ASHRAE Energy Audit Programs

Presented by

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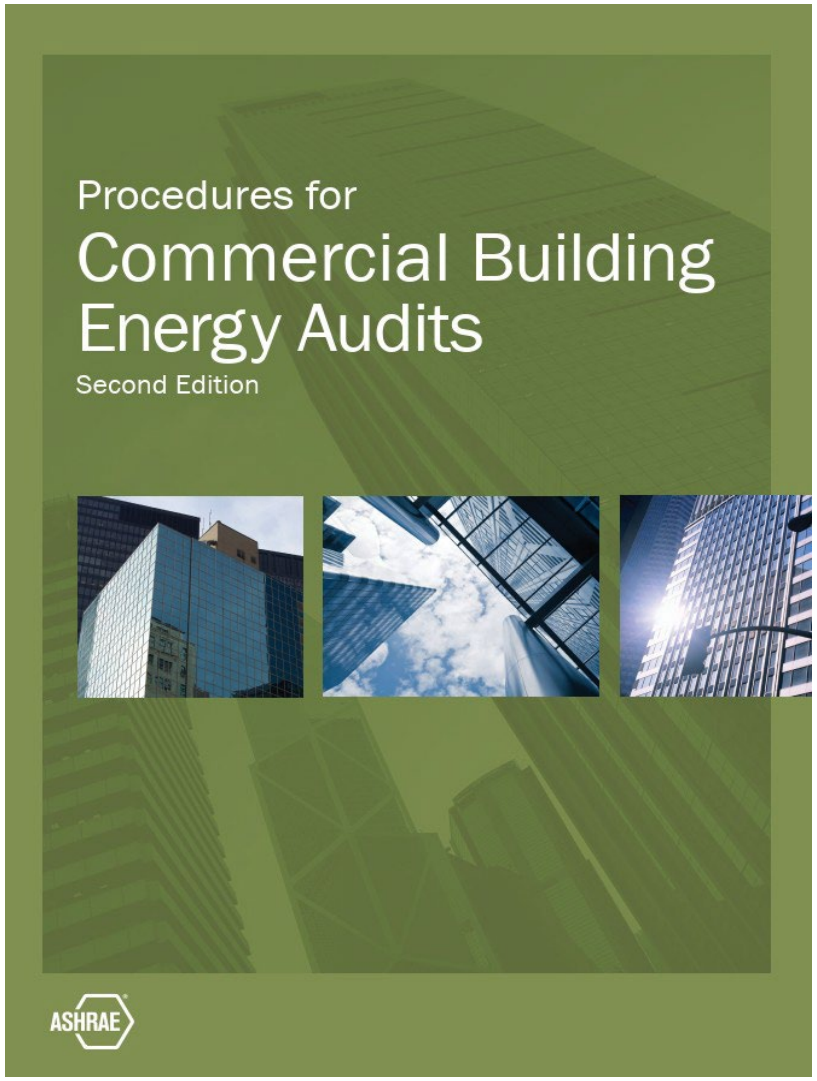
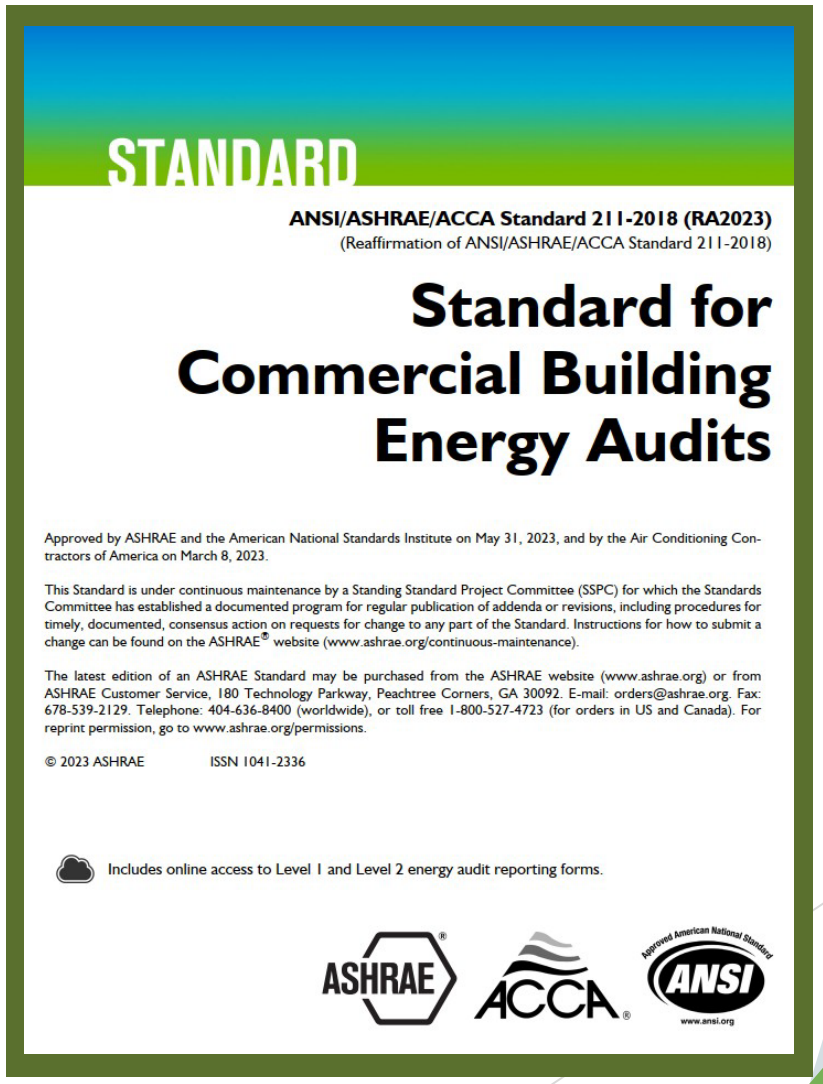
ASHRAE Resources

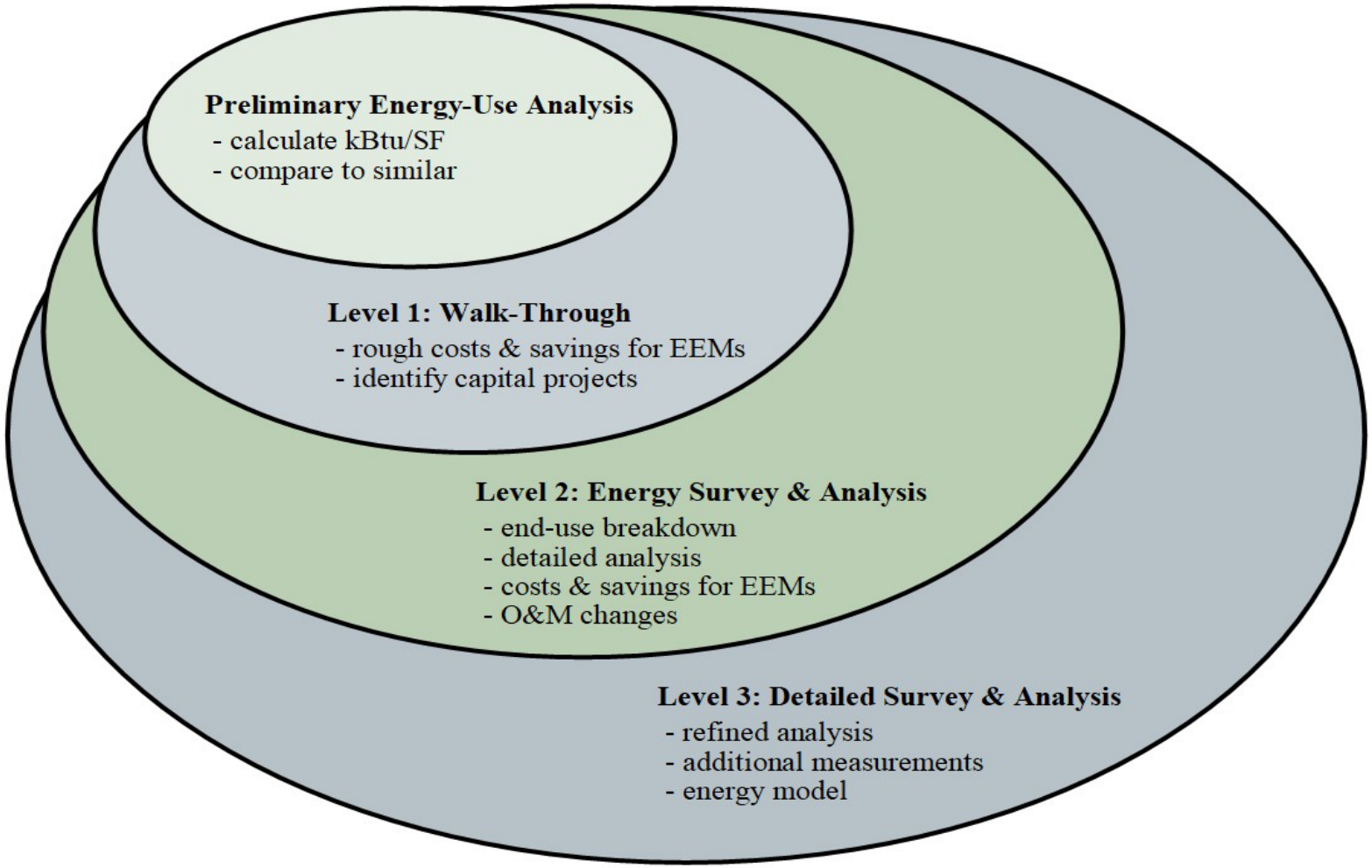




What is an energy audit?

- a systematic process to evaluate energy consumption of a facility or system identifying energy-saving opportunities, inefficiencies, and recommendations to reduce energy waste & address occupant concerns.

3 Levels of ASHRAE Energy Audits



Source: ASHRAE (Procedures for Commercial Building Energy Audits, 2nd edition)

Energy Audit Process Tasks

Energy Audit Process Tasks	Level		
	1	2	3
Conduct preliminary energy-use analysis	X	X	X
Conduct walk-through survey	X	X	X
Identify low-cost/no-cost recommendations	X	X	X
Identify potential capital improvements	X	X	X
Review mechanical/electrical design & condition and O&M practices		X	X
Measure key parameters		X	X
Analyze capital measures (savings & costs, including interactions)		X	X
Meet with owner/operators to review recommendations		X	X
Conduct additional testing/monitoring			X
Perform detailed system modeling			X
Provide schematic layouts for recommendations			X

Source: ASHRAE (Procedures for Commercial Building Energy Audits, 2nd edition)

Energy Audit Report Tasks

Energy Audit Report Tasks	Level		
	1	2	3
Summarize utility data & compare EUI to EUIs of similar sites	X	X	X
Estimate savings if EUI were to meet target	X	X	X
Estimate low-cost/no-cost savings		X	X
Calculate detailed end-use breakdown		X	X
Estimate capital project costs & savings		X	X
Complete building description & equipment inventory		X	X
Document general description of considered measures		X	X
Recommend measurement & verification (M&V) method		X	X
Perform financial analysis of recommended measures		X	X
Write detailed descriptions of recommended measures			X
Compile detailed measure cost estimates			X

Source: ASHRAE (Procedures for Commercial Building Energy Audits, 2nd edition)

Why do a Level 1 audit?

- Most basic level of audit designed to provide a starting point for making changers or for further in-depth auditing
- High-level view of building operation & energy usage
- Identify glaring areas of energy inefficiency
- Report detailing no- to low-cost changes as well as capital improvements earmarked for further study
- Gives stakeholders a picture of where building currently stands, how it compares to similar buildings, what areas need further investigation or improvement

Why do a Level 2 audit?

- Builds on Level 1 audit, takes data collection & final reporting a step further
- Breaks down energy consumption by end-use, helping identify areas with greatest opportunities for improved efficiency
- Analyzes utility rates to see if a lower rate may be secured
- Data to justify implementation of a project without need for additional data collection & analysis
- Utilize whole building functioning to identify projects to provide greatest energy reduction at best return on investment

Why do a Level 3 audit?

- Builds on Level 2 audit, offering a more in-depth engineering analysis of potential changes
- Field data is collected & analyzed more intensely for areas of improvement & potential costs
- Provide computerized energy model
- Utility data is supplemented by submetering of key systems & monitoring of those systems' individual characteristics
- Offers a more complete baseline, allowing comparison of energy & operating savings both pre- & post-implementation
- Used when more data is needed before making investment on capital cost projects

Key Elements of Audit Process

Build Team	Assemble right participants & establish clear responsibilities
Preliminary Energy Use Analysis	Analysis of two or more years of utility consumption & cost
Site Visit Procedures	Activities to prepare for on-site audit
Measurement	Collect data to quantify operating parameters & performance
Analysis	Describe & analyze energy using systems of building
Energy Efficiency Measure Types	Classify & recommend EEMs; bundle together synergistic measures
Economic Evaluation	Evaluate capital costs & life cycle costs
Develop Audit Report	Provide owner info to determine which measures to implement
Presentation	Meet with owner, review report, explain results, plan next steps
Implement Measures	Implement chosen EEMs; include M&V & continuous Cx

Source: ASHRAE (Procedures for Commercial Building Energy Audits, 2nd edition)

PCBEA Form Categories

General Information	Basic Site Info, Capital Improvement Plan, O&M Costs, Space Function Summary
Geometry & Envelope	Sketches, Opaque Surfaces, Fenestration, Opaque Doors
Schedules	Occupancy, Lighting, Plug Loads, HVAC, Peak Occupancy
Lighting	Interior, Exterior, Plug Loads, Thermal Zoning
Domestic Hot Water	Equipment, Fixtures & Use
HVAC & Controls	Boilers, Chillers, Cooling Towers & Fluid Coolers, Pumps & Piping Systems, Air-Handling System Equipment & Controls, Air System Terminal Units, Zone Heating Equipment, Fan-Coil Units, Exhaust/Return Fans, Packaged Units: DX & Heat Pumps, Condensing Unit & Condensers
Specialty Load	Swimming Pools, Kitchen Equipment, Lab Equipment, Refrigeration Equipment, Data Centers/IT Rooms, Process Equipment

Source: ASHRAE (Procedures for Commercial Building Energy Audits, 2nd edition)

PCBEA Form Samples

1.0 BASIC SITE INFORMATION
PCBEA Sample Forms

Project Name

Client Name

Site Address

City/State | **Year**

Building Type and/or Functions | **Gross Area**

Lease Type | **No. Stories**

Key Contacts

Name and Position	Phone/Email

Economic Criteria for Energy Projects

Previous Audit or Engineering Study Availability

Notes

NOTE: Request utility/fuel bills for two- to three-year period.

1.10 CAPITAL IMPROVEMENT PLAN
PCBEA Sample Forms

To calculate the marginal capital costs of efficiency measures, it is necessary to document any plans for capital improvement. Since a whole-building retrofit may alter the course of almost any type of planned improvements, it is important to document them all (several types are indicated below). Print multiple sheets as necessary.

Type	Description of planned replacement, renewal, or system expansion	Planned	Cost	Citation
HVAC				

Type	Description of planned replacement, renewal, or system expansion	Planned	Cost	Citation
Envelope				

Type	Description of planned replacement, renewal, or system expansion	Planned	Cost	Pump hp
Electrical				

Type	Description of planned replacement, renewal, or system expansion	Planned	Cost	Citation
Plumbing				

Type	Description of planned replacement, renewal, or system expansion	Planned	Cost	Citation
Aesthetic				

Type	Description of planned replacement, renewal, or system expansion	Planned	Cost	Citation
Aesthetic				

Type	Description of planned replacement, renewal, or system expansion	Planned	Cost	Citation
Other				

TOTAL $ -

Source: ASHRAE (Procedures for Commercial Building Energy Audits, 2nd edition)

PCBEA Form Samples

1.51 INTERIOR LIGHTING
PCBEA Sample Forms

Use this sheet to describe the electric lighting plan for each zone in your building. Print multiple sheets as necessary.

Zone Name/Description			Area (ft^2):	
Fixture				
Fixture Type	Area Task Exit Track Display Other:		No. of Fixtures:	
Mounting	Recessed Suspended Surface Mount Other:		No. of Lamps/Fixtures:	
Lamp Type	Fluorescent Tube Length:	Diameter: T12 T8 T5 Other:	Wattage of Lamps:	
	Circle one: CFL Incandescent Halogen LED HID Other:			
Ballast	Circle one: Magnetic Electronic	No. of Ballasts/Fixtures:	BF:	Watts:
Control Type (circle one)	Manual Switch Bi-Level Switch Time Clock Daylight Sensor Occupancy Sensor Dimming Step Dimming None Other:		Total Watts:	
Work Plane Height:	*Horizontal Illuminance:*	*Vertical Illuminance Sensitivity:*	*Lamp Color Temp:*	

Fixture				
Fixture Type	Area Task Exit Track Display Other:		No. of Fixtures:	
Mounting	Recessed Suspended Surface Mount Other:		No. of Lamps/Fixtures:	
Lamp Type	Fluorescent Tube Length:	Diameter: T12 T8 T5 Other:	Wattage of Lamps:	
	Circle one: CFL Incandescent Halogen LED HID Other:			
Ballast	Circle one: Magnetic Electronic	No. of Ballasts/Fixtures:	BF:	Watts:
Control Type (circle one)	Manual Switch Bi-Level Switch Time Clock Daylight Sensor Occupancy Sensor Dimming Step Dimming None Other:		Total Watts:	
Work Plane Height:	*Horizontal Illuminance:*	*Vertical Illuminance Sensitivity:*	*Lamp Color Temp:*	

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Fixture Type	Area Task Exit Track Display Other:		No. of Fixtures:	
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Control Type (circle one)	Manual Switch Bi-Level Switch Time Clock Daylight Sensor Occupancy Sensor Dimming Step Dimming None Other:		Total Watts:	
Work Plane Height:	*Horizontal Illuminance:*	*Vertical Illuminance Sensitivity:*	*Lamp Color Temp:*	

Zone W/ft^2		**Corresponding Schedule**	

Notes

2.4 AIR-HANDLING SYSTEM EQUIPMENT
PCBEA Sample Forms

General Information

Site Name			
Air Handler ID/Tag			
Location/Service			
Manufacturer/Model #			
Year Built		Serial Number	

Supply Fan Data

Manufacturer	
Model Number	
Serial Number	
Fan Type/Size	
Fan Efficiency	

Supply Fan Motor Data

Full-Load hp	
Frame Size	
Enclosure Type	
Full-Load rpm	
Synch. rpm	
Motor Efficiency	
Volts	
Phase	
Full-Load Amps	
Motor in Supply Airstream?	yes / no
Drive Type	

Supply Fan Design/Operating Conditions

	Design	Measured
Total Static Pressure		
Occupied cfm		
Unoccupied cfm		
Fan rpm		
Volts		
Occupied Amps		
Unoccupied Amps	n/a	
Occupied kW		
Unoccupied kW	n/a	
Power Factor	n/a	

Filter Data

	Pre	Final
Manufacturer		
Model Number		
Type		
Efficiency		
Initial/Final Pressure Drop		

Fan Configuration

Blow-Thru	
Draw-Thru	

Return Air Path

Ducted	
Plenum	

Humidifier

Type	
Capacity (lb/h)	

Cooling Coil

	NONE	
Chilled Water (2-Way/3-Way Valve)		
Sensible/Latent Capacity		
Design cfm/gpm		
Design EDB/EWB		
Design LDB/LWB		
Design EWT/LWT		
Measured EWT/LWT		
Air Pressure Drop		

Pre-Heat Coil

	NONE	
Medium Type		
Capacity (MBtuh)		
Design cfm/gpm		
Design EDB/LDB		
Design EWT/LWT		
Measured EWT/LWT		

Heating Coil

	NONE	
Medium Type		
Capacity (MBtuh)		
Design cfm/gpm		
Design EDB/LDB		
Design EWT/LWT		
Measured EWT/LWT		

Source: ASHRAE (Procedures for Commercial Building Energy Audits, 2nd edition)

Benchmarking Sources

- Commercial Buildings Energy Consumption Survey (CBECS)
- St. Louis Building Energy Performance Standards (BEPS)
- Department of Energy/Energy Star

CBECS - Benchmarking

2018 Commercial Buildings Energy Consumption Survey final results

Based on the 2018 *Commercial Buildings Energy Consumption Survey* (CBECS), the estimated 5.9 million U.S. commercial buildings consumed 6.8 quadrillion British thermal units of energy and spent $141 billion on energy in 2018. Electricity and natural gas were the main energy sources. Space heating accounted for close to one-third of end-use consumption in 2018.

https://www.eia.gov/consumption/commercial/data/2018/index.php?view=consumption

CBECS –Building Categories

Education	College/University, K-12, Preschool/Daycare, Other
Food Sales	Convenience Store (w/ & w/o gas station), Grocery Store/Food Market
Food Service	Fast Food, Restaurant/Cafeteria, Other Food Service
Health Care	Inpatient, Outpatient (Diagnostic, Clinic)
Lodging	Hotel, Motel/Inn, Dormitory, Nursing Home/Assisted Living, Other
Mercantile	Retail, Strip Shopping Center, Enclosed Mall
Office	Admin/Professional, Bank/Financial, Government, Medical, Mixed-Use
Public Assembly	Library, Entertainment/Culture, Recreation, Social/Meeting
Public Order & Safety	Fire/Police Station, Courthouse/Probation Office,
Religious Worship	
Service	Post Office, Vehicle Service/Repair, Vehicle Storage/Maintenance
Warehouse/Storage	Warehouse, Distribution/Shipping Center, Self Storage, Refrigerated
Other	Laboratory, Other

Table C12. Sum of major fuel consumption totals and gross energy intensities by building activity subcategories, 2018.

CBECS – EUI Table Sample

	All buildings			Sum of major fuel consumption			Distribution of building-level intensities (thousand Btu/square foot)		
	Number of buildings (thousand)	Total floorspace (million square feet)	Floorspace per building (thousand square feet)	Total (trillion British thermal units [Btu])	Per building (million Btu)	Per square foot (thousand Btu)	25th per-centile	Median	75th per-centile
All buildings	5,918	96,423	16.3	6,787	1,147	70.4	22.6	45.0	80.6
Principal building activity (expanded)									
Education	437	13,623	31.1	854	1,952	62.7	31.1	48.6	74.4
College or university	60	1,827	30.6	157	2,625	85.8	32.7	48.6	78.4
K–12	264	10,619	40.3	632	2,395	59.5	31.9	48.6	69.5
Preschool or daycare	81	482	5.9	28	341	57.7	26.8	52.4	74.4
Office	970	16,662	17.2	1,093	1,127	65.6	36.3	53.5	77.2
Administrative or professional	553	9,294	16.8	588	1,062	63.2	33.5	52.2	72.0
Bank or other financial	47	628	13.4	44	944	70.6	46.3	63.0	92.1
Government	129	2,526	19.6	163	1,268	64.7	36.3	52.9	68.5
Medical (non-diagnostic)	46	356	7.7	23	497	64.2	34.1	54.5	85.3
Mixed-use	119	3,359	28.3	248	2,087	73.8	42.4	57.9	82.2

Table C12. Sum of major fuel consumption totals and gross energy intensities by building activity subcategories, 2018.

St. Louis BEPS - Benchmarking

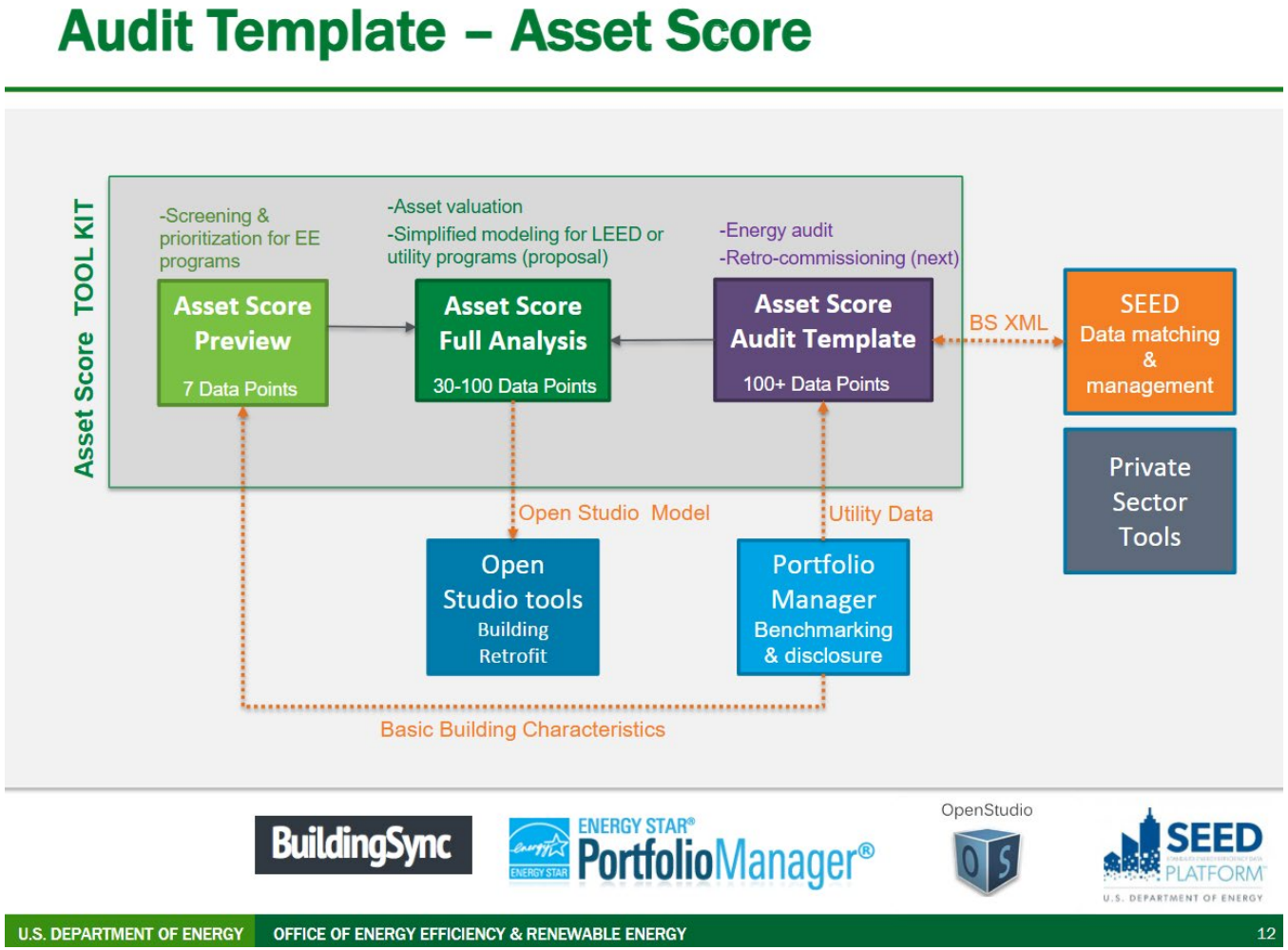
Building Energy Performance Standard Targets

The St. Louis Board of Aldermen unanimously passed and Mayor Krewson signed into law, St. Louis's **Building Energy Performance Standard (BEPS)** in May 2020, making St. Louis the 4th jurisdiction in the country and the 1st in the Midwest to adopt this ambitious law to mandate significant reductions in building energy use.

The ordinance covers municipal, commercial, institutional and residential properties 50,000 square feet and larger. The standards will be set and published by May 4th, 2021. Most buildings will have four years to meet the standard (May 4, 2025). Qualified affordable housing buildings and houses of worship will have six years to meet the standard (May 4, 2027). One benefit of providing additional time for these building types is to allow owners to wrap energy upgrades into larger improvement projects at the time of mortgage refinance. Property owners will have the flexibility to decide what combination of physical or operational improvements can best achieve the standard. Standards are calculated such that at least 65% of buildings have to improve their energy performance.

https://www.stlouis-mo.gov/government/departments/public-safety/building/building-energy-improvement-board/beps-targets.cfm

Department of Energy/Energy Star



https://buildingenergyscore.energy.gov/documents/AuditTemplate_LL87_Webinar_06282018_PresentationSlides.pdf

Department of Energy/Energy Star

Audit Template: Generating an Asset Score

Building Asset Data Includes:
- ✓ Building attributes (stories, conditioned space, orientation, age, etc.)
- ✓ Building envelope (roof, insulation & air sealing, windows, foundation)
- ✓ Building equipment (HVAC, lighting, hot water, etc.)

Building Performance Data Includes:
- ✓ Occupant behavior (hours of operation, occupant density, etc.)
- ✓ Actual energy usage (metered data by fuel type)
- ✓ Actual energy spend (utility bills, etc.)

BUILDING ENERGY ASSET SCORE AUDIT TEMPLATE
U.S. DEPARTMENT OF ENERGY

ENERGY STAR® Portfolio Manager®

How your building *should* perform based on construction

How your building *actually* performs based on use

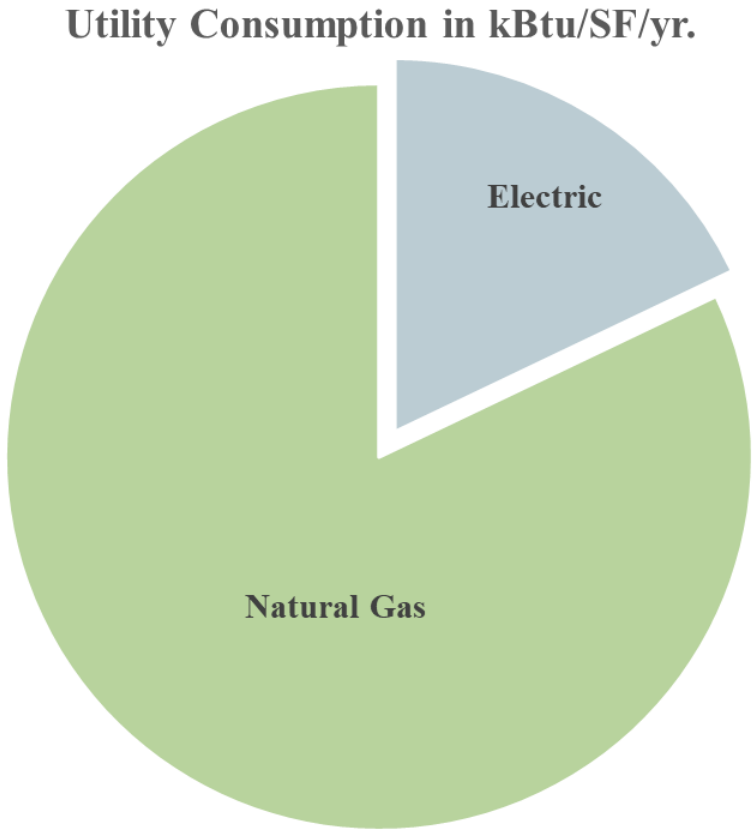
https://buildingenergyscore.energy.gov/documents/AuditTemplate_LL87_Webinar_06282018_PresentationSlides.pdf

Sample Energy Audit Project

- A sample project is included to better tie the Energy Audit processes to real work efforts.
- This project included a 51,900 sq.ft. building with 10,000 sq.ft. of office space and 41,900 sq.ft. of heated warehouse.
- This project is located within the City of St. Louis, and as the project exceeds 50,000 sq.ft. needs to comply with the the City's Building Energy Performance Standards.
- The City initially expected the entire building to meet the baseline for a non-refrigerated warehouse, 17.6 kBtu/sq.ft., which would have required a 60% reduction.
- The City accepted an "Alternative Compliance Option", which included a target usage level of 32.7 kBtu/sq.ft.

Utility Data Analysis

Sample Building Reported Utility Usage	Total kBtu/SF/yr.
Electrical Energy	8.341
- Percent of Usage	18%
Natural Gas Energy	38.220
- Percent of Usage	82%
Total Utility Reported Usage	**46.561**



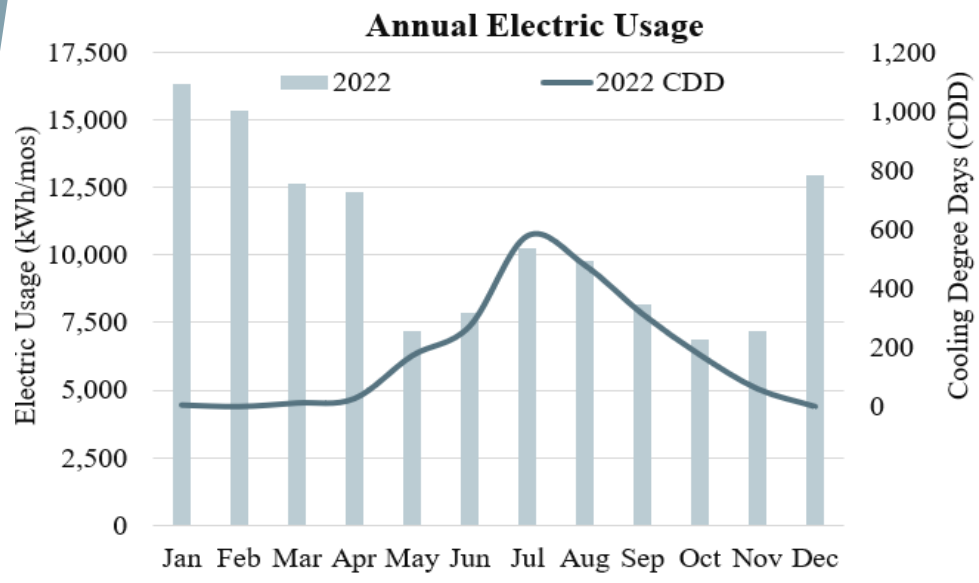
Utility Data Analysis, Benchmarking

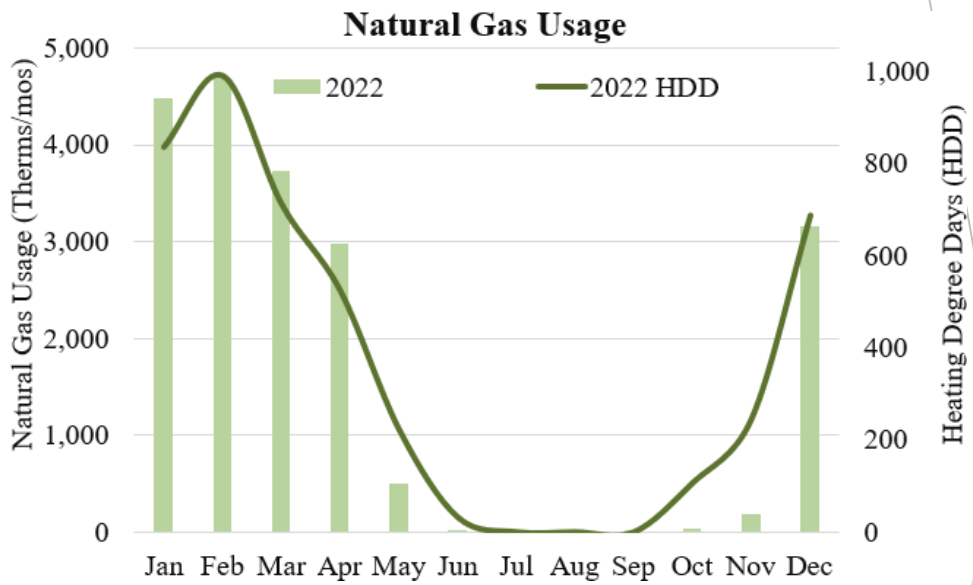
Sample Building Reported Utility Usage	Total kBtu/SF/yr.
Total Reported Energy Usage	46.561

2018 CBECS Data	25th%ile	Median	75th%ile
- Nonrefrigerated Warehouse	5.500	18.800	40.100
- Office, Administrative or professional	33.500	52.200	72.000
Prorated CBECS Data for ICS Const. Serv.	**10.895**	**25.235**	**46.246**

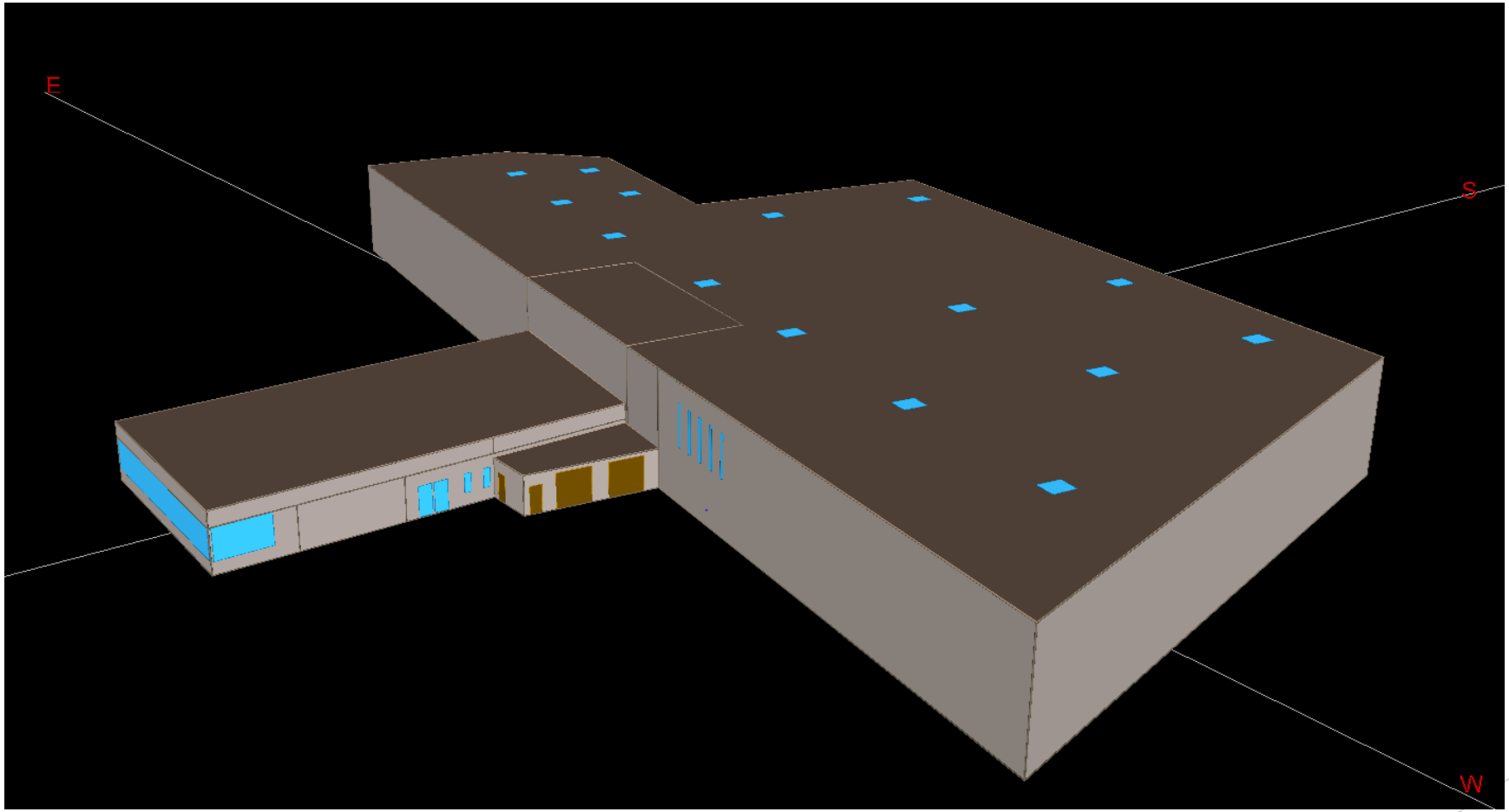
BEPS Requirement	kBtu/SF/yr.
- Nonrefrigerated Warehouse	17.600
- Custom Alternative Compliance Pathway	32.700

Utility Data Analysis

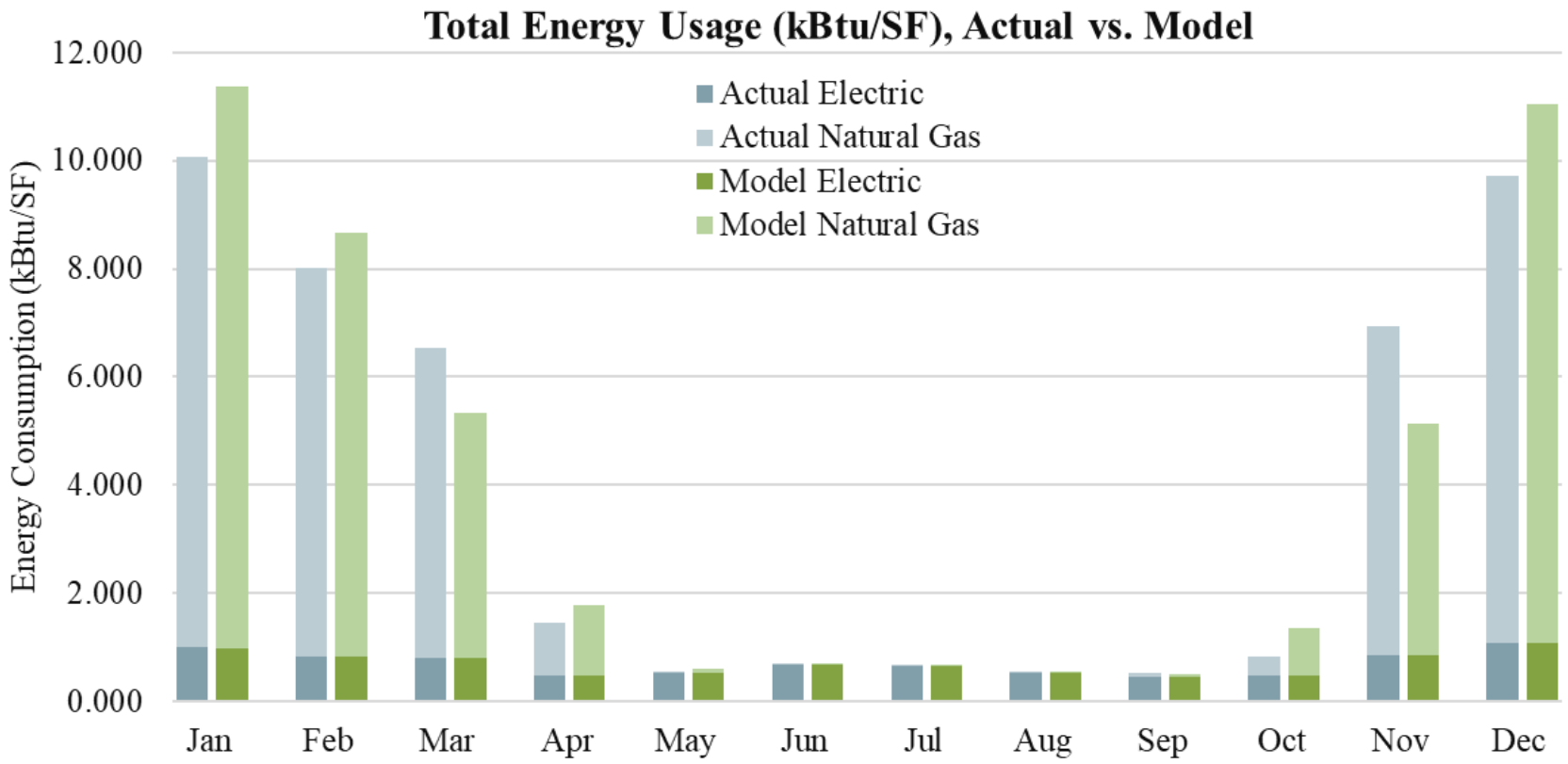




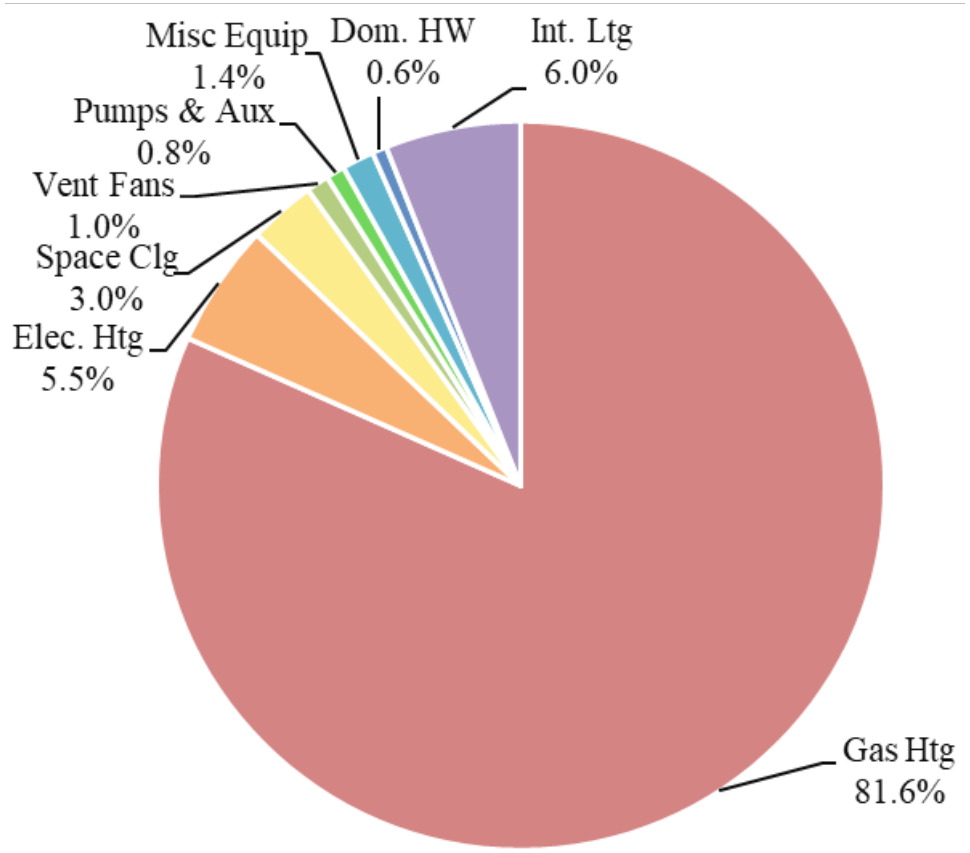
eQuest Energy Model 3D Rendering



Utility Data Analysis, Energy Model



Building Energy Use by Equipment



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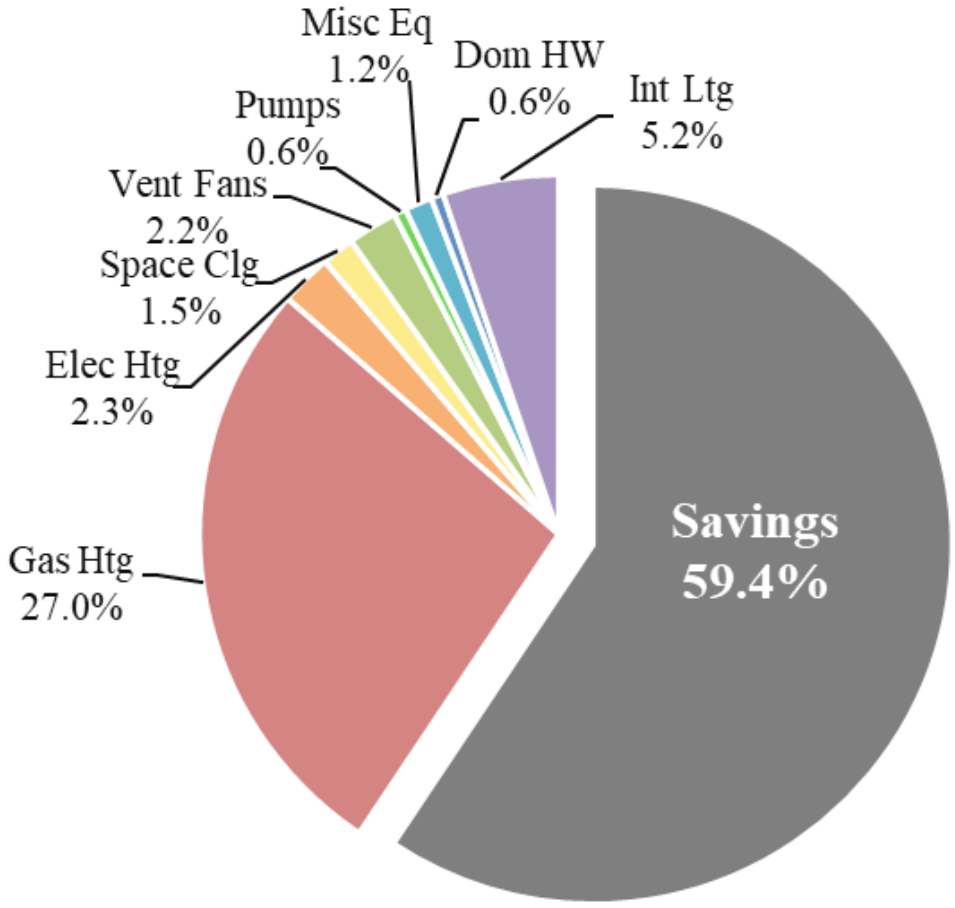


After Implementation

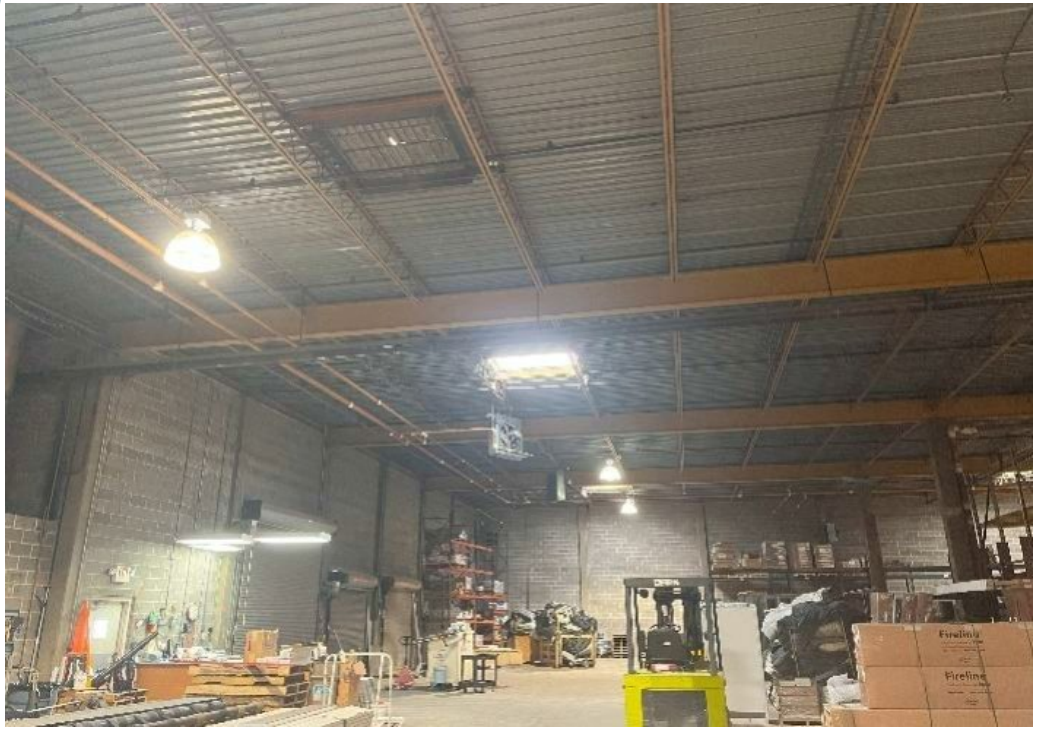
Executive Summary Table

Sample Building Energy Savings Data	Electricity kWh	Cost	Nat Gas therms	Cost	Total Cost	Projected Ann. Utility Savings kWh	therms	Savings
Existing Utility (12/21-11/22)	126,880	$17,674	19,836	$19,241	$36,915			
Baseline CxE Model	129,050	$17,977	20,447	$19,834	$37,810			
Vent. Adj., New Baseline	160,759	$22,394	23,208	$22,512	$44,905	-31,709	-2,761	-$7,095
Measures to Meet BEPS (EEM 1-3)	126,062	$17,560	10,049	$9,748	$27,308	34,697	13,159	$17,598
Additional Measures (EEM 4-6)	109,330	$15,230	7,909	$7,672	$22,901	16,732	2,140	$4,407
Annual Projected Utility Savings						51,429	15,293	$21,999

Energy (EUI) Summary Table

Sample Building Energy Savings Data	Site EUI (Not Additive) - kBtu/SF WH	Off	Total	Utility Costs
	41,900 SF	10,000 SF	51,900 SF	
		Alt. BEPS Target	32.700	
Existing Utility (12/21-11/22)	41.486	67.826	46.561	$36,917
Baseline CxE Model	42.719	69.509	47.881	
- Vent. Adj., New Baseline	42.712	107.908	55.274	$44,900
Measures to Meet BEPS Goal				
- Office Setback Controls	43.674	84.891	51.616	
- Seal Exhaust Fans	36.157	84.817	45.532	
- WH to 45F add wifi monitoring	13.454	87.132	27.650	
Additional Measures				
- New Rooftop Units	13.454	82.008	26.663	
- Office Roof Insul to R30	13.454	65.912	23.561	
- WH Roof Insul to R10	12.289	64.903	22.426	
				Savings
Total Utility Cost Savings	30.423	43.006	32.847	$21,999
Revised Usage after Upgrades	**12.289**	**64.903**	**22.426**	**$22,901**

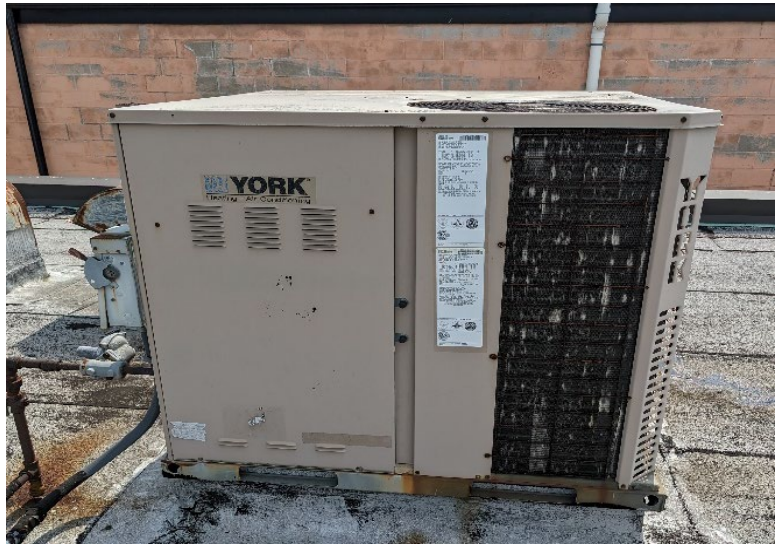
Warehouse Photos



Roof Penetrations

Rooftop HVAC Units

Rooftop Unit Data						
Plan Mark	York Model No.	Service	Nominal Tonnage	Airflow CFM	Input MBH	Fan HP
RTU-1	D1NA048N11025C	SW Office	4	1,600	135.0	1.00
RTU-2	DM090N15B2AAA1A	Center Office/Conf Rm	7.5	3,000	180.0	1.50
RTU-3	D1NA048N11025C	SW Office	4	1,600	135.0	1.00
RTU-4	DM078N15N2AAA2A	North Center Office	7.5	3,000	180.0	2.00
RTU-5	D2NA060N11025D	North Exterior Office	5	2,000	135.0	1.00
RTU-6	DM090N15B2AAA1A	Warehouse Office	7.5	3,000	180.0	1.50



Warehouse Destratification Fans

Measures Summary Table

EEM No.	Sample Building Energy Efficiency Measure (EEM) Description	Estimated Amounts			Simple Payback (years)
		Annual Utility Cost Savings	Measure Cost	Ameren Incentives	
1	Rooftop Setback Controls	$5,130	$3,229	$1,140	0.63
2	Seal Exhaust Fans, 9 of 10	$3,138	$9,315	$0	2.97
3	Warehouse to 45F add wifi monitoring	$9,324	$26,984	$0	2.89
4	New Rooftop Units - Incremental Cost	$1,532	$12,420	$1,754	8.11
5	Office Roof Insulation to R30	$2,223	TBD	TBD	TBD
6	Warehouse Roof Insulation to R10	$652	TBD	TBD	TBD

QUESTIONS?

Thank you from CXE Group

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