GBI’s DOD for Guiding Principles Compliance New Construction

INTRODUCTION TO LIFE-CYCLE COST ANALYSIS (LCCA)

LEARNING OBJECTIVES

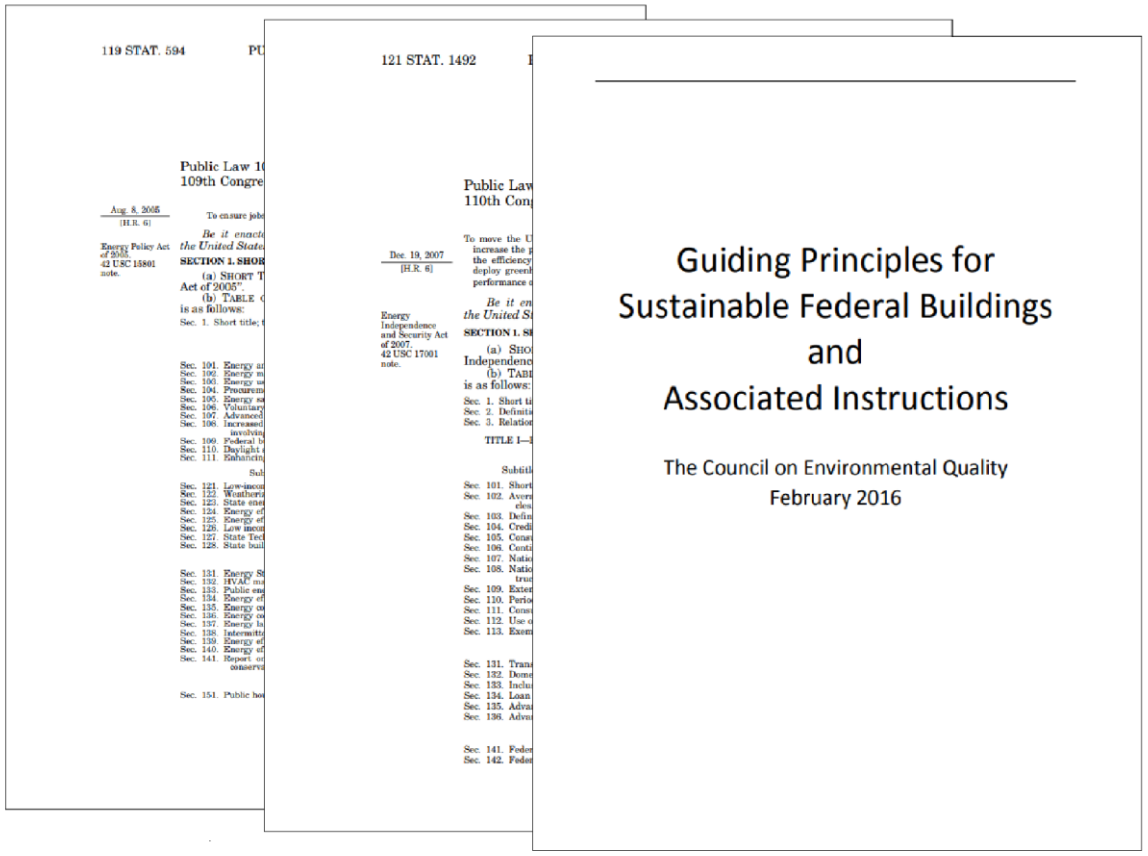
At the end of the course, participants will be able to…

- Describe the background, scope, and purpose of DoD's Life-Cycle Cost Analysis (LCCA) requirement.
- Recall LCCA requirements per GBI's DoD Guiding Principles Compliance for New Construction program.
- Understand methodology and procedures for determining life-cycle cost effective (LCCE) measures for designing new or retrofitting existing Federal buildings.
- Identify key steps to a life-cycle cost analysis, as well as all documentable items.
- Know certain LCCA details such as setting study periods; different discounting methods and inflation estimation methods; how to estimate costs; and how to calculate LCC costs.
- List available resources for preparing LCCA.

Background on UFC 1-200-02

Unified Facilities Criteria (UFC) 1-200-02, "High Performance and Sustainable Buildings Requirements" provides minimum requirements and guidance for compliance with

1. *Energy Policy Act of 2005* (EPAct);
2. *Energy Independence and Security Act of 2007* (EISA);
3. Executive Order 13693 "*Planning for Federal Sustainability in the Next Decade*"*; and
4. Implementation requirements in "*Guiding Principles for Sustainable Federal Buildings and Associated Instructions*" (aka "Guiding Principles")*.

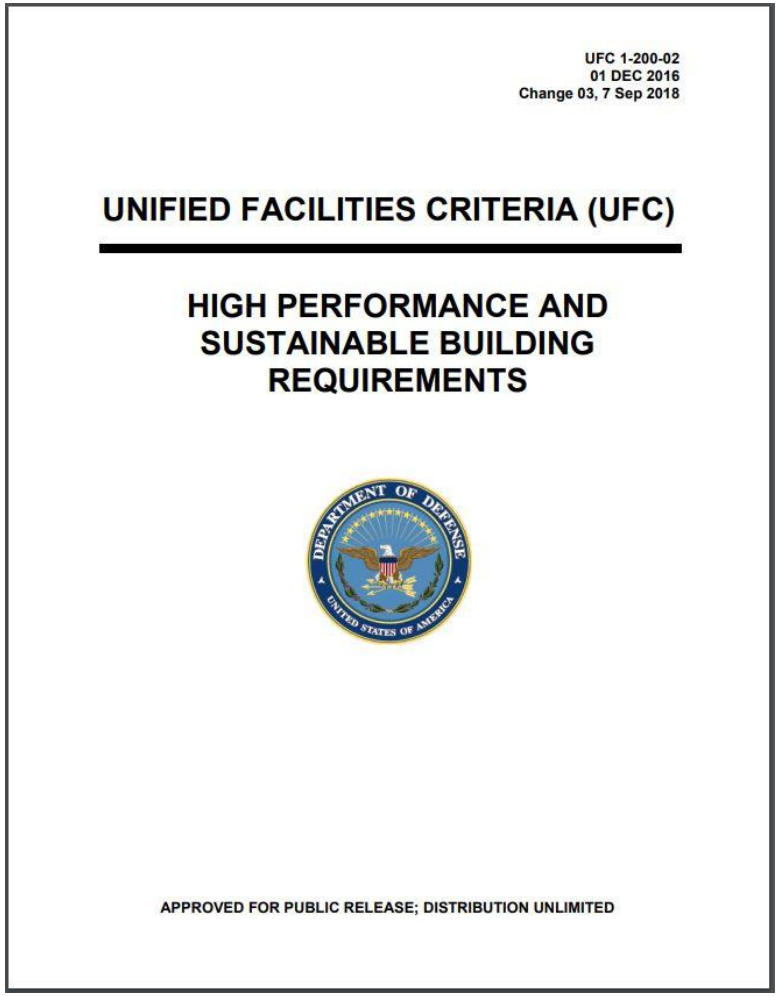


**Executive Order 13834 "Efficient Federal Operations" was released May 17, 2018, which revokes E.O. 13693. Guidance and Instructions for E.O. 13834 remain forthcoming, until which time the existing Guiding Principles remain in effect.*

LCCA REQUIREMENT – SCOPE

UFC 1-200-02 and Life-Cycle Cost Analysis (LCCA)

- UFC 1-200-02 includes Paragraph 1-7 dedicated to establishing requirements for life-cycle cost analysis (LCCA), including LCCA format, LCCA building-level analysis, and LCCA individual component or system alternatives analysis.
- LCCA requirement cites CFR Title 10 Part 436, Subpart A, which establishes methodology and procedures for determining life-cycle cost effective measures for designing new or retrofitting existing Federal buildings.
- Additionally, UFC incorporates ASHRAE 189.1 when appropriate and life-cycle cost effective (LCCE). ASHRAE provisions are referenced as either a means of compliance or as an alternative compliance pathway.


UFC 1-200-02
01 DEC 2016
Change 03, 7 Sep 2018

UNIFIED FACILITIES CRITERIA (UFC)

HIGH PERFORMANCE AND SUSTAINABLE BUILDING REQUIREMENTS

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

*As of December 12, 2018, the most recent UFC 1-200-02 is Change 03 (7 Sep 2018).

LCCA REQUIREMENT – PURPOSE

UFC 1-200-02, Paragraph 1-7 Life-Cycle Cost Analysis (LCCA):

"The purpose of the LCCA methodology…is to identify and compare life-cycle cost-effective (LCCE) building energy and water systems that will in total achieve the energy and water requirements in (UFC 1-200-02)."

Life-Cycle Cost Analysis is <u>required</u> for the following:

1. **Energy consuming systems;**
2. **Renewable energy generating systems;**
3. **When "life-cycle cost-effectiveness" (LCCE) is selected as the reason for any UFC requirement that is "Partially Compliant" or "Not Applicable."**

At discretion of the project team, LCCA methodology may also be used to evaluate multiple options (e.g. building construction type, comparing compliant materials, etc.).

DoD GPC NC LCCA REQUIREMENTS

LCCA Requirements – DoD GPC NC Survey

i.a.1.1: Prepare the LCCA in accordance with CFR Title 10 Part 436, Subpart A and NIST Handbook 135 "*Life-Cycle Costing Manual for the Federal Energy Management Program*."

i.a.1.2: Prepare the LCCA using the Building Life-Cycle Costing (BLCC) program from NIST. Use the implied long-term inflation rate and discount rates identified in the Annual supplement to NIST Handbook 135.

i.a.1.3: LCCAs comparing individual component or system alternatives comply with UFC 1-200-02, Paragraph 1-7.3 (LCCA Individual Component or System Alternatives Analysis).

Required Documentation

- LCCA report from Building Life-Cycle Costing (BLCC) program;
- Narrative describing estimated building life.

References

- UFC 1-200-02, Paragraph 1-7: Life-Cycle Cost Analysis (LCCA)
- 10 CFR Part 436, Subpart A
- NIST Handbook 135, "Life-Cycle Costing Manual for the Federal Energy Management Program"
- Building Life Cycle Cost (BLCC) Programs, NIST
- Annual Supplement to Handbook 135, "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis"
- UFC 3-410-01 "Heating, Ventilating, and Air Conditioning Systems," Appendix E.1 (HVAC System Selection Flow Chart)

Introduction to Life-Cycle Cost Analysis (LCCA)

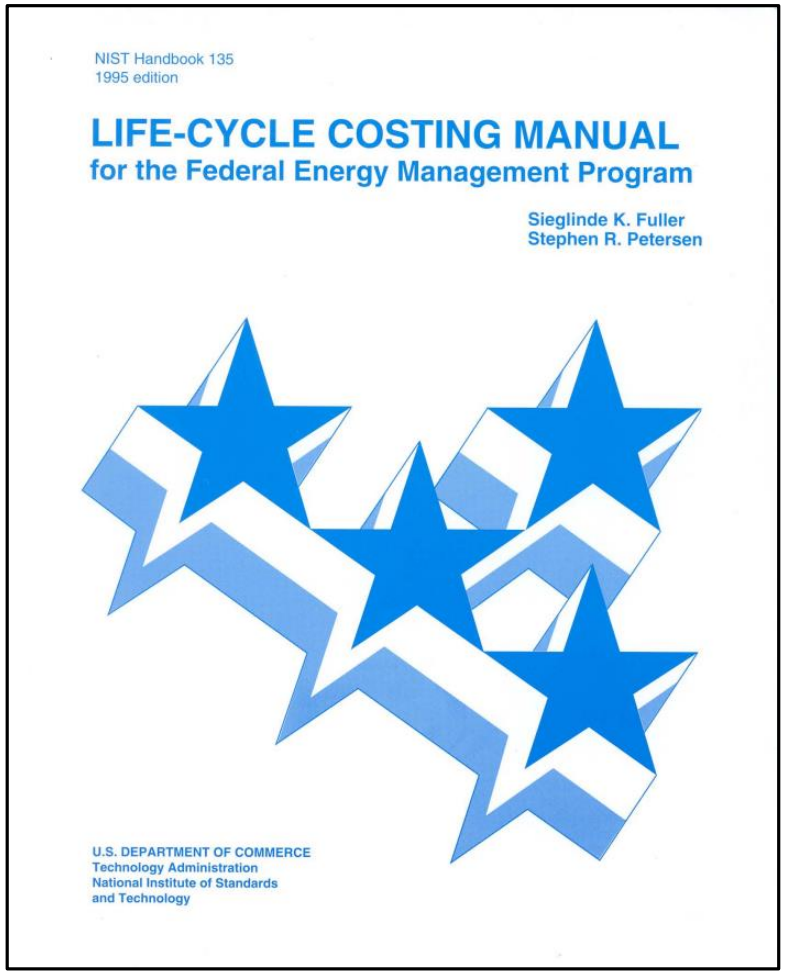
What is Life-Cycle Cost Analysis?

> "*(LCCA) is an economic method of project evaluation in which all costs arising from owning, operating, maintaining, and ultimately disposing of a project are considered to be potentially important to that decision."* [1]

LCCA is appropriate for evaluating building design alternatives that satisfy required level(s) of building performance, but with different initial investment costs and/or OM&R costs (incl. water and energy usage).

Strongly recommend reviewing NIST Handbook 135,

Life-Cycle Costing Manual for the Federal Energy Management Program



[1] NIST Handbook 135 *Life-Cycle Costing Manual for the Federal Energy Management Program*

LCCA – KEY STEPS & EXAMPLES

Life-Cycle Cost Analysis Key Steps[1]

1. Define problem and state objective;
2. Identify feasible alternatives;
3. Establish common assumptions and parameters;
4. Estimate costs and times of occurrence for each alternative;
5. Discount future costs to present value;
6. Compute and compare LCC for each alternative;
7. Compute supplementary measures if required for project prioritization;
8. Assess uncertainty of input data;
9. Take into account effects for which dollar costs or benefits cannot be estimated;
10. Advise on the decision.

LCCA Component Examples

- On-site renewable energy systems (e.g. photovoltaic panels)
- Solar domestic hot water (SDHW)
- HVAC systems
- Lighting systems
- Thermal insulation
- Window systems

[1] NIST Handbook 135 *Life-Cycle Costing Manual for the Federal Energy Management Program*

Getting Started With LCCA

- Preliminary Considerations
- Define Project And Objective
- Identify Feasible Alternatives
- Set Study Period

Preliminary Considerations

- LCCA Timing
- Level of Effort
- Level of Documentation

Identify Feasible Alternatives

- Identifying Constraints
- Identifying Alternatives

Define Project And Objective

- Project Description
- Investment Decision Type
- Energy Conservation Projects

Set Study Period

- Base Date, Service Date, & Planning/Construction Period
- Length of Study Period & Service Period

LCCA Items for Documentation

1. **Project Description**
   - ❑ General info
   - ❑ Type of decision
   - ❑ Constraints
2. **Alternatives**
   - ❑ Technical description
   - ❑ Rational for inclusion
   - ❑ Non-monetary considerations
3. **Common Parameters**
   - ❑ Study period
   - ❑ Base date
   - ❑ Service date
   - ❑ Discount rate
   - ❑ Inflation
   - ❑ Operational assumptions
   - ❑ Energy and water price schedules
4. **Cost Data and Related Factors**
   - ❑ Investment-related costs
   - ❑ Operational costs
   - ❑ Energy usage (by type)
   - ❑ Water usage and disposal
   - ❑ Timing of costs
   - ❑ Cost data sources
   - ❑ Uncertainty assessment
5. **Computations**
   - ❑ Discounting
   - ❑ Life-cycle cost computations
   - ❑ Computations of supplementary measures
6. **Interpretation**
   - ❑ Results of LCC comparisons
   - ❑ Uncertainty assessment
   - ❑ Sensitivity analysis results
6. **Non-monetary Savings or Costs**
   - ❑ Description of intangibles
7. **Other Considerations**
   - ❑ Narrative
8. **Recommendations**
   - ❑ Project team's recommendation

Setting the Study Period – Base Date, Service Date, and Planning/Construction Period

- **The same study period must be used in the LCCA for each project alternative**

Base Date

- ✓ Typically first day of the study period for the project – normally date LCCA is performed.
- ✓ Base date defines time reference for constant dollars.
- ✓ Base date serves as reference date for estimating all future costs.

Service Date

- ✓ Date which project is expected to be implemented.
- ✓ O&M (incl. energy- and water-related costs) are typically incurred after this date.
- ✓ New buildings sometimes refer to this as the **occupancy date**.

Planning/Construction (P/C) Period

- ✓ When delay between beginning of study period and service date.
- ✓ Intervening time is called **planning/construction (P/C) period.**

Service & Study Period

- ✓ Maximum **service period** is **40 years**.[1]
- ✓ Maximum **study period** = **40 years + P/C period** (if any).

[1] UFC 1-200-02 (01 DEC 2016), Change 03 (7 SEP 2018)

LCCA – DISCOUNT RATES & INFLATION

Discount Rates for LCCA

- Project-related costs that occur at different points in time must be discounted to their **present value** (as of the base date).
- Discount rates used for energy- and water-related investments in federal buildings is established each year by DOE (FEMP). Non-energy or water investments by OMB (Circular A-94).
- *Once FEMP or OMB discount rate has been chosen, same rate must be used for all cost components of that system.*

Two Discounting Methods

- ✓ Method for discounting **one-time amounts.**
- ✓ Method for discounting a **series of annually recurring amounts**.

Two Methods for Estimating Inflation

- **Method 1**: Estimate future costs and savings in **constant** dollars, and discount with a "**real**" discount rate.
  - *Real discount rate excludes rate of inflation.*
- **Method** 2: Estimate future costs and savings in **current** dollars, and discount with a "**nominal**" discount rate.
  - *Nominal discount rate includes rate of inflation.*
- ***It is generally easier to utilize <u>constant</u> dollars.***

Estimating Costs for LCCA

- Costs are **relevant** when they change between alternatives.

Cost Categories

1. Investment Costs vs. Operational Costs

- All acquisition costs (incl. costs related to planning, design, purchase, and construction) are **investment-related**.
- Operating, maintenance, and repair (OM&R) costs (incl. energy and water) are **operational costs**; and are normally paid from annual operating budget.

2. Initial Investment Costs vs. Future Costs

- Costs incurred in planning, design, construction, &/or acquisition phase of a project are **initial investment costs**, and usually occur before a building is occupied or system is installed.

3. Single Costs vs. Annually Recurring Costs

Single costs are one-time costs that occur at non-annual intervals one or more times during the study period.

- Includes initial investment costs, replacement costs, residual values, maintenance costs (1+ yr intervals), and repair costs.

Annually recurring costs occur regularly every year during the service period in approx. the same amount.

- Includes energy costs, water costs, and routine annual maintenance costs.

FEMP LCCA Summary of Criteria[1] *(example)*

METHODOLOGY

Evaluation Method	Life-cycle cost analysis
Discounting Approach	*Present value (PV)* at the base date
Cost Measurement Basis	*Constant dollars* as of the base date
Cash-Flow Convention	End-of-year cash flows or when incurred
Evaluation Criteria	Lowest life-cycle cost; highest net savings; SIR > 1 for ranking; AIRR > FEMP discount rate for ranking
Uncertainty Assessment	Sensitivity analysis

DOCUMENTATION

Basic Requirement	Written record for every economic analysis
Format	BLCC computer printouts; worksheets; additional records

DATA AND PARAMETERS

Base Date	Date of study / beginning of study period
Service Date	Beginning of study period when building is occupied or system taken into service
Study Period	P/C period (if any) added to max 25-year service period
Discount Rate	Real rate determined annually by DOE
Energy Prices	Local energy prices at the building site used to calculate annual energy costs for each energy type
Cost Escalation	DOE-projected differential energy price changes (incl. in FEMP UPV discount factors for each energy type) 0% differential price change (unless justified by reliable projections)

[1] NIST Handbook 135, Table 5-1 *Summary of Criteria for FEMP LCC Analyses*

Calculating Life-Cycle Costs

There are two general formulas for calculating life-cycle costs:

1: **General Formula for LCC** 2: **LCC Formula for Building-Related Projects**

General Formula for LCC

The following is general formula for the LCC present-value model:

$$LCC = \sum_{t=0}^{N} \frac{C_t}{(1 + d)^t}$$

LCC = Total LCC in present-value dollars of a given alternative;
C_t = Sum of all relevant costs, including initial and future costs, less any positive cash flows, occurring in year *t*;
N = Number of years in the study period; and
d = Discount rate used to adjust cash flows to present value.

- General LCC formula requires that all costs be identified **by year** and **by amount**.

LCC Formula for Building-Related Projects

A simplified LCC formula can be used to compute the LCC of energy and water projects in buildings as follows:

LCC = I + Repl - Res + E + W + OM&R

LCC = Total LCC in present-value dollars of a given alternative
I = Present-value investment costs;
Repl = Present-value capital replacement costs;
Res = Present-value residual value (resale value, scrap value, salvage value) less disposal costs;
E = Present-value energy costs;
W = Present-value water costs;
OM&R = Present-value non-fuel operating, maintenance, and repair costs

LCCE EXAMPLES

NIST BLCC 5.3-16: Comparative Analysis

Consistent with Federal Life Cycle Cost Methodology and Procedures, 10 CFR, Part 436, Subpart A

Base Case: Baseline No PV

Alternative: PV System 200kW

General Information

File Name:	C:\Users\skimsey\projects\ LCCA PV1T.xml
Date of Study:	Wed Aug 02 07:30:28 EDT 2017
Project Name:	PV SOLAR LCCA
Project Location:	Texas
Analysis Type:	MILCON Analysis, Energy Project
Analyst:	SK
Base Date:	January 1, 2019
Beneficial Occupancy Date:	January 1, 2019
Study Period:	40 years 0 months(January 1, 2019 through December 31, 2058)
Discount Rate:	3%
Discounting Convention:	End-of-Year

Energy Savings Summary

Energy Savings Summary (in stated units)

Energy Type	Average Annual Consumption Base Case	Alternative	Savings	Life-Cycle Savings
Electricity	5,291,128.0 kWh	5,016,387.0 kWh	274,741.0 kWh	10,988,887.8 kWh

Energy Savings Summary (in MBtu)

Energy Type	Average Annual Consumption Base Case	Alternative	Savings	Life-Cycle Savings
Electricity	18,054.1 MBtu	17,116.6 MBtu	937.5 MBtu	37,495.6 MBtu

Comparison of Present-Value Costs

PV Life-Cycle Cost

	Base Case	Alternative	Savings from Alternative
Initial Investment Costs:			
Capital Requirements as of Base Date	$0	$852,123	-$852,123
Future Costs:			
Energy Consumption Costs	$8,497,794	$8,056,548	$441,247
Energy Demand Charges	$0	$0	$0
Energy Utility Rebates	$0	$0	$0
Water Costs	$0	$0	$0
Routine Recurring and Non-Recurring OM&R Costs	$0	$115,582	-$115,582
Major Repair and Replacements	$0	$110,735	-$110,735
Residual Value at End of Study Period	$0	$0	$0
Subtotal (for Future Cost Items)	$8,497,794	$8,282,865	$214,929
Total PV Life-Cycle Cost	$8,497,794	$9,134,988	-$637,194

Net Savings from Alternative Compared with Base Case

PV of Non-Investment Savings	$325,664
- Increased Total Investment	$962,858
Net Savings	-$637,194

Savings-to-Investment Ratio (SIR)

SIR = 0.34

SIR is lower than 1.0; project alternative is not cost effective.

Adjusted Internal Rate of Return

AIRR = 0.25%

AIRR is lower than your discount rate; project alternative is not cost effective.

Payback Period

Estimated Years to Payback (from beginning of Beneficial Occupancy Period)

Simple Payback never reached during study period.

Discounted Payback never reached during study period.

Emissions Reduction Summary

Energy Type	Average Annual Emissions Base Case	Alternative	Reduction	Life-Cycle Reduction
Electricity				
CO2	3,491,081.81 kg	4,671,495.05 kg	-1,180,413.23 kg	-47,213,297.46 kg
SO2	7,714.99 kg	6,158.54 kg	1,556.45 kg	62,253.92 kg
NOx	2,533.57 kg	7,115.73 kg	-4,582.16 kg	-183,274.05 kg
Total:				
CO2	3,491,081.81 kg	4,671,495.05 kg	-1,180,413.23 kg	-47,213,297.46 kg
SO2	7,714.99 kg	6,158.54 kg	1,556.45 kg	62,253.92 kg
NOx	2,533.57 kg	7,115.73 kg	-4,582.16 kg	-183,274.05 kg

LCCE EXAMPLES

Baseline Building Electrical Useage FOR BLCC			
Building EMD		1870	kVA
Building EMD in kW (assume 0.85PF)		1590	kW
hours/yr		8760	Hours
annual load factor from UFC 3-501-01		0.38	percent
kWH with UFC load		5,291,128	kWH
energy rate	$	0.061	
annual energy cost	$	322,759	

PV Building Electrical Useage FOR BLCC			
Building EMD		1870	kVA
Building EMD in kW (assume 0.85PF)		1590	kW
hours/yr		8760	Hours
annual load factor from UFC 3-501-01		0.38	percent
kWH with UFC load		5,291,128	kWH
kWH from 200kW PV system (PVWatts)		(274,741)	kWH
resultant energy useage		5,016,387	kWH
energy rate	$	0.061	
annual energy cost	$	306,000	

Readouts from DOE LIFE-CYCLE COST ANALYSIS (BLCC5 Program), NIST

SF:	267,513
TYPE:	MILCON Analysis Energy Project
PROJECT NAME:	PHOTOVOLTAIC OPTION
LOCATION:	TEXAS
ANALYST:	SK
DISCOUNTING:	END OF YEAR
DOLLAR ANALYSIS:	CONSTANT
REAL DISCOUNT RATE:	3.0%
BASE MONTH:	JANUARY
BASE YEAR:	2019
SERVICE DATE:	BASE DATE
STUDY LENGTH (YRS):	40
BASELINE ALTERNATE:	**BASELINE BUILDING - NO PV**
ENERGY TYPE:	ELECTRICITY
BASE YR ANNUAL CONSUMPTION (KWH):	5,291,128
UTILITY RATE:	COMMERCIAL
PRICE PER KWH:	$0.0750
BASE YR ANNUAL CONSUMPTION (THERMS):	0
UTILITY RATE:	COMMERCIAL
PRICE PER THERM:	$0.4610
DOE PRICE ESCALATION RATES:	PER BLCC5
INVESTMENT COST:	$0.00
EXPECT LIFE(YRS):	40
ANNUAL O&M NAME:	ANNUAL O&M
ANNUAL O&M COST/YR:	$0.00
20 YR ITEMS	$0.00
ALTERNATE 1:	**PROPOSED BUILDING - PV OPTION 200 kW**
ENERGY TYPE:	ELECTRICITY
BASE YR ANNUAL CONSUMPTION (KWH):	5,016,387
UTILITY RATE:	COMMERCIAL
PRICE PER KWH:	$0.0750
BASE YR ANNUAL CONSUMPTION (THERMS):	0
UTILITY RATE:	COMMERCIAL
PRICE PER THERM:	$0.4610
DOE PRICE ESCALATION RATES:	PER BLCC5
INVESTMENT COST:	$852,123.00
EXPECT LIFE(YRS):	40
ANNUAL O&M NAME:	ANNUAL O&M
ANNUAL O&M COST/YR:	$5,000.00
20 YR ITEMS	$200,000.00

LCCE EXAMPLES

ASHRAE 189.1 7.2 ON-SITE RENEWABLE ENERGY SYSTEMS

item	units	data	item	cost	ext cost	lab/unit	ext lab	lab/hour	ext lab cost	subtotal
Roof Area	SF	86450								
Roof Area	SM	8031								
Required Annual Power Production (32kWh/SM)	kWh	257007								
PV system size needed (from PVWatts)	kW - DC	200kW - DC								
kWH from 200kW PV system (PVWatts)	kWH	274,741								
PV System Costs										
use 720 modules rated for 290W ea	watts - DC	208,800								
number of PV modules/string	ea	720	Phono Solar PS290P-24/T	$ 415	$ 298,800	1.00	720.00	$ 56.00	$ 40,320	**$ 339,120**
number of 50kW inverters	ea	4	Power One PVI Central 50-US-480v	$ 39,910	$ 159,640	40.00	160.00	$ 56.00	$ 8,960	**$ 168,600**
number of PV modules/string	ea	10								
number of strings per 50kW inverter	ea	18								
misc install, mounts etc	ea	720	misc	$ 150	$ 108,000	1.50	1,080.00	$ 56.00	$ 60,480	**$ 168,480**
misc power for feeders, tie	lot	1	misc	$ 15,000	$ 15,000	80.00	80.00	$ 56.00	$ 4,480	**$ 19,480**
subtotal			http://pvdepot.com/		$ 581,440				$ 114,240	**$ 695,680**
OH	10%									**$ 69,568**
subtotal										**$ 765,248**
P	5%									**$ 38,262**
subtotal										**$ 803,510**
bond	1%									**$ 8,035**
subtotal										**$ 811,546**
conting	5%									**$ 40,577**
total										**$ 852,123**

COST **$ 852,123** dollars OUTPUT **200,000** watts COST PER W **4.26** $/watt

LCCA DIFFERENCES BETWEEN 3RD PARTY SYSTEM

Differences w/Other 3rd Party Systems

- LEED v4.1 BD+C (draft) does not specify "LCCA" or "life-cycle cost," although it may be addressed via IN Credit (innovation).

- GBCI's Guiding Principles Assessment program requires LCCA narrative from…
  1. Lead Project Architect,
  2. Lead Project Mechanical Engineer, AND
  3. Lead Project Electrical Engineer.

  - Still requires use of NIST Handbook 135.

GBI's DoD GPC for New Construction

- ✓ **Program developed w/feedback from DoD**
- ✓ **Built to mirror DoD's requirements exactly**
- ✓ **<u>No additional requirements</u>**

LCCA Resources for Federal Agencies

- Building Life Cycle Cost (BLCC) Programs, The National Institute of Standards and Technology (NIST): https://www.energy.gov/eere/femp/building-life-cycle-cost-programs
- LIFE-CYCLE COSTING MANUAL for the Federal Energy Management Program, NIST Handbook 135: https://www.nist.gov/publications/life-cycle-costing-manual-federal-energy-management-program-nist-handbook-135-1995
- UNIFIED FACILITIES CRITERIA (UFC), Whole Building Design Guide: http://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc
- Annual Supplement to Handbook 135, "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis:" http://www.nist.gov
- Green Building Initiative's DoD Guiding Principles Compliance Program Resources: https://www.thegbi.org/guiding-principles-compliance-certification/new-construction/

Questions?

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