alternatives should consider the effects of diminishing returns. Often, energy efficiency measures look less attractive in combination than when modeled individually. Where possible, effects should be calculated for each measure individually as well as for the measures in combination. For example, shading devices and high-performance glazing could each have a five-

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year payback, whereas the two combined may have a seven-year payback if they have a higher combined cost and address the same energy use issues.

4 - Gather Cost Information

Cost information can come from a variety of source, including cost estimating consultants, contractors, vendors and designers.

For each alternative, gather all of the cost information described below under Cost Components of LCCA (e.g., construction, utility, maintenance, service, and in cases remodeling costs). Identify additional soft cost requirements for the alternatives as well.

Construction costs can be informed by recent University of Chicago projects. Utility and maintenance costs can be informed by Facility Services. Project Managers will manage the development of this information.

5 - Perform Life Cycle Cost Calculations

For each alternative, calculate the metrics listed in Step 2 above, using the parameters listed under Life Cycle Cost Parameters below. Test each alternative against the two metrics and make a recommendation on which to incorporate into the design.

Cost Components of LCCA

- Project costs
- Utility costs
- Maintenance costs
- Service costs
- Remodeling costs
- End-of-life costs

Project Costs

Project costs, often referred to as initial or first costs, include both “hard” or construction costs (labor, materials, equipment, furnishings, etc.) and “soft” costs (design fees, permit fees, etc.). Cost estimates and information from contractors, vendors and design teams can be used to develop project costs for LCCA alternatives.

In LCCA studies, the cost difference between alternates are usually what is important, not the absolute costs. Costs only need to be developed for the components that vary between alternatives. For example, in comparing two HVAC systems that have the same zonal equipment (e.g., VAV boxes) but varying central equipment (e.g., air handlers), the VAV box costs are ignored and only costs of the air handler developed. It is important to be thorough when considering cost variations between alternatives; all costs must be captured to make a valid comparison.

Utility Costs

a. Energy Costs

The majority of University of Chicago Facilities receives steam and chilled water from central plants. Electricity is distributed by Commonwealth Edison while generated by a number of

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producers. For each type of utility service there is a cost per unit of energy delivered that will be charged to the building. The rates for these utilities must be obtained from Facilities Services

b. Energy Estimating Methods

Typically the mechanical and/or electrical engineers on a design team will estimate the amount and rate of building energy use. The most comprehensive and widely used method of performing these estimates is energy modeling. If the level of effort needed should be evaluated on a case by case basis, simplified methods exist for estimating energy use. These include:

- Equivalent full-load hours
- Degree-day methods
- Outside temperature bin methods

c. Non-Energy Utility Costs

Domestic water and sewer service are two non-energy utility costs that need to be developed when affected by alternatives being modeled.

Maintenance Costs

Maintenance refers to the costs incurred to keep building system running properly. The wide array of activities performed by the University's maintenance staff fall into four cost categories: preventive, reactive, planned and deferred. These data should be based on historic data provided by facilities operations.

a. Preventative Maintenance

Preventative maintenance is routine, scheduled activity intended to keep a system running at its best. This maintenance is performed whether or not there are any problems with a system. It is designed to prevent breakdowns. Changing filters and lubricating bearings are examples.

Preventative maintenance costs should be incorporated into LCCA calculations.

b. Reactive Maintenance

Reactive maintenance is performed in response to problems. If a fan belt breaks, for example, a technician issues a work order to replace the belt and address any associated damage to get the system running again.

Reactive maintenance is unpredictable. In theory, if systems are running well and all required preventive maintenance is performed, then reactive maintenance should be minimal. In practice, unplanned failures will occur and will require repairs.

For a project to retrofit an existing building that has ongoing reactive maintenance needs, the LCCA base case should include those costs, and the alternate can model reasonable and appropriate reductions.

c. Planned Maintenance

Planned maintenance refers to large-scale maintenance that is not addressed under preventative maintenance. It is the replacement of building subsystems at the end of their useful lives.

LCCA calculations expressly include planned maintenance in a form of replacement costs of equipment and systems. For example, if the time frame of a study is 30 years and a component of a

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mechanical system (e.g., a heat pump) needs to be replaced every 10 years, then the life cycle costs need to include the cost of that replacement at year 10, year 20 and year 30.

Factoring system and component replacement costs into LCCA calculations requires a number of assumptions about the useful life of these items. These assumptions should be clearly stated and documented so that they can be confirmed by the appropriate members of the Project Team..

d. Deferred Maintenance

Deferred maintenance represents a backlog of planned maintenance. It is the University's goal to keep deferred maintenance to a minimum, but at present deferred maintenance does exist.

Deferred maintenance is not considered in LCCA for new buildings. For renovation projects, the deferred maintenance cost can be included in the base case. It should be addressed as appropriate for alternatives that reduce the maintenance needs in other ways, such as system or component replacement.

Service Costs

Service costs include items such as janitorial services, pest control, and elevator maintenance. Since these costs depend more on the programmatic elements of a building than on the architecture, systems and other components, they are typically not considered in LCCA. However, they should be included if for some reason they differ among the design alternatives.

Remodeling Costs

Remodeling costs may or may not be included in LCCA depending on the specific building program. Typically they are not included, but some systems or components specifically require them (e.g., underfloor air delivery or wireless). It is within the Project Team's discretion to decide whether and how to capture these costs.

End-of-Life Costs

a. Residual Value

Assume all buildings have zero residual value at the end of the study life. In the interest of keeping the initial LCCA studies as simple as possible, it will be used consistently across studies.

b. Demolition

Usually this cost is assigned to the new project on a site. When the extent or nature of the required demolition varies among alternatives, it is appropriate to include these costs.

5. References

Refer to the University of Chicago's Strategic Sustainability Plan.

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