UMass Chan Medical School

Office of Facilities

Life Cycle Cost Analysis Guidelines

Design Technology Group

March 2026

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OVERVIEW

1.1 EXECUTIVE SUMMARY

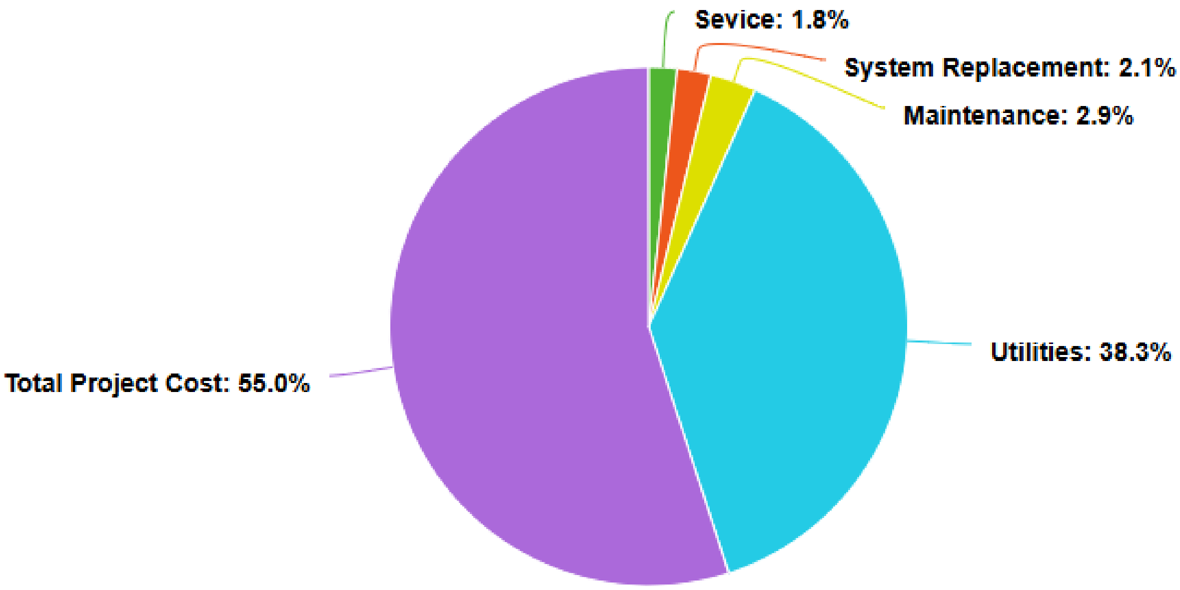
- UMass Chan seeks to ensure that new and renovated buildings meet student, staff, and faculty needs as effectively and efficiently as possible. UMass Chan's Design Technology Group has outlined a thorough Project Delivery Process (PDP) that addresses all aspects of planning, budgeting, design and construction.
- These guidelines are intended to establish a basic life cycle cost analysis (LCCA) process framework, provide recommendations to UMass Chan practitioners for developing project-specific LCCAs, and serve as a resource to support decision-making for UMass Chan Capital Projects. These guidelines are also relevant to multiple stakeholders, including UMass Chan's leadership and representatives, UMass Chan Capital Program offices, and associated design professionals and facilities and asset managers.
- This is a resource that can be utilized as a practical tool to help facilitate collaboration and communication withing Project Teams, Consultants, Design and Construction, Space Planning and Management, Energy Services, Sustainability and Project Management, among others.
- With an understanding that every project is unique in its origin and circumstances, the contents of these guidelines are not intended to be requirements for strict adherence but rather serve as a reference when approaching an individual project or use case. The UMass Chan LCCA guidelines are a living document and intended to be informed by and updated based upon lessons learned among the UMass Chan community network.
- To provide feedback or ask to follow up questions, please contact UMass Chan Design Technology Group or the Office of Sustainability.

1.2 WHAT IS LIFE CYCLE COST ANALYSIS (LCCA)?

- Life Cycle Cost Analysis (LCCA) is a process of evaluating the economic performance of a building over its entire life. Sometimes known as "whole cost accounting" or "total cost of ownership" LCCA balances initial monetary investment with the long-term exposure of owning and operating a building.
- LCCA is based upon the assumption that multiple building design options can meet programmatic needs and achieve acceptable performance, and that these options have different life cycles. For a given design, LCCA estimates the total cost of the resulting building, from initial construction through operation and maintenance, for some portion of the life of the building (generally referred to as the LCCA "study life"). By comparing life cycle costs of various design configurations, LCCA can explore trade-offs between low initial costs and long-term cost savings, identify the most cost-effective system for a given use, and determine how long it will take for a specific system to "Pay back" its incremental cost. Because creating an exhaustive life cycle cost estimate for every potential design element of a building would not be practical, the guidelines for LCCA focus on features and systems most likely to impact long-term costs.

1.3 WHY IS LCCA IMPORTANT

- ➔ As the chart below illustrates, over the first 10 years of building's life, the present value of the maintenance, operations, and utility costs is nearly as great as the total project costs.



Albert Sherman Center 10-Year LCC

- ➔ Funds secured or set aside to construct new campus buildings rarely extend to ongoing operational costs. Increasingly, campuses are experiencing shortfalls in their annual budget for building operations. These lead to deferred maintenance and eventually to decline building utility and performance.
- ➔ Designing new and renovated buildings with maintenance and operating costs in mind can result in significant savings. The guidelines for LCCA help Project Teams calculate these costs and use them to inform planning, design, and construction decisions. UMass Chan's decision to implement LCCA as part of the PDP is a direct effort to reduce the total cost of building ownership.

1.4 LCCA'S RELATIONSHIP WITH OTHER LAND AND BUILDING DOCUMENTS

- ➔ Whenever possible, the LCCA process should incorporate the directives and guidance contained in other UMass Chan publications and guidelines. Reference resiliency and sustainability guidelines.

1.5 SUSTAINABILITY

- ➔ Part of UMass Chan's commitment to quality building projects is a strong belief in the value of sustainability. Sustainable buildings use energy, water, and other natural resources efficiently and provide a safe and productive indoor environment. Guided by Massachusetts Governor's Executive Order 594, "Leading by Example—Clean Energy and Efficient Buildings," UMass Chan Medical School collaborates with its community on a comprehensive sustainability program. This includes strategic life cycle cost analysis (LCCA), which plays a crucial role in guiding the university's decisions toward financial and environmentally sustainable practices. By evaluating the long-term costs and benefits of materials, energy systems, and other resources, UMass Chan aims to make informed investments that reduce waste, enhance efficiency, and support its goals in the 2021-2026 Sustainability and Climate Action Plan. This approach strengthens UMass Chan's commitment to sustainable growth, aligning campus expansions and maintenance projects with both immediate environmental needs and the future health of our community and planet.

- ➔ As a quality assurance tool, LCCA is related to – but not synonymous with – sustainability. LCCA is a cost-based process; its goal is to identify the most cost-efficient building design and construction strategies over the life of the asset. LCCA addresses values that can be stated in dollars, not subjective issues such as occupant comfort or environmental impact. The most cost-effective solution is not always the most environmentally ideal choice. For example, a building system might consume very little energy but costs more to maintain than it saves in energy costs.
- ➔ Very often, however, LCCA points to solutions that are environmentally desirable. Careful design choices that result in efficient use of energy and water often do yield long-term cost savings. Or, if environmentally favorable choices do not actually save money, LCCA may reveal that their additional cost over time is minimal. At the heart of "sustainability" is a balance between human concerns (e.g., cost, health, comfort) and environmental concerns (e.g., resources use, ecological degradation). LCCA is part of UMass Chan's overall effort to strike this balance.

1.6 CONTACT INFORMATION

- ➔ Group Name: UMass Chan Design Technology Group
  - Email: DesignTechGroup@umassmed.edu
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  - Email: FECRequests@umassmed.edu
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IMPLEMENTING THE LCCA PROCESS AT UMASS CHAN

2.1 STUDY CATEGORIES

- ➔ The Project Team will assess the value of the project of up to 16 possible life cycle cost (LCC) comparisons in six general categories: Energy Systems, Mechanical Systems, Electrical Systems, Building Envelope, Siting/Massing, and Structural Systems. Within each category, the specific comparisons involve options for addressing the same need. The 16 comparison areas follow, with examples of options that might be considered in each. These examples are only for clarification; specific systems or options considered will vary with the type, scale, and intended use of the building.

2.1.1 ENERGY SYSTEMS

- ➔ Central plant-connected vs. stand-alone system (steam and chilled water)
- ➔ Alternative energy systems (e.g., solar photovoltaics, solar thermal, heat pumps)
- ➔ Equipment options for stand-alone systems (e.g., air-cooled chillers vs. refrigerant-based direct expansion [DX] units)
- ➔ Heat recovery

2.1.2 MECHANICAL SYSTEMS

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

2.1.3 ELECTRICAL SYSTEMS

- ➔ Indoor lighting sources and controls
- ➔ Outdoor lighting sources and controls
- ➔ Distribution (e.g., transformers, buss ducts, cable trays)

2.1.4 BUILDING ENVELOPE

- ➔ Skin and insulation options
- ➔ Roofing systems (various materials and insulation methods)
- ➔ Glazing, daylighting, and shading options
- ➔ Curtain wall systems

2.1.5 SITING/MASSING

- ➔ Orientation, floor-to-floor height, and overall building height
- ➔ Landscape, irrigation, and hardscape options

2.1.6 STRUCTURAL SYSTEMS

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

2.2 OPERATIONS & MAINTENANCE (O&E) COST BENCHMARKING

➔ During the Feasibility and Programming phases of the PDP, the Project Manager develops a "Benchmark Budget" with design and construction cost estimates based upon data from past projects. At this time, the Project Team will also develop an O&M Benchmark using historical operations and maintenance data from existing campus buildings for those LCCA components, as defined below, that apply to the project.

2.3 COMPARATIVE ANALYSIS

➔ During the Schematic Design (SD) and Design Development (DD) phases of other PDP, 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 Project Manager will direct the team to conduct a series of analyses comparing the total costs of various building system options. See the Technical Guidelines for LCCA which defines steps to follow in conducting these analyses and provides constants (energy rates, discount rates, etc.) to be used.

2.4 STUDY SELECTION

➔ The Project Team will determine which of the six categories of studies and the 14 comparative analyses 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 Figure 1 sample below. The vertical axis represents the potential cost impact to the project. The horizontal axis reflects the complexity of the analysis required.

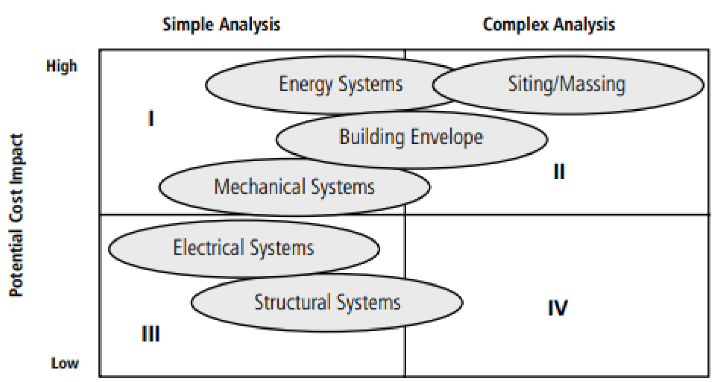

Figure 1: Sample LCCA Decision Matrix

➔ When the six categories and/or 16 analyses are compared on such a matrix, they become easier to prioritize. Those in Quadrant I (simple analysis with high potential cost impact) should have the highest priority. Studies that require complex analysis but have a high potential impact should be prioritized next (Quadrant II). Simple analyses with low potential impact would be next (Quadrant III), followed by complex analyses with low potential impact (Quadrant IV). By taking the time to prioritize LCC analyses, the Project Team can focus on those studies most appropriate for the project. At a minimum the project team must evaluate everything as quadrant 1.

2.5 CONDUCTING COMPARATIVE ANALYSIS

- Each comparative analysis is developed on a project specific basis. The Project Manager, Technical 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. For example, in analyzing mechanical distribution systems, the team might decide to consider a base case of overhead air distribution and an alternative underfloor approach.
- The Technical Guidelines section discusses the format used to record the results of the comparative analyses. While this format is intentionally generic (to accommodate various types of studies), all 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 the Department of Project Management's LCCA library for future reference. In this way, Stanford will create a database of building studies as both a reference for future projects and a tool for understanding similarities and differences between building systems.

2.6 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 which elements to include in the final project design.
- 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 and require the approval of the Associate Vice Chancellor of Facilities to be exempted. Alternatives resulting in paybacks over 10 years are discretionary.
- Documentation and appropriate explanations should be included to support the inclusion or exclusion of alternatives considered. See UMass Chan LCCA Process Phases section for further details

2.7 ARCGIS

- Coordinate with UMass Chan Project Manager to receive utility drawings data maintained on our ArcGIS.

UMASS CHAN LCCA PROCESS PHASES

➔ The UMass Chan process includes a five-step framework to initiate and complete a life cycle cost analysis. Figure 2 provides an overview. This framework serves as a baseline example to be used and adapted to meet unique needs of individual projects.

1 DEFINE PROJECT GOALS

- Establish minimum performance requirements by 20% or more
- Define key performance indicators (e.g., ROI, Payback, NPV)
- Identify project team roles, repsonsibilities, and primary decision makers
- Define scope of the LCCA, including building systems

2 EXPLORE DESIGN OPTIONS

- Establish baseline system options that meet minimum requirements
- Identify alternative building design options to evaluate
- Provide qualitative assessment of design options
- Select top design options for full life cycle cost analysis

3 ANA]LYZE PROJECT COSTS

- Provide energy modeling for utility cost and emissions projections
- Develop construction cost estimates
- Estimate operational, maintenance, repair, and replacement costs

4 QUANTIFY LIFE CYCLE COST

- Apply the UMass Chan LCCA Guidelines
- Review results with key project stakeholders
- Assess other financial, enviromental, and operation considerations

5 INFORM DESIGN DECISIONS

- Provide a LCCA Results Summary Report
- Review results with primary decision makers
- Determine a recommend design approach

Figure 2: UMass Chan Process Framework

3.1 STEP 1: DEFINE PROJECT GOALS

- ➔ The first step of an LCCA is to define the project goals. This is critical for providing a successful analysis. This includes identifying energy and sustainability requirements and goals, defining scope analysis, identifying key performance indicators (KPIs), and establishing project team roles and responsibilities.

3.1.1 LCCA STUDY SCOPE

- ➔ The project team must define what building systems should be included in the analysis. A LCCA can be used to evaluate multiple building systems collectively (e.g., Mechanical, Energy Resources, and Plumbing), or used for individual, specific building systems where there are various design options being considered (e.g., Mechanical HVAC systems).

3.1.2 ENERGY AND SUSTAINABILITY REQUIREMENTS AND GOALS

- ➔ The project team must define the key energy and sustainability goals for the project to ensure that all design options meet the minimum performance requirements and adhere to the Sustainability and Resiliency Guidelines.
- ➔ Below is an example set of project goals for a new construction project:
  - 20% savings compared to a similar functioning building design
  - Minimum of LEED Silver rating
  - Lab and healthcare space should achieve an energy use intensity (EUI) 100kBtu/SF or lower

3.1.3 KEY PERFORMANCE INDICATORS (KPI)

- ➔ After determining the scope of the analysis, the project team should determine the appropriate KPIs. This involves defining the criteria by which different options will eventually be compared and assessed. It is important to define KPIs early in the LCCA process because options could potentially be favorable in certain KPIs but not in others. Defining which KPIs are most important in achieving project goals will bring clarity to the results.
- ➔ Table 1. LCCA Key Performance Indicators includes typical KPIs for consideration. It is recommended that the Net Present Valus (NPV) and Carbon Reduction Effectiveness are used as the guideline KPI, unless specific project requirements call for using different metrics.

KPI	DESCRIPTION
Net Present Value (NPV)	Cumulative cash flows discounted to show value added in today's dollars
Internal Rate of Return (IRR)	The discount rate at which NPV is equal to zero. A higher IRR shows better intrinsic performance.
Savings to Investment Ratio (SIR)	Comparison between lifetime savings and cost. Used to prioritize deployment of different projects.
Carbon Reduction Effectiveness ($/MTCO2E)	A ratio of project costs and carbon reduction. This represents the dollar costs to reduce a metric ton of carbon.

Table 1: LCCA Key Performance Indicators

3.1.4 QUALITY MANAGEMENT

➔ Project teams set quality assurance and control requirements for LCCA studies. They must establish uniform LCCA inputs, reviewed by the UMass Chan Design Technology Review Committee (DTRC). Teams should also ensure building designs include monitoring and controls for post-occupancy measurements and verification (M&V) processes.

3.1.5 ROLES AND RESPONSIBILITIES

➔ Clearly defined roles and responsibilities should be established for each project. Table 2 provides an example of UMass Chan DTRC, and the need to provide input and review during the LCCA process. A primary decision maker should be established at the start of the LCCA process.

UMASS CHAN DTRC	EXAMPLE OF INPUT PROVIDED	EXAMPLE SCOPE OF REVIEW
Assistant Vice Chancellor or Admin/Finance	Financial terms and KPIs	Financial Inputs
Project Management	Project requirements, system options	LCCA results
Associate Director of Sustainability & Campus Services	Carbon offsets, energy efficiency, sustainability initiatives	Sustainability considerations
Director of Maintenance Services	Operational efficiency, preventative maintenance, resource allocation, compliance and safety	Maintenance considerations
Senior Director of Capital - Facilities	Strategic goals, compliance, and financial efficiency	Owner Representative of compliance
Senior Director of Facilities Engineering & Infrastructure	Technical expertise, infrastructure planning	Facilities Engineering considerations
User Groups	Project goals and user requirements	Project goals

Table 2: Example of LCCA Owner Roles and Responsibilities

A LCCA should consider input from various members of the project design teams. Table 3 outlines the example of roles and responsibilities within a consultant team.

CONSULTANT TEAM	ROLE & RESPONSIBILITY
Architect	System options, space programing, design considerations
General Contractor	Constructability, cost estimates
Subcontractors (Trades)	Constructability, cost estimates
Cost Estimator	Cost estimates
MEP Engineers	System options, design considerations
Energy Consultant	Energy modeling, utility costs, LCCA lead
Sustainability Consultant	Sustainability goals & considerations
Other Design Disciplines	Design considerations

Table 3: Example of LCCA Consultant Team Roles and Responsibilities

3.2 STEP 2: EXPLORE DESIGN OPTIONS

- The second step of an LCCA is to identify and explore potential design options. For each building system assessed, project teams should establish a baseline system and identify several alternative designs for consideration. The baseline must comply with Executive Order 594 and the DOER Stretch Energy Code, which require a minimum of 20% energy performance improvement over the Massachusetts Building Energy Code baseline. This involves comparing the proposed building's energy performance to a baseline model that meets ASHRAE 90.1. Examples of baselines include traditional designs (e.g., in-kind replacement),
- or common options for similar projects. The baseline provides a control scenario for comparing alternatives, which must be qualitatively assessed for feasibility before detailed financial analysis.
- Figure 3 outlines an example process of exploring design options for an Energy Resource building system. Baseline design was established as having no onsite distributed energy resources, and other potential alternative options were identified for consideration. A qualitative assessment then determined that geothermal and hydrogen fuel cells were not viable options based on project constraints, such as site conditions and high capital costs. As a result, LCCA will move forward considering the baseline option, and the remaining alternative options.

Define Baseline Design

Baseline design did not include any distributed energy generation or storage resources

Identify Alternative Options

Potential energy resources identified included the following:

-Geothermal
-Solar PV
-Battery Energy Storage System (BESS)
-Solar PV + BESS
-Solar Hot Water
-Hydrogen Fuel Cell

Assess Qualitative Impacts

Design options were narrowed down to include the following in a full LCCA:

-No Distributed Energy Resources (Baseline)
-Add 100kW Solar PV
-Add 100kW Solar PV + 100kW/400kWh BESS
-Add 20 Solar Hot Water Panels

Finalize LCCA Scope

Design options were reviewed compared to the following considerations:

-Minimum Requirements
-Overall Project Goals
-Project Budget and Cost Impact
-Design Impacts
-Energy and GHG Emissions
-Hydrogen Fuel Cell

Figure 3: Example of Exploring Energy Resource Options

3.3 STEP 3: ANALYZE PROJECT COSTS

➔ The third step of LCCA is to estimate and analyze the comprehensive costs associated with all options resulting from the previous step of exploring of design options. This includes construction cost estimates, utility cost modeling, operation & maintenance costs, and future repair or replacement costs. Table 4 provides an overview of design option cost components, and example data sources to aid in the development and estimation for cost.

COST COMPONENTS	EXAMPLE DATA SOURCE
CONSTRUCTION Upfront capital required for initial construction	-Detailed cost estimate from Cost Estimator/ Contractor/Consultant -Industry guidelines (e.g., RS Means) -Previous campus project
O&M, REPAIR AND REPLACEMNET General operations & maintenance (O&M), periodic equipment repairs, and end of the life replacement costs	-Industry guidelines (e.g., RS Means, CBRE Cost Lab, Whitestone Manual) -Estimates from Facilities and Asset Departments -Industry organizations (e.g., Building Owners and Managers Association (BOMA), International Facility Management Association (IFMA), Association of Physical Plant Administrators (APPA))
ENERGY & UTILITIES Current rates and expected escalation of electricity, natural gas, water, sewer, etc.	-Utility rates -Energy Model results
HEATING & COOLING Efficiency and cost of generating and disturbing heating and cooling	-Central Plant efficiency -Heating & Cooling recharge rates -Energy Model demands
CARBON Embodied carbon is associated with project materials and processes. Operational GHG emissions from utilities, heating & cooling, lighting, refrigeration	-Compliance Offsets (Cap & Trade) -Voluntary Offsets -Social Cost of Carbon
USABLE BUILDING AREA Value of building are if design options impact the amount of usable square footage available to achieve project programming goals and objectives	-Impact on useable space -Value of space ($/SF)
RESIDUAL VALUE Value of an asset or material after it has fully depreciated or has reached/is beyond its useful life	-Industry guidelines -Estimates from Facilities and Asset Departments

Table 4: LCCA Cost Components

Note: It is best practice to consider all cost components of design options, however UMass Chan, as well as industry-wide, consensus on categories such as Social Cost of Carbon, Useable Building Area, and Residual Value are still being explored. At this time, UMass Chan campuses and locations should consider all cost components of design options and provide justification and reasoning for incorporating or not incorporating costs associated with such categories until substantial consensus is reached, and additional guidance is available. Furthermore, a sensitivity analysis can be provided for these cost categories.

3.2.1 CONSTRUCTION COSTS

- Construction costs include the upfront capital expenditures associated with a project. For example, costs related to design, land acquisition, permitting, materials, equipment, construction, and project administration. Construction costs are typically viewed as non-recurring items that are needed to get the project or system operational. Determining capital costs in early project phases can be challenging as direct quotes and bids may not be available, and the project may not be fully defined. If possible, it is recommended to engage an experienced contractor or professional cost estimator to advise on construction costs. For early-stage or preliminary plan phase cost estimates, construction cost databases may help provide rough order of magnitude estimates.

3.2.2 OPERATIONS & MAINTENANCE, REPAIR, AND REPLACEMENT

- Operations & Maintenance (O&M), Repair and Replacement costs include expenditures required to keep the building system running and achieving project goals throughout its useful life. These include recurring costs such as facilities personnel labor, replacement of spent items and materials, insurance, and preventative maintenance. Additionally, these costs include non-routine expenditure related to reactive maintenance in response to non-planned issues or disruptions, such as equipment failure or malfunction.
- O&M, Repair and Replacement costs may be difficult to estimate since there is wide variability in how building systems are utilized. Generalized O&M costs may be referenced from industry guidelines such as Whitestone Research publications, CBRE Cost Lab, and RS Means from Gordian. These resources provide a breakdown of life cycle costs including annual maintenance, periodic repairs, and end of life replacements.
- Additionally, historical data from specific or aggregated UMass Chan campus or location Facilities and Asset Management Departments (e.g., Space Management and Planning, and Facilities Management) can be used to develop estimates for improvement projects to existing buildings, or new buildings of comparable size, systems, and other characteristics. When and if utilizing historic data to develop projections within and among different campuses and locations, it is important that project teams clearly communicate assumptions made and the impact to cost estimate uncertainties. While all campuses and locations have similarities, they also have unique features in their organization and procedures.
- While equipment may be utilized beyond it's expected useful life, when performing a LCCA it is suggested to assume the manufacturer's recommended replacement timeline – and any desired adjustments must be confirmed among the project team and appropriate UMass Chan stakeholders.

3.2.3 ENERGY & UTILITIES

- Energy and utility costs (e.g., electricity, water, gas) are a primary driver of potential project savings. Further, project teams should assess greenhouse gas emissions associated with energy and utility systems.
- It is recommended to utilize energy calculations from professional engineering sources to determine predicted utility consumption. For projects that are served by campus utilities (e.g., electricity, chilled water, hot water), fully burdened utility costs and projected escalation rates should be provided by campus Energy Managers. For projects that have dedicated utility meters, project teams should account for detailed time of use (TOU) rate structures rather than defaulting to blended utility rates.

3.2.4 CARBON

➔ In support of the UMass Chan Sustainability and Climate Action Plan, projects and design options that minimize or neutralize carbon emissions must be favorably prioritized by UMass Chan project teams. Reducing carbon emissions is critical for limiting UMass Chans' impact on climate change and achieving emissions reductions under EO594.

3.2.5 CARBON SOURCES

➔ It is recommended that project teams provide a full accounting of the carbon emissions when possible. Operational emissions are typically categorized into Scope 1, Scope 2, and Scope 3 emissions measured in equivalent metric tons of carbon dioxide.

- Scope 1 Emissions – Direct emissions on campus. Examples include emissions from natural gas for space heating, UMass Chan campus vehicles, diesel generators, and fugitive refrigerant emissions.
- Scope 2 Emissions – Indirect emissions from campus sources. Examples include all forms of non-renewable electricity purchased from a local utility.
- Scope 3 Emissions – All other indirect emissions that are a consequence of the activities of an institution but occur from sources not owned or controlled. Examples include commuting, waste, and purchased goods.

➔ Embodied carbon of construction materials and building systems (e.g., emissions resulting from the manufacturing, transportation, and installation processes) should be included in a LCCA, when available, and especially when alternative design options have the potential for significant embodied carbon savings.

3.2.6 CARBON COST

➔ Full cost accounting for carbon is in the process of being standardized by the UMass Chan system. Until further guidance is established, UMass Chan campuses and locations must account for direct costs associated with carbon emissions, and reasonably account for adjacent costs associated with carbon emissions. Carbon emissions have a vast impact on environmental systems, community health and wellness, and business objectives and must be thoughtfully considered when making project design decisions. Direct and indirect costs associated with carbon emissions include the following:

- Cap & Trade: Compliance offsets that are required as part of the Massachusetts emissions trading program through Regional Greenhouse Gas Initiative (RGGI). Cost projections should be confirmed with UMass Chan project teams, which may include Sustainability Departments.
- Voluntary Offset: Voluntary carbon offsets to meet organizational initiatives and goals.
- Social Cost of Carbon (SCC): An estimate of the economic damage that results from the emission of one additional metric ton of CO2, including the financial harm caused to business and social productivity, and public health.

➔ It is best practice to consider the total SCC when developing capital projects. Consensus on the SCC is being explored within UMass Chan and across the industry. Additional guidance will be made available in the future, consult with the campus Office of Sustainability for additional resources and references for carbon accounting practices

3.4 STEP 4: QUANTIFY LIFE CYCLE COST

➔ The fourth step of LCCA is to develop long-term cashflows and compare financial KPIs of the alternative design options. This can be either the full total cost of ownership in absolute terms, or the relative cost difference between a baseline or business-as-usual design option.

3.4.1 FINANCIAL INPUTS

➔ Table 5 describes general financial inputs to be incorporated into a LCCA. See the additional resources section for additional information.

<table>
<tr><th>LCCA FINANCIAL INPUTS</th><th>CONSIDERATIONS</th></tr>
<tr><td>ANALYSIS PERIOD
Expected lifetime of a project, or standardized time period of LCCA review and assessment</td><td><table><tr><th>Program Space Type</th><th>Example Default (Years)</th></tr><tr><td>Academic/Admin Non-Complex</td><td>50</td></tr><tr><td>Housing</td><td>30</td></tr><tr><td>Lab/Complex</td><td>50</td></tr><tr><td>Medical</td><td>40</td></tr></table>
-Analysis Period should be adjusted based on LCCA scope and project life to capture full life cycle costs</td></tr>
<tr><td>DISCOUNT RATE
Opportunity cost of capital for UMass Chan capital projects</td><td>-Example Default Value: 3.0%
-Discount rate to represent and understand the present and future value of money</td></tr>
<tr><td>GENERAL INFLATION
Increase in overall cost of goods and services</td><td>-Example Default 2.5%
Based on historical US inflation rates</td></tr>
<tr><td>CONSTRUCTION ESCALATION
Increase in costs of construction materials and labor</td><td>-Example Default Value 4.0%:
-Construction costs have historically outpaced general inflation in most of Massachusetts</td></tr>
<tr><td>O&M ESCALATION
Increase in costs to operate & maintain buildings</td><td>-Example Default Value: 3.0%
-Default rate is set to match/align with general inflation</td></tr>
</table>

Table 5: Example of LCCA Financial Inputs

Note: *“Default” values shown here are generalized figures based on common industry practice and assumptions. It is recommended that LCCA financial input values be developed, reviewed, and confirmed by the project team specifically for each project.*

3.4.2 DISCOUNTED CASH FLOW

➔ A discounted cash flow table enables the comparison of the net present value (NPV) of design options with consideration for relevant discount and escalation rates. These concepts are crucial for making informed decisions about long-term investments and ensuring that projects are financially sustainable.

➔ There are multiple methodologies of LCCA, including how to address the time value of money. UMass Chans prefer the current dollar analysis. The chosen approach will impact on how discount rates, inflation, and escalation rates are applied.

3.5 STEP 5: INFORM DESIGN DECISIONS

- ➔ The final step of a LCCA is to develop a report or set of deliverables that clearly communicate a summary of LCCA results, and how these results may be used to inform project design decisions aligned with project goals and objectives. The report should include the following components.
  - Executive Summary: High-level synopsis of the project and any relevant background, context or assumptions, project goals and objectives, design options being considered, results of the LCCA, and recommendations.
  - Process Description and Details: Summary of LCCA procedures implemented, scope of LCCA, KPIs utilized, LCCA inputs and data sources.
  - LCCA Results: Tables and graphics that simply and succinctly communicate LCCA results and KPIs – along with narrative text that explain this information.
  - Discussion of Results and Recommendations: Analysis of trends, risks, opportunities, and factors influencing design options, with guidance on achieving project goals.
  - Appendices and Supporting Data: Facts, data, and information relevant to the preparation, implementation, and outcomes of the LCCA (e.g., detailed cost estimates, detailed cash flows, energy modeling reports)
- ➔ Please refer to UMass Chan LCCA Reporting for additional information

UMASS CHAN LCCA REPORTING

4.1 LCCA REPORT COMPONENTS

➔ A LCCA report succinctly conveys results of the LCCA process, provides relevant detail for review and validation of the methodology, and guides interpretation of outcomes with the perspective of achieving projects goals. Figure 8 outlines an example of LCCA report format.

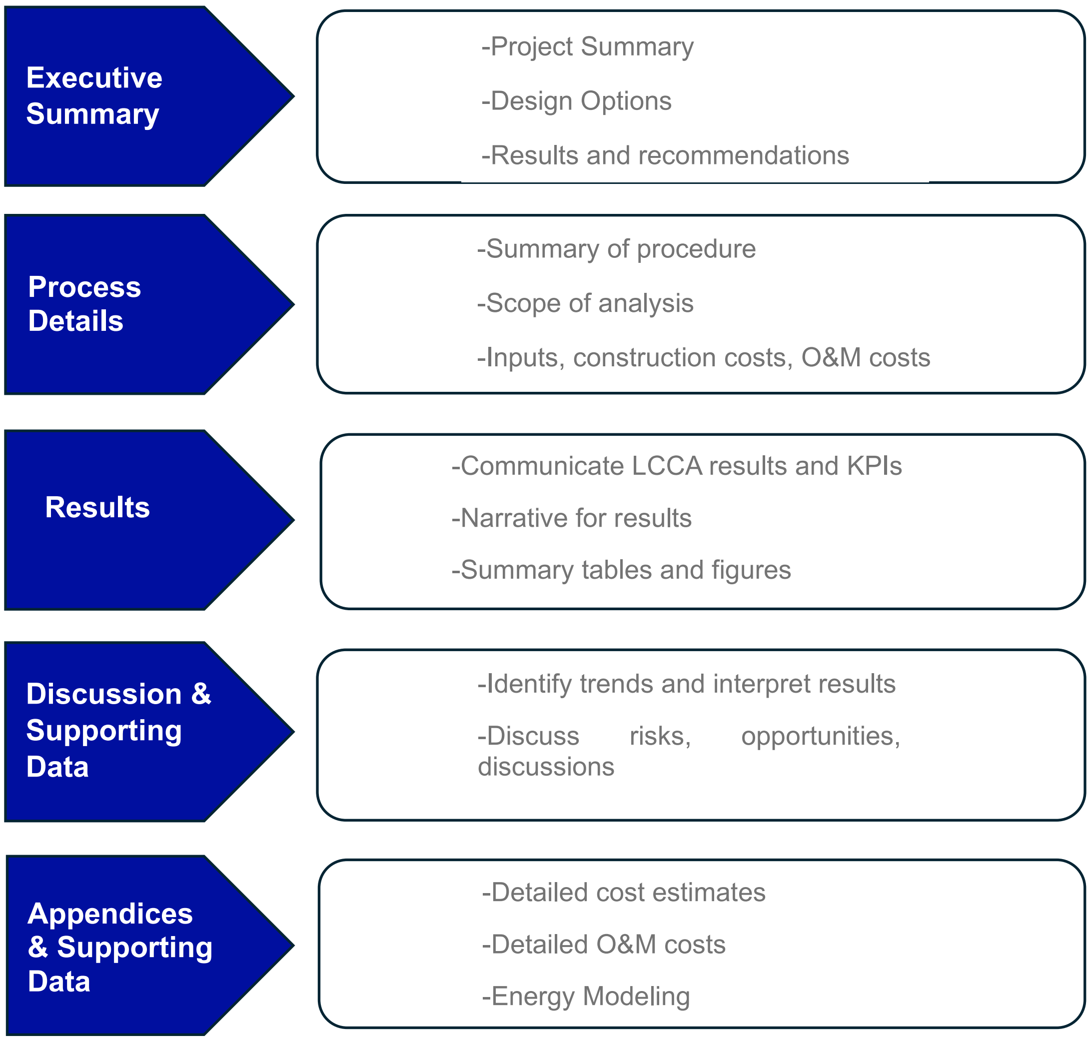

Figure 4: Example of LCCA Report Format

4.2 LCCA APPROVAL PROCESS

➔ This flow chart provides a clear, visual representation of the steps involved in the LCCA approval process, helping stakeholders understand their roles and responsibilities. It also facilitates efficient communication and coordination among departments, ensuring that all projects are evaluated based on comprehensive cost-benefit analyses over their entire life cycle. By standardizing this process, we can make more informed, sustainable, and financially sound decisions that align with our campus's long-term goals.

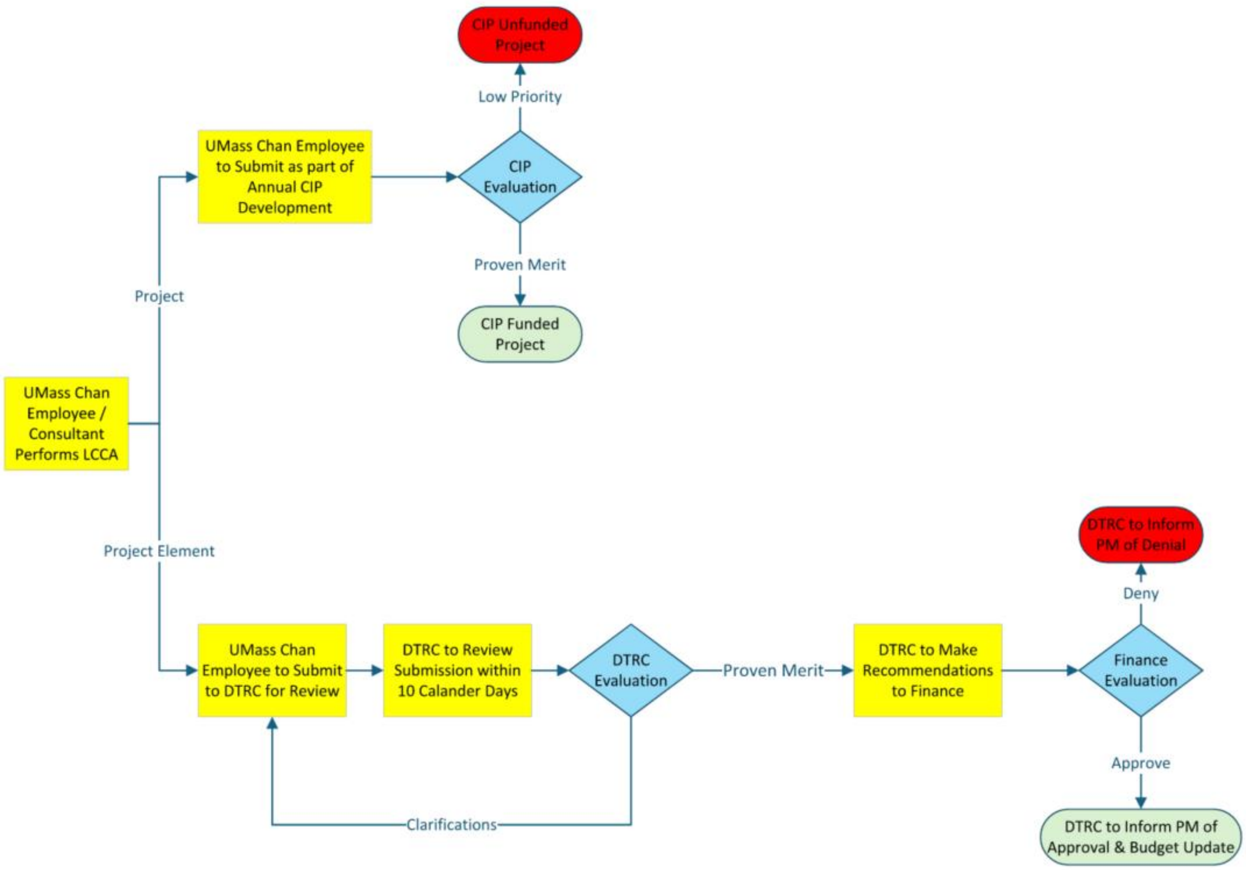

Figure 5: UMass Chan LCCA Approval Process

TECHNICAL GUIDELINES

5.1 RESIDUAL VALUE

➔ When building systems or equipment reach the end of their service life, Life Cycle Cost Analysis (LCCA) must consider associated costs. Residual or salvage value, especially for equipment with precious metals or extended use, should be included. For projects like electric transportation, battery storage, or solar systems, residual value is crucial. UMass Chan aims for buildings to last 50 years, treating end-of-life value as $0, as removal costs are offset by salvaging materials.

5.2 SUBSYSTEM LIFE EXPECTANCY

➔ The life expectancy of every part of the building is shown below.

Subsystem Categories	Average Life Cycle
1a. Roofing – Tile	80 years
1b. Roofing – Metal, Concrete	50 years
1c. Roofing – Membrane, Built-up, Shingle, Bitumen, Foam	20 years
2. Building Exteriors, Doors, and Windows (Hard)	80 years
2a. Building Exteriors (Soft)	20 years
3. Elevators and Conveying Systems	25 years
4. HVAC – Equipment and Controls	20 years
5. HVAC – Distribution Panels	40 years
6. Electrical Equipment	30 years
7. Plumbing Fixtures	30 years
8. Plumbing Rough-In	50 years
9. Fire Protection Systems	40 years
10. Fire Detection Systems	20 years
11. Built-In Specialties and Equipment	25 years
12. Interior Finishes	15 years
Other Categories	Average Life Cycle
13. Foundations	Lifetime
14. Subgrade drainage and waterproofing	As needed
15. Vertical Elements	Lifetime
16. Horizontal Elements	Lifetime
17. Interior Partitions	As needed
18. Electrical Rough-In	Lifetime
19. Site Preparation	Lifetime
Other Categories	Average Life Cycle
20. Site Development – Softscape	Infrastructure
21. Site Development – Hardscape	Infrastructure
22. Site Development – Distribution	Infrastructure
23. Site Utilities	Infrastructure

Figure 6: Subsystem Life Cycles

5.3 LIFE CYCLE COST PARAMETERS

➔ To provide a reference for users and allow for periodic updates, all the values for parameters in the UMass Chan LCCA procedure are presented below. For each parameter, a responsible office is indicated so that users can obtain updated information or determine appropriate values for a specific project. Verify all rates with project manager.

5.4 STUDY LIFE

DESCRIPTION	VALUE RANGE	AUTHORITY
New Construction Projects	30 years	Project Manager
Retrofit or Renovation Projects	15 years	Project Manager
Labs or High-Tech Buildings	10 years	Project Manager

5.5 CAMPUS TIME-VALUE-OF-MONEY RATES

DESCRIPTION	NEAR-TERM VALUE (YEARS 0-5)	LONG-TERM VALUE (YEARS 6+)	AUTHORITY
Nominal UMass Chan Discount Rate	6%	7%	Land and Buildings
Inflation	1.5%	3.0%	Land and Buildings
Real UMass Chan Discount Rate (Adjusted to take out inflation)	4.4%	3.9%	(Calculated)

5.6 ESCALATION RATES

DESCRIPTION (All rates are "real" – they have been adjusted to take out inflation)	NEAR-TERM VALUE (YEARS 0-5)	LONG-TERM VALUE (YEARS 6+)	AUTHORITY
Maintenance, Labor, and Materials	0%	1%	Facilities Operation
Energy and Water Utilities	0.5%	1%	Utilities

5.6.1 UTILITY RATES

- Steam (per 1,000 lb)
- Chilled Water (per ton-hour)
- Electricity (per kWh)
- Natural Gas (per therm)
- Domestic Water (per 1,000 gal)
- Lake Water (per 1,000 gal)
- Sewer (per 1,000 gal)

5.6.2 UMASS CHAN - FY26 - BUDGETED

UTILITY TYPE	UOM	TOTAL RATE
Chilled Water	TON-DAY	9.14900
Electricity	KWH	0.17000
Sewer	GAL	0.01286
Steam	KLBS	32.1060
Water	GAL	0.00536

*Total Rate is the Capacity + Commodity

ADDITIONAL RESOURCES

6.1 EXAMPLE LIST OF LCCA INPUTS

- The following are lists of LCCA inputs and factors that project teams may use as a reference guide. Please note, actual LCCA input values should be confirmed with relevant campus departments and personnel (e.g., Energy Managers, Sustainability, Capital Programs, Finance, Facilities and Assets, Capital Planning) for each project and use case. In addition, please contact UMass Chan Office of Sustainability for any available systemwide default energy and energy costs assumptions. Contact UMass Chan's Facilities Engineering and Construction Management for construction cost escalation and related factors.

6.1.1 FINANCIAL INPUTS

FINANCIAL	CONSIDERATIONS & NOTES
Analysis Period	Building lifetime
Discount Road	Cost of capital
General Inflation	Long term
Construction Escalation	Near term inflation during design & construction
O&M Escalation	Long term escalation of maintenance/repair costs
Usable Area	Value of additional useable building square footage

6.1.2 CONSTRUCTION COST ESTIMATE

COST ESTIMATE	CONSIDERATIONS & NOTES
Contingency	Confirm project specific requirements
Escalation	Align with project construction timeline
General Conditions/Requirements	Confirm project specific requirements
Contractor Overhead & Profit	Confirm project specific requirements
Insurance & Bonds	Confirm project specific requirements

- Cost estimates at various project phases should be provided at the following level of detail at a minimum. UMass Chan campuses should confirm the level of detail required for each project phase.

PROJECT PHASE
Scoping / Concept
Feasibility Study
Schematic Design
Design Development
Construction Documents

6.1.3 UTILITY COSTS

UTILITIES (MAIN CAMPUS)	LCCA INPUT	CONSIDERATIONS & NOTES
Electricity	$/kWh	Consider blended campus electricity rate
Electricity Escalation		Consider utility and MA state projections
Electricity Emissions		
Natural Gas	$/therm	40% biogas starting in 2025
Natural Gas Escalation		
Natural Gas Emission	MTCO2e/therm	ENERGY STAR Portfolio Manager 40% biogas starting in 2025 (carbon free)
Water - Potable	$/HCF	
Water - Sewer	$/HCF	
Water & Sewer Escalation		

HEATING & COOLING	LCCA INPUT	CONSIDERATIONS & NOTES
Chilled Water Energy Cost	$/ton	Cost of energy to produce chilled water
Chiller Water Delivered Cost	$/ton	Total cost of delivering hot water including energy, O&M, equipment repair & replacement
Chilled Water Efficiency	kW/ton	
Chiller Water Delivery Escalation		
Hot Water Energy Cost		Cost of energy to produce hot water
Hot Water Delivered Cost	$/MBtu	Total cost of delivering hot water including energy, O&M, equipment repair & replacement
Hot Water Efficiency	Therms/MBtu	
Hot Water Efficiency	kWh/MBtu	
Hot Water Delivery Escalation		

6.1.4 GHG EMISSONS

CARBON INPUTS	LCCA INPUT
Cap & Trade Rates	$/MMBtu
Voluntary Offsets	$/MTCO2E
Voluntary offsets Escalation	
Social Cost of Carbon (equity weighted)	$/MTCO2
Social Cost of Carbon Escalation	

6.2 GLOSSARY OF TERMS AND ABBREVIATIONS

Analysis Period or Study Period – The time over which the LCCA is evaluated.

Association of Physical Plant Administration (APPA) – Facilities and asset management industry organization.

Building Owners and Managers Association (BOMA) – Facilities and asset management industry organization.

Capital Investment – First or Initial cost of a project.

Discount Rate – Factor which is used to incorporate the time value of money.

DTRC – Design Technology review Committee.

Energy Conservation Measure (ECM) – A project or building modification which aims to reduce energy.

Energy Use Intensity (EUI) – Ratio of facility energy use to square footage. Typically expressed in the units of thousand British thermal units per square foot per year {kBtu/SF-yr].

Escalation Rate – Factor which is used to account for rising costs of a specific good or service.

Future Value (FV) – Time equivalent value of present or past value.

Greenhouse Gas (GHG) – Gases which absorb radiant energy and contribute towards the greenhouse effect.

Inflation – Factor which is used to account for rising costs of general goods and services.

Internal Rate of Return (IRR) – The lowest rate of return where the life cycle cost or net present value is equal to zero.

International Facility Management Association (IFMA) – Facilities and asset management industry organization.

Key Performance Indicator – Significant metric aligned with project goals and objectives, used to evaluate performance.

Life Cycle Cost (LCC) – The value of all lifetime costs discounted to present value.

Life Cycle Cost Analysis (LCCA) – Evaluation of financial strength of project design options by determining total cost of ownership.

Measurement and Verification (M&V) – Process for assessing expected performance versus actual performance.

Minimum Acceptable Rate of Return (MARR) – Minimum rate which the organization is willing to accept for a given project.

Monitor Based Commissioning (MBCx) – Process to continuously confirm building operates within expected ranges. Typically, fault detection is utilized to inform facilities staff.

Net Savings (NS) – Savings less costs.

Present Value (PV) – Time equivalent value of today's dollar value.

Residual Value – The value of a project, building, or piece of equipment at the end of the useful life.

Savings to Investment Ratio (SIR) – Ratio of cost savings to project costs.

SF – Square foot/feet

Value Engineering (VE) – Process of weighing costs against project requirements and eliminating unnecessary costs.

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