National Institute of Standards and Technology
U.S. Department of Commerce

NIST Handbook 135 - 2020 Revision: Life Cycle Costing Manual for the Federal Energy Management Program

Joshua Kneifel, PhD
Economist
Applied Economics Office
Engineering Laboratory

Building Life Cycle Cost Project (FEMP)

Goal:

Provide computational support (methodology, data, software) for the analysis of capital investments in buildings based on current statutes and data

Resources:

1. **Handbook 135 - Life Cycle Costing Manual for FEMP**
2. **Annual Supplement to NIST HB 135 - Energy Price Indices and Discount Factors for Life Cycle Cost Analysis**
3. **Energy Escalation Rate Calculator (EERC) software**
4. **Building Life Cycle Cost (BLCC) software**

FY2020 Activities

EERC:
EXE transitioning to Web Interface in FY2021

BLCC:
EXE (discussion of transitioning to Web Interface)

Annual Supplement:
Updated each year with new EIA projections

Handbook 135:
Revised Sept. 2020

Why revise Handbook 135?

- **Last published in 1995**
  - Yes, 25 years ago!
- **Added historical context on legislation and E.O.s**
  - EO 13123 (1999), EPACT (2005), EO 13423 (2007), EO13693 (2015)
  - Most recent is EO 13834 (2018)
  - What’s required versus recommended / rule of thumb?
- **Underlying LCC methodology remains unchanged**
  - ASTM Building Economics Standards, 10 CFR 436
- **Entire document revised and reorganized with relevant information and broadened scope**
- **Now a “living” document**

Handbook 135 Revision

NIST

Key Changes Include…

- **The maximum study period was extended from 25 years to 40 years (2005)**
- **Options available for estimating residual value**
- **Greater discussion of difficult-to-value and/or non-monetary benefits and costs and uncertainty**
- **Greater focus on considerations for whole building/facility/campus evaluation and “bundling”**
- **More detail on energy savings performance contracts (ESPCs)**
- **List of resources for additional details on specific topics (140+ references)**
- **New examples explaining how to evaluate new project goals**
    - Many actual project case studies on deep energy retrofits, sustainability, and resilience

Handbook 135 Revision

Broadening of scope

- **EO 13834 - "agencies shall meet such statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment…each agency shall prioritize actions that reduce waste, cut costs, enhance the resilience of Federal infrastructure and operations, and enable more effective accomplishment of its mission."**
- **Optimize Overall Life Cycle Performance**
  - Improve efficiency, resource use, human health, environmental impacts, sustainability, resilience, and productivity in a cost-effective manner

Project Scope and Goals / Constraints Examples

NIST

Scope

- Building System
- Building
- Facility
- Campus
- Community

Goals or Constraints

- LCC Savings
- Energy Reduction
- Water Reduction
- Renewable Energy Target
- Resilience Performance
- Embodied Energy/Carbon Reduction Targets

Additional (Relevant) Costs to Consider

Previous Analysis

- **Initial Costs**
- **Maintenance & Repair Costs**
- **Operational Energy and Water Costs**
- **Replacement Costs**
- **Residual Value**
  - Linear Depreciation

New Analysis Could Add

- **Residual Value**
  - Alternative methods
- **Value of High Performance**
  - Premium resale/rents
  - Productivity
  - Space Utilization
  - Risk Mitigation
- **Non-Monetary Benefits**
  - Emissions reductions
  - Human Health

New Examples

Deep Energy Retrofit

- **Bundling**
  - Energy Efficiency
  - Water Conservation
  - Smart Controls
  - Renewable Energy

On-site Renewable Energy

- **Different Baseline Cases**
- **ESPC Option**

Sustainability

- **Direct Costs**
- **Externalities**
  - Environmental Impacts

Resilience

- **Bundling**
  - Energy Reductions
  - On-site generation and storage
- **Resilience as a Constraint**
- **Optimize over Resilience and LCC**

Example: Energy Resilience using REopt

NIST

Project Scope

- **Evaluate economic & resiliency impacts of photovoltaics & storage on NYC fire station**
- **Optimization relative to BAU**
- **Short (2 hr) and Long (22 hr) Outage/Yr Scenarios**
- **LCC with and without resilience related cost savings**
- **Source: (Anderson et al., 2016)**

Cost Data

Category	Solar PV	Storage	Diesel*
Installation Cost	$3.88/W_{DC}$	$520/kWh, $1000/W	$1.50/W
NYSERDA Rebate	$0.80/kW		
Replacement Cost		$200/kWh, $200/kW	
O&M Cost	$20/kW/yr		$0.02/kWh
Fuel Cost			$2.52/gal
*Includes 250 gal storage capacity			

Example: Energy Resilience using REopt

Grid Outage Cost

$917.43/hr using DOE Interruption Cost Estimator

Based on Con Edison historical values from

- **SAIFI (System Average Interruption Frequency Index or average number of interruptions to a customer)**
- **SAIDI (System Average Interruption Duration Index or average outage duration across all customers)**
- **CAIDI (Customer Average Interruption Duration Index or average outage duration per utility customer affected)**

Alternatives to BAU Baseline

1. **Solar photovoltaics + storage sized for economic savings; no resilience requirement imposed**
2. **Resilient solar photovoltaics + storage sized to meet resilience needs**
3. **Resilient solar photovoltaics + storage and a generator (hybrid system) sized to meet resilience needs**
4. **Generator sized to meet resilience needs**

Example: Energy Resilience using REopt

NIST

Scenario		Components			Costs and Benefits		LCC
Alternative	Outage Duration	PV (kW)	Battery (kWh/kW)	Diesel (kW)	Capital Costs	Resilience Value	NPV
1 PV + Battery (Economics)	Short	10	43/16	-	$69 413	$0	$22 365
	Short	10	43/16	-	$69 413	$31 767	$54 132
	Long*	-	-	-	-	-	-
2 PV + Battery (Resilience)	Short	0	136/41	-	$111 930	$0	-$12 070
	Short	10	131/40	-	$138 828	$22 219	$10 149
	Long	10	613/40	-	$389 706	$0	-$256 158
	Long	10	613/40	-	$389 706	$349 276	$93 118
3 PV + Battery + Diesel (Resilience)	Short	4	73/18	23	$102 328	$0	$0
	Short	10	74/18	22	$120 505	$25 384	$25 384
	Long	1	61/17	26	$89 381	$0	-$1679
	Long	10	66/20	24	$121 164	$346 527	$344 848
4 Diesel (Resilience)	Short	-	-	41	$61 620	$0	-$51 731
	Short	-	-	41	$61 620	$31 767	-$19 964
	Long	-	-	41	$61 620	$0	-$52 896
	Long	-	-	41	$61 620	$349 276	$296 380

*** Alternative 1 did not include the 22-hour outrage scenario.**

Example: Energy Resilience using REopt

Summary

Alt 1 is preferred when no resilience value is included

Alt 3 is the preferred option regardless of the scenario relative to Alt 2 or Alt 4

- lower costs of diesel generators and operation than battery storage (2016)

Scenario	2 hr outage/yr; no resilience value	22 hr outage/yr; no resilience value	2 hr outage/yr; resilience value	22 hr outage/yr; resilience value
Alternative 1	**$22 365**	-	**$54 132**	-
Alternative 2	-$12 070	-$256 158	$10 149	$93 118
Alternative 3	$0	-$1679	$25 384	**$344 848**
Alternative 4	-$51 713	-$19 964	-$52 896	$296 380

Summary

NIST

- **Handbook 135 has been revised**
  - Life cycle cost methodology for capital projects
  - Provide relevant information and examples
  - Broaden scope as defined in legislation and E.O.s
- **Deep Energy Retrofits and Sustainability**
  - Bundling of energy efficiency, water conservation, and renewable energy measures
  - Consideration to additional types of costs/savings
- **Resilience**
  - Resilience Requirements as a Constraint
  - Resilience Benefits as a decrease in life cycle costs

For further information…

NIST

Joshua Kneifel, PhD
joshua.kneifel@nist.gov

NIST EL Applied Economics Office
http://www.nist.gov/el/economics/

FEMP Building Life Cycle Cost Program
https://www.energy.gov/eere/femp/building-life-cycle-cost-programs

Anderson et al., (2016)
Anderson, K., Burman, K., Simpkins, T., Helson, E., Lisell, L., & Case, T. (2016). *New York Solar Smart DG Hub-Resilient Solar Project: Economic and Resiliency Impact of PV and Storage on New York Critical Infrastructure*. Retrieved from https://www.nrel.gov/docs/fy16osti/66617.pdf:

Savena et al., (2017)
Savena, M., Judson, N., & Pina, A. (2017). The Cost of Energy Security and Resilience. In. https://www.energy.gov/sites/prod/files/2017/11/f46/25-fupwgfall2017_savena_judson_pina_rev.pdf: 2017 Fall Federal Utility Partnership Working Group Seminar