

### 1. INTRODUCTION:

- 1.1. LIFE CYCLE COST ANALYSIS (LCCA):** This is an economic analysis technique considering initial acquisition costs and the recurring cost associated with the operation, maintenance, energy use, and other costs of ownership. The objective of LCCA is to optimize the cost of ownership of a building.

### 2. APPLICABILITY:

- 2.1.** This procedure shall be followed by all Architectural and Engineering (A/E) firms, and Consulting Firms conducting business with the University: It is the policy of the University that State owned or financed buildings shall be constructed in a manner to minimize initial costs of construction, recurring costs associated with the consumption of energy resources, and the operation and maintenance of those buildings.
- 2.2.** The Procedures described in this document shall be utilized to analyze Architectural, Structural, Mechanical and Electrical components, materials, and systems for all New Buildings, Additions to Existing Buildings, and Major Renovations of Existing Buildings.
- 2.3.** The A/E Team shall meet with the University to select the components, materials, and systems that should be analyzed.

### 3. PROCEDURES:

- 3.1. LCCA Procedures:** Through the use of LCCA Procedures, the Consultant shall determine:
- a.** The System's Cost Effectiveness for new construction, where the optimum building system or component has the lowest total life cycle cost that meets the requirements of the building.
  - b.** The Cost Effectiveness of Retrofit Systems for renovation projects, where the most effective system that has the lowest total life cycle cost that meets the requirements of the building.
- 3.2. Implementation of Life Cycle Cost Analysis:** The step by step procedure to analyze the Life Cycle Cost of any component, material, or system is described in this section. The steps and forms in section 4 were developed for use in evaluating a base mechanical or plumbing system and alternative mechanical or plumbing systems. The forms shall be modified as appropriate to evaluate other systems, components, or materials, such as Architectural, Structural, Electrical or other systems.
- a. Step One: System Descriptions:** Using Form 4.1, describe five (5) complete HVAC systems, base system plus four (4) alternate systems.
  - b. Step Two: Utility Cost Data:** Using Form 4.2, identify the utility cost data.
  - c. Step Three: Initial Cost Estimate - Base System:** Using the 4.3 Forms identify the initial cost of the mechanical base system.
  - d. Step Four: Initial Cost Estimate - Alternate:** Using the 4.4 Forms identify the initial cost of each mechanical alternate system.
  - e. Step Five: Annual Cost - Base System:** Using the 4.5 Forms, identify the energy cost and the service and maintenance cost of the mechanical base system. The

Consultant shall establish the utility and maintenance unit cost in consultation with the University.

- f. **Step Six: System Replacement Cost - Base System:** Using Form 4.6, identify the present value of replacement cost of the major equipment in the mechanical base system. The Consultant shall establish the system and component and salvage (life expectancy) values in consultation with the University.
- g. **Step Seven: Annual Cost - Alternate:** Using the 4.7 Forms, identify the energy cost and the service and maintenance cost for each mechanical alternate system. Use duplicate forms for each alternate. The Consultant shall establish the utility and maintenance unit cost in consultation with the University.
- h. **Step Eight: System Replacement Cost Alternate:** Using Form 4.8, identify the present value of replacement cost of major equipment in each mechanical alternate system. Use duplicate forms for each alternate. The Consultant shall establish the system and component and salvage (Life Expectancy) values in consultation with the University.
- i. **Step Nine: Summary – LCCA:** Using Form 4.9, summarize the LCCA Data for the mechanical base system and each mechanical alternate system. Identify the recommended system.

4. **FORMS:** The Forms on the following pages are available from UMB, electronically.

## CHAPTER FOUR – LIFE CYCLE COST ANALYSIS

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### 4.1. SYSTEM DESCRIPTIONS

Project:	Date:
Location:	

By:(Engineer's Name and Title)
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<b>Base System:</b>

<b>Alternate #1:</b>

<b>Alternate #2:</b>

<b>Alternate #3:</b>

<b>Alternate #4:</b>

**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**4.2. UTILITY COST DATA**

<b>ENERGY TYPE</b>	<b>COST</b>	<b>ESCALATION RATE</b>
Electric Energy Charge	\$ Per KWH (Winter)	
	\$ Per KWH (Summer)	
Electric Demand Charge	\$ Per KWH (Winter)	
	\$ Per KWH (Summer)	
Steam Energy Charge	\$ Per MLB (Winter)	
	\$ Per MLB (Summer)	
Steam Demand Charge	\$ Per MLB (Winter)	
	\$ Per MLB (Summer)	
Gas	\$ Per MCF or Therm	
Fuel Oil	\$ Per Gallon	
Others	\$ Per Unit	
Electric Energy Charge		

Utility Summer Rate Months: (from) _____ (to) _____
Utility Winter Rate Months: (from) _____ (to) _____
LCCA Term (Typically 30 Years): _____
Discount Rate: _____

**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**4.3. INITIAL COST ESTIMATE – BASE SYSTEM**

**a. HVAC MAJOR EQUIPMENT**

ITEM	QTY UNITS	CAPACITY	UNIT PRICE		TOTAL PRICE	
			MATERIAL	LABOR	MATERIAL	LABOR
1. Chillers		Tons				
2. Cooling Towers		Tons				
3. HT. Exchangers		GPM MBH				
4. Pumps		GPM TH HP				
5. A.H.U.		CFM CMBH HMBH HP				
6. Supply Fans		CFM HP				
8. Return Fans		CFM HP				
9. Exhaust Fans		CFM HP				
10. Other Fans		CFM HP				
11. Terminal Units		CFM				
12. Misc Equip.		MBH CFM HP				
13. Fuel Oil w/ Leak Detection.		Gal .				
14. ATC						

<b>Base System HVAC Major Equipment Sub Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**b. HVAC MATERIAL**

ITEM	QTY	UNITS OF MEASURE	UNIT PRICE		TOTAL PRICE	
			MATERIAL	LABOR	MATERIAL	LABOR
1. Supply / Return Ductwork, complete including diffusers, grilles, dampers, insulation etc						
2. General Exhaust Ductwork, complete including diffusers, grilles, dampers, insulation etc						
3. Special Exhaust Systems						
4. Heating Piping (HS, HR)		FEET				
5. Chilled Piping (CHS, CHR)		FEET				
6. Condenser Water Piping (CWS, CWR)		FEET				
8. Steam Piping (MP, LP)		FEET				
9. Steam Condensate Piping (MP, LP)		FEET				

**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**b. HVAC MATERIAL (Continued)**

ITEM	QTY	UNITS OF MEASURE	UNIT PRICE		TOTAL PRICE	
			MATERIAL	LABOR	MATERIAL	LABOR

10. Natural Gas Piping (Non - Lab)		FEET				
11. Pipe Insulation						

<b>Base System HVAC Material Sub Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**c. PLUMBING MAJOR EQUIPMENT**

ITEM	QTY UNITS	CAPACITY	UNIT PRICE		TOTAL PRICE	
			MATERIAL	LABOR	MATERIAL	LABOR
1. Domestic Water Heaters and Storage Tank		Storage in Gal.  Recovery GPH MBH				
2. Circulating Pumps		GPM TH HP				
3. Sump Pumps		GPM TH HP				
4. Sewage Ejectors		GPM TH HP				
3. RO/DI Water Equipment						

<b>Base System Plumbing Major Equipment Sub Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**d. PLUMBING MATERIAL**

<b>ITEM</b>	<b>QTY</b>	<b>UNITS OF MEASURE</b>	<b>UNIT PRICE</b>		<b>TOTAL PRICE</b>	
			<b>MATERIAL</b>	<b>LABOR</b>	<b>MATERIAL</b>	<b>LABOR</b>

1. Domestic Water Piping with Insulation (CW, HW, HWR)		FEET				
2. Sanitary & Vent (Non – Lab Above Grade)						
3. Sanitary & Vent (Lab – Acid Waste Above Grade)						
4. Storm Water (Above Grade)						
5. Lab Support Piping – Air, Vac, Natural Gas						
6. RO / DI Piping System						
7. Sprinkler System, Complete						

<b>Base System Plumbing Material Sub Total:</b>
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<b>Base System Mechanical Installation Initial Cost Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**4.4. INITIAL COST ESTIMATE – ALTERNATE SYSTEM #**

**a. HVAC MAJOR EQUIPMENT**

ITEM	QTY UNITS	CAPACITY	UNIT PRICE		TOTAL PRICE	
			MATERIAL	LABOR	MATERIAL	LABOR
1. Chillers		Tons				
2. Cooling Towers		Tons				
3. HT. Exchangers		GPM MBH				
4. Pumps		GPM TH HP				
5. A.H.U.		CFM CMBH HMBH HP				
6. Supply Fans		CFM HP				
8. Return Fans		CFM HP				
9. Exhaust Fans		CFM HP				
10. Other Fans		CFM HP				
11. Terminal Units		CFM				
12. Misc Equip.		MBH CFM HP				
13. Fuel Oil w/ Leak Detection.		Gal .				
14. ATC						

<b>Alternate System HVAC Major Equipment Sub Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**b. HVAC MATERIAL**

ITEM	QTY	UNITS OF MEASURE	UNIT PRICE		TOTAL PRICE	
			MATERIAL	LABOR	MATERIAL	LABOR
1. Supply / Return Ductwork, complete including diffusers, grilles, dampers, insulation etc						
2. General Exhaust Ductwork, complete including diffusers, grilles, dampers, insulation etc						
3. Special Exhaust Systems						
4. Heating Piping (HS, HR)		FEET				
5. Chilled Piping (CHS, CHR)		FEET				
6. Condenser Water Piping (CWS, CWR)		FEET				
8. Steam Piping (MP, LP)		FEET				
9. Steam Condensate Piping (MP, LP)		FEET				

**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**b. HVAC MATERIAL (Continued)**

<b>ITEM</b>	<b>QTY</b>	<b>UNITS OF MEASURE</b>	<b>UNIT PRICE</b>		<b>TOTAL PRICE</b>	
			<b>MATERIAL</b>	<b>LABOR</b>	<b>MATERIAL</b>	<b>LABOR</b>

10. Natural Gas Piping (Non - Lab)		FEET				
11. Pipe Insulation						

<b>Alternate System HVAC Material Sub Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**c. PLUMBING MAJOR EQUIPMENT**

ITEM	QTY UNITS	CAPACITY	UNIT PRICE		TOTAL PRICE	
			MATERIAL	LABOR	MATERIAL	LABOR
1. Domestic Water Heaters and Storage Tank		Storage in Gal.  Recovery GPH MBH				
2. Circulating Pumps		GPM TH HP				
3. Sump Pumps		GPM TH HP				
4. Sewage Ejectors		GPM TH HP				
3. RO/DI Water Equipment						

<b>Alternate System Plumbing Major Equipment Sub Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**d. PLUMBING MATERIAL**

ITEM	QTY	UNITS OF MEASURE	UNIT PRICE		TOTAL PRICE	
			MATERIAL	LABOR	MATERIAL	LABOR
1. Domestic Water Piping with Insulation (CW, HW, HWR)		FEET				
2. Sanitary & Vent (Non – Lab Above Grade)						
3. Sanitary & Vent (Lab – Acid Waste Above Grade)						
4. Storm Water (Above Grade)						
5. Lab Support Piping – Air, Vac, Natural Gas						
6. RO / DI Piping System						
7. Sprinkler System, Complete						

**Alternate System Plumbing Material Sub Total:**

**Alternate System Mechanical Installation Initial Cost Total:**

**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**4.5. ANNUAL COST – BASE SYSTEM**

**a. ENERGY (Excluding Lights & Receptacles)**

<b>ENERGY SOURCE</b>	<b>UNITS OF MEASURE</b>	<b>ANNUAL ENERGY CONSUMPTION</b>	<b>ENERGY COST</b>	<b>DEMAND CHARGE</b>	<b>TOTAL ANNUAL ENERGY COST</b>
1. Electric (Winter)					
2. Electric (Summer)					
3. Gas (Winter)					
4. Gas (Summer)					
5. Steam (Winter)					
6. Steam (Summer)					
7. Fuel Oil					
8. Others					

**Base System Annual Energy Cost Total:**

**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**b. SERVICE AND MAINTENANCE COST**

<b>MAJOR EQUIPMENT</b>	<b>ANNUAL SERVICE COST</b>	<b>ANNUAL MAINTENANCE COST</b>	<b>TOTAL SERVICE &amp; MAINTENANCE COST</b>
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1. Chillers			
2. Cooling Towers			
3. Heat Exchangers			
4. Pumps			
5. Air Handling Units			
6. Supply Fans			
7. Return Fans			
8. Exhaust Fans			
9. Terminal Units			
10. Domestic Water Heaters			
11. RO / DI Equipment			
12. Exhaust Fans			
13. ATC			
14. Misc. Equipment			

<b>Base System Service and Maintenance Cost Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**4.6. SYSTEM REPLACEMENT COST – BASE SYSTEM**

<b>PRESENT VALUE OF EQUIPMENT REPLACEMENT COST</b>				
<b>Major Equipment</b>	<b>Useful Life</b>	<b>Replacement Cost In Current Dollars (RC)</b>	<b>Present Worth Factor (PWF)</b>	<b>Present Value (PV) of Replacement Cost PWF x RC</b>

<b>Base System Present Value of Equipment Replacement Cost Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**4.7. ANNUAL COST – ALTERNATE #**

**a. ENERGY (Excluding Lights & Receptacles)**

<b>ENERGY SOURCE</b>	<b>UNITS OF MEASURE</b>	<b>ANNUAL ENERGY CONSUMPTION</b>	<b>ENERGY COST</b>	<b>DEMAND CHARGE</b>	<b>TOTAL ANNUAL ENERGY COST</b>
1. Electric (Winter)					
2. Electric (Summer)					
3. Gas (Winter)					
4. Gas (Summer)					
5. Steam (Winter)					
6. Steam (Summer)					
7. Fuel Oil					
8. Others					

<b>Alternate System Annual Energy Cost Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**b. SERVICE AND MAINTENANCE COST**

<b>MAJOR EQUIPMENT</b>	<b>ANNUAL SERVICE COST</b>	<b>ANNUAL MAINTENANCE COST</b>	<b>TOTAL SERVICE &amp; MAINTENANCE COST</b>
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1. Chillers			
2. Cooling Towers			
3. Heat Exchangers			
4. Pumps			
5. Air Handling Units			
6. Supply Fans			
7. Return Fans			
8. Exhaust Fans			
9. Terminal Units			
10. Domestic Water Heaters			
11. RO / DI Equipment			
12. Exhaust Fans			
13. ATC			
14. Misc. Equipment			

<b>Alternate System Service and Maintenance Cost Total:</b>
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**4.8. SYSTEM REPLACEMENT COST – ALTERNATE #**

**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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<b>PRESENT VALUE OF EQUIPMENT REPLACEMENT COST</b>				
<b>Major Equipment</b>	<b>Useful Life</b>	<b>Replacement Cost In Current Dollars (RC)</b>	<b>Present Worth Factor (PWF)</b>	<b>Present Value (PV) of Replacement Cost PWF x RC</b>

<b>Alternate System Present Value of Equipment Replacement Cost Total:</b>
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**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**4.9. SUMMARY - LCCA**

**PROJECT:**

**DATE:**

<b>COSTS</b>	<b>BASE SYSTEM</b>	<b>ALTERNATIVE #1</b>	<b>ALTERNATIVE #2</b>
1. Mechanical Installation Initial Cost Total			
2. Incremental Cost For Architectural Components (+ / - over base system)	N / A		
3. Incremental Cost For Structural Components (+ / - over base system)	N / A		
4. Incremental Cost For Electrical Components (+ / - over base system)	N / A		
Total Initial Cost			
Annual Energy Cost			
Annual Service Cost			
Annual Routine Maintenance Cost			
Total Annual Cost			
Present Value (PV) of Total Annual Cost (Total Annual Cost x PW Factor)			
Present Value of Equipment Replacement Cost			
Total Life Cycle Cost (Total Initial Cost + PV of Total Annual Cost + PV of Equipment Replacement Cost)			

**CHAPTER FOUR – LIFE CYCLE COST ANALYSIS**

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**4.9. SUMMARY - LCCA (Continued)**

**PROJECT:**

**DATE:**

<b>COSTS</b>	<b>BASE SYSTEM</b>	<b>ALTERNATIVE #3</b>	<b>ALTERNATIVE #4</b>
1. Mechanical Installation Initial Cost Total			
2. Incremental Cost For Architectural Components (+ / - over base system)	N / A		
3. Incremental Cost For Structural Components (+ / - over base system)	N / A		
4. Incremental Cost For Electrical Components (+ / - over base system)	N / A		
Total Initial Cost			
Annual Energy Cost			
Annual Service Cost			
Annual Routine Maintenance Cost			
Total Annual Cost			
Present Value (PV) of Total Annual Cost (Total Annual Cost x PW Factor)			
Present Value of Equipment Replacement Cost			
Total Life Cycle Cost (Total Initial Cost + PV of Total Annual Cost + PV of Equipment Replacement Cost)			

<b>Recommended System:</b>
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**END OF CHAPTER 4**