
Introduction to Commercial Building Audits

Course No. ENRG 50

Introduction to Commercial Building Audits

Outline

A. Introduction to concept of commercial building energy auditing

1. Why energy efficiency (EE) is important
2. Energy use and waste in commercial building operations
3. Prioritizing energy efficiency over renewable energy generation

B. Ordinances, policies and standards governing commercial building audits

1. San Francisco Existing Commercial Buildings Performance Ordinance
2. State of California energy goals
3. ASHRAE standards, including Building Energy Assessment Professional (BEAP)
4. Other audit standards

C. Three ASHRAE audit levels

1. Preliminary energy use analysis
2. Level 1, Walk-through analysis
3. Level 2, Intermediate, energy survey and energy analysis
4. Level 3, Detailed analysis of capital-intensive modifications

D. Developing the scope of work in a commercial building audit

1. Objectives of the audit, including needed data and

resources

2. Assessment management

3. Responsibilities of audit team members

E. Elements in preliminary analysis of building performance data

1. Engineering and architectural document review
2. Geographical and climatic review
3. Review and analysis of current energy use and costs
4. Benchmarking procedures

F. Factors in on-site building assessment

1. Common safety hazards and field safety techniques
2. Occupant interviews and assessment of building operations
3. Building envelope
4. Electrical systems
5. HVAC&R systems
6. Lighting systems and use
7. Miscellaneous other energy use systems
8. Domestic water systems and use
9. Indoor environmental quality

G. Analysis of data collected

1. Identify opportunities for efficiency improvement
2. Calculate value of efficiency improvements and return on investment
3. Prioritize options based on client criteria

H. Audit completion activities

1. Prepare and present written report
2. Assist with development of implementation plan

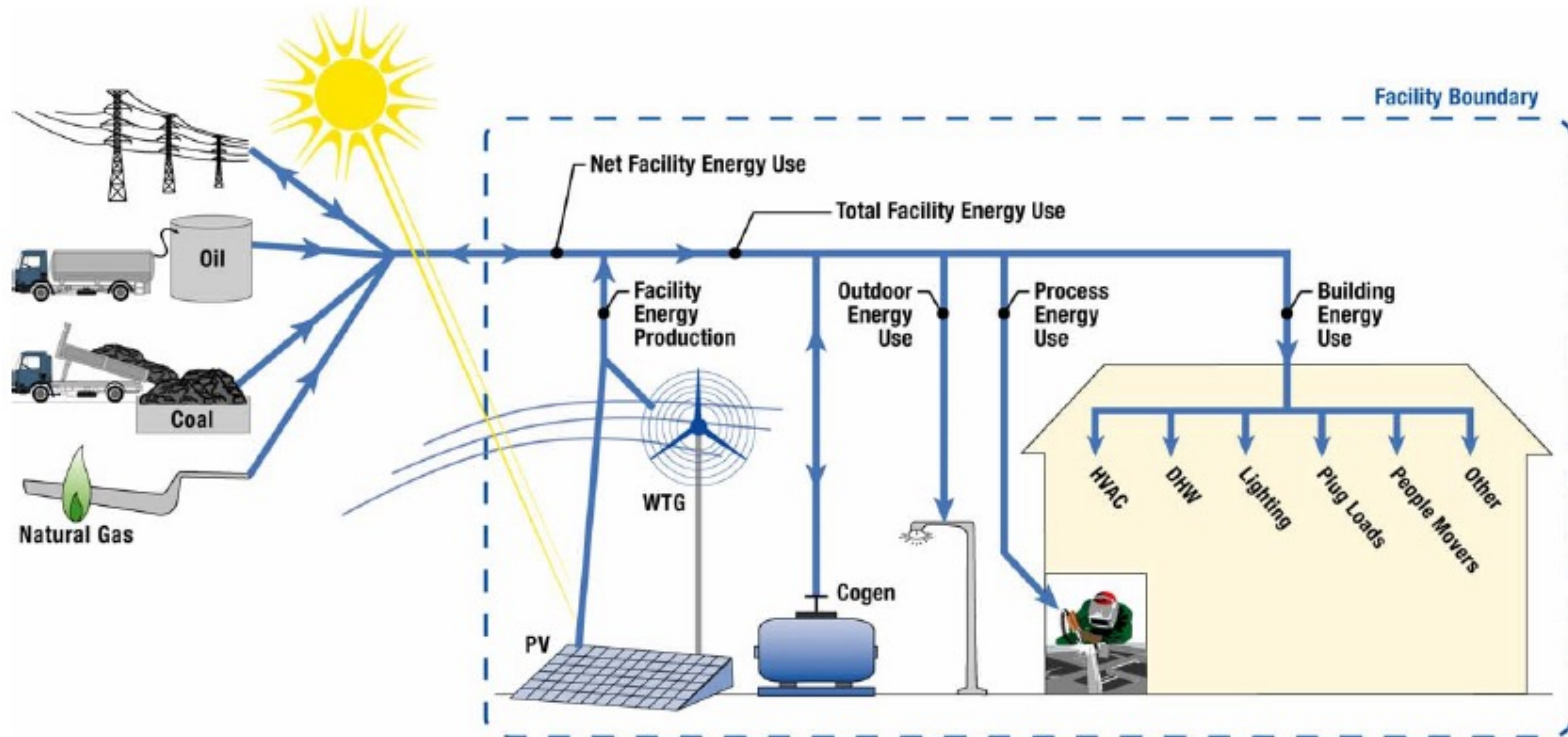
D. Developing the scope of work in a commercial building audit

1. Objectives of the audit, including needed data and resources
2. Assessment management
3. Responsibilities of audit team members

D. Developing the scope of work in a commercial building audit

1. Objectives of the audit, including needed data and resources
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Objectives of the audit, including needed data & resources



<http://www.nrel.gov/docs/fy06osti/38601.pdf>

Before starting the audit, define the audit criteria

- Audit objectives
- Audit type
- Audit methodology and standards
- Staff involvement
- Site or utility boundary
- Timeline
- Reporting requirements

Audit objectives

- Objectives
 - understand how energy is used within the facility
 - find opportunities for improvement and energy saving
 - evaluate the effectiveness of an energy efficiency project or program

Available resources

- Staff and experience
- Time
- Tools and software
- The budget for conducting the energy audit
- Government or utility incentive programs

Make an audit plan

- Scope of the audit
 - customer's expectations
 - building function
 - typical EEMs for similar facilities and businesses
- Time of the audit and its duration, milestone for each step
- Elements of the audit that have a high priority
- Responsibilities and tasks of each audit team member
- Format of the audit report and its outline

Preparing an audit checklist

- Steps to be taken during the energy audit
- Data and information that should be collected
- Existing measurement instrument and the data recorded
- Required measurements during the energy audit and the list of parameters to be measured
- Major equipment to be assessed in more detail
- List of main components of the results section of the audit report, for guidance
- Other major concerns and considerations

Collecting energy bills and available data/information

- 12-36 months of utility bills
- Building function and usage allocation
- Climatic data for the period in which the auditing is conducted
- Possible archived records with measurements from existing recorders
- Architectural and engineering plans of the plant and its equipment
- Status of energy management and any energy-saving measures implemented
- General information about the plant (year of construction, ownership status, renovations, types of products, operation schedule, operating hours, scheduled shut-downs, etc.)

Collecting energy bills and available data/information

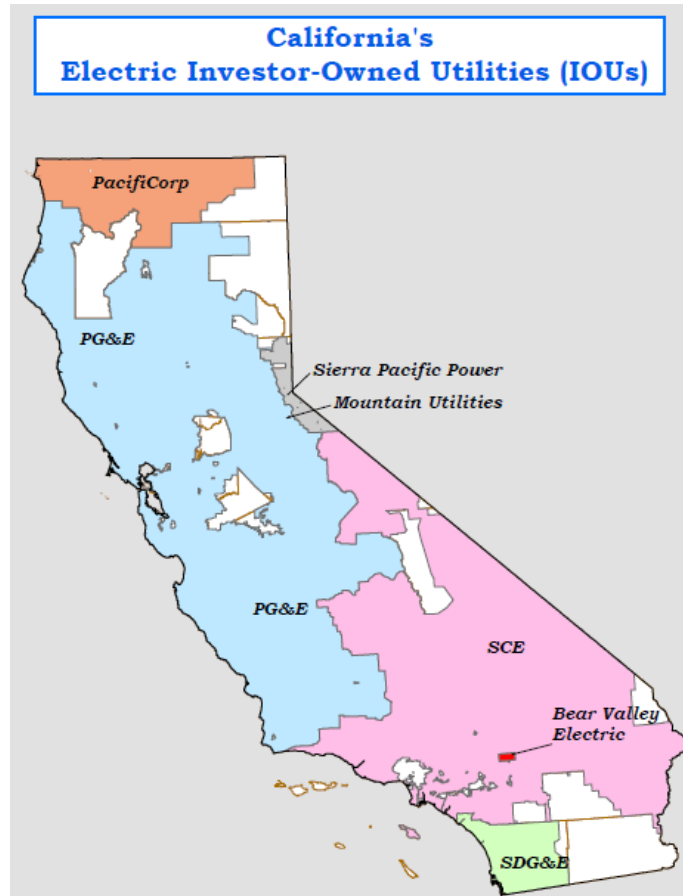
- Building function and usage allocation

Quincy New Residence Hall Space Types (Sq. Ft.)						
Floor	Residence	Office	Common	Other (Mechanical & Storage)	Kitchen (not in audit scope)	Total
Basement	2,909	1,551	7,476	9,811	0	21,747
First	5,687	2,731	10,424	1,987	0	20,829
Second	12,892	0	6,065	0	4,995	23,952
Third	14,844	0	0	0	0	14,844
Fourth	14,844	0	0	0	0	14,844
Fifth	14,844	0	0	0	0	14,844
Sixth	14,844	0	0	0	0	14,844
Seventh	14,844	0	0	0	0	14,844
Penthouse	4,647	0	0	0	0	4,647
Totals	100,355	4,282	23,965	11,798	4,995	145,395

http://www.uos.harvard.edu/fmo/building_maintenance/quincy_house_energy_audit.pdf

Energy bill analysis

- CA utility distribution



http://www.energy.ca.gov/maps/serviceareas/CA_Electric_IOU.pdf

http://www.energy.ca.gov/maps/serviceareas/natural_gas_detailed_service_areas.pdf

Electric rates & charges (PG&E)

- Fixed and variable costs
- Rate schedule
- Season
- Demand charge
- TOU
- Energy charge
- PF charge
- Credits

- Check the utility's updated tariff sheet!
- PG&E: <http://www.pge.com/tariffs/>
- A separate course about utility rates

Calculate energy use per day
- electricity: kWh/day
- natural gas: therms/day

More Utility info: <http://www.energy.ca.gov/maps/>

PG&E – Electric rate schedules (partial)

ELECTRIC SCHEDULES

Tariff Name	PDF (KB)	Title
A-1	PDF	Small General Service
A-6	PDF	Small General Time-of-Use Service
A-10	PDF	Medium General Demand-Metered Service
A-15	PDF	Direct-Current General Service
AG-1	PDF	Agricultural Power
AG-4	PDF	Time-of-Use Agricultural Power
AG-5	PDF	Large Time-of-Use Agricultural Power
AG-ICE	PDF	Agricultural Internal Combustion Engine Conversion Incentive Rate
AG-R	PDF	Split-Week Time-of-Use Agricultural Power
AG-V	PDF	Short-Peak Time-of-Use Agricultural Power
CCA-CRS	PDF	Community Choice Aggregation Cost Responsibility Surcharge (Interim)
DA-CRS	PDF	Direct Access Cost Responsibility Surcharge
E-1	PDF	Residential Services
E-6	PDF	Residential Time-of-Use Service
E-7	PDF	Residential Time-of-Use Service
E-8	PDF	Residential Seasonal Service Option
E-9	PDF	Experimental Residential Time-of-Use Service for Low Emission Vehicle Customers
E-19	PDF	Medium General Demand-Metered TOU Service
E-20	PDF	Service to Customers with Maximum Demands of 1000 Kilowatts or More
E-31	PDF	Distribution Bypass Deferral Rate
E-37	PDF	Medium General Demand-Metered Time-of-Use Service to Oil & Gas Extraction Customers

PG&E: <http://www.pge.com/tariffs/>

PG&E rate schedule demo - A10

ELECTRIC SCHEDULE A-10 MEDIUM GENERAL DEMAND-METERED SERVICE

Sheet 5

RATES: Time-of-Use Rates for Optional or Real-Time Metering Customers

Table B

TOTAL RATES

	Secondary Voltage	Primary Voltage	Transmission Voltage
<u>Total Customer/Meter Charge Rates</u>			
Customer Charge (\$ per meter per day)	\$4.59959	\$4.59959	\$4.59959
Optional Meter Data Access Charge (\$ per meter per day)	\$0.98563	\$0.98563	\$0.98563
<u>Total Demand Rates (\$ per kW)</u>			
Summer	\$12.12 (R)	\$11.35 (R)	\$7.43 (R)
Winter	\$5.63	\$5.84	\$4.13
<u>Total Energy Rates (\$ per kWh)</u>			
Peak Summer	\$0.15023 (R)	\$0.13927 (R)	\$0.11425 (R)
Part-Peak Summer	\$0.14442 (R)	\$0.13513 (R)	\$0.11047 (R)
Off-Peak Summer	\$0.12677 (R)	\$0.11931 (R)	\$0.09610 (R)
Part-Peak Winter	\$0.11034 (R)	\$0.10469 (R)	\$0.09189 (R)
Off-Peak Winter	\$0.09520 (R)	\$0.09231 (R)	\$0.08049 (R)

http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_A-10.pdf

PG&E rate schedule demo - A10

PDP Rates (Consecutive Day and Four-Hour Event Option)*

PDP Charges (\$ per kWh)

All Usage During PDP Event	\$0.90	\$0.90	\$0.90
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PDP Credits

Demand (\$ per kW)

Maximum Summer	(\$2.11)	(\$1.99)	(\$2.23)
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Energy (\$ per kWh)

Peak Summer	(\$0.00875)	(\$0.00899)	(\$0.00648)
Part-Peak Summer	(\$0.00875)	(\$0.00899)	(\$0.00648)
Off-Peak Summer	(\$0.00875)	(\$0.00899)	(\$0.00648)

http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_A-10.pdf

Reading link: Understanding your bill

http://www.pge.com/includes/docs/pdfs/b2b/newgenerator/understandinyourbill_residential.pdf

PG&E rate schedule demo - A10

DEFINITION OF TIME PERIODS:

Customers who have received new hourly interval meters under the real-time metering program funded by CEC, or who have voluntarily arranged for the installation of such meters, will pay TOU charges specified in this rate schedule.

Times of the year and times of the day for the TOU rates are defined as follows:

SUMMER Period A (Service from May 1 through October 31):

Peak: 12:00 noon to 6:00 p.m. Monday through Friday

Partial-Peak 8:30 a.m. to 12:00 noon Monday through Friday (except holidays)
AND 6:00 p.m. to 9:30 p.m.

Off- Peak: 9:30 p.m. to 8:30 a.m. Monday through Friday
All day Saturday, Sunday, and holidays

WINTER Period B (service from November 1 through April 30):

Partial-Peak 8:30 a.m. to 9:30 p.m. Monday through Friday (except holidays)

Off-Peak 9:30 p.m. to 8:30 a.m. Monday through Friday (except holidays)
All day Saturday, Sunday, and holidays

http://www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_A-10.pdf

PG&E – Gas rate schedules (partial)

GAS SCHEDULES

Tariff Name	PDF (KB)	Title
G-1	PDF	Residential Service
G-10	PDF	Service to Company Employees
G-AA	PDF	As Available Transportation On-System
G-AAOFF	PDF	As-Available Transportation Off-System
G-AFT	PDF	Annual Firm Transportation On-System
G-AFTOFF	PDF	Annual Firm Transportation Off-System
G-AMDS	PDF	Experimental Access to Meter Data Services
G-BAL	PDF	Gas Balancing Service for Intrastate Transportation Customers
G-CARE	PDF	CARE Program Service For Qualified Nonprofit Group-Living & Qualified Agricultural Employee Housing Facilities
G-CFS	PDF	Core Firm Storage
G-CRED	PDF	Billing Credits for CTA-Consolidated Billing
G-CP	PDF	Gas Procurement Service to Core End-Use Customers
G-CPX	PDF	Crossover Gas Procurement Service to Core End-Use Customers
G-CT	PDF	Core Gas Aggregation Service
G-EG	PDF	Gas Transportation Service to Electric Generation
G-ESISP	PDF	Exchange Service Through ISP Facilities
G-ESP	PDF	Consolidated PG&E Billing Services to Core Transport Agents
G-LEND	PDF	Market Center Lending Services
G-LNG	PDF	Experimental Liquefied Natural Gas Service

<http://www.pge.com/tariffs/GRS.SHTML#GRS>

PG&E rate schedule demo – G-NR1

TERRITORY: Schedule G-NR1 applies everywhere PG&E provides natural gas service.

RATES: Customers on this schedule pay a Customer Charge, a Procurement Charge and a Transportation Charge, per meter, as specified below. Customers that have executed a Request for Reclassification from Noncore Service to Core Service (Form 79-983) will pay the Customer Charge and Transportation Charge shown below. Such Customers will pay the Procurement Charge specified in Schedule G-CPX for any of the first twelve (12) regular monthly billing periods that they are taking core procurement service from PG&E. After the twelfth regular monthly billing period, such Customers will pay the Procurement Charge specified on this schedule.

The applicable Customer Charge specified below is based on the Customer's highest Average Daily Usage (ADU) determined from among the billing periods occurring within the last twelve (12) months, including the current billing period. PG&E calculates the ADU for each billing period by dividing the total usage by the number of days in the billing period.

	ADU (Therms)									
	0 – 5.0		5.1 to 16.0		16.1 to 41.0		41.1 to 123.0		123.1 & Up	
Customer Charge: (per day)	\$0.27048		\$0.52106		\$0.95482		\$1.66489		\$2.14936	
	Per Therm									
	<u>Summer</u>				<u>Winter</u>					
	<u>First 4,000 Therms</u>		<u>Excess</u>		<u>First 4,000 Therms</u>		<u>Excess</u>			
Procurement Charge:	\$0.39972	(I)	\$0.39972	(I)	\$0.39972	(I)	\$0.39972	(I)		
Transportation Charge:	\$0.31815		\$0.12948		\$0.38822		\$0.15800			
Total:	\$0.71787	(I)	\$0.52920	(I)	\$0.78794	(I)	\$0.55772	(I)		

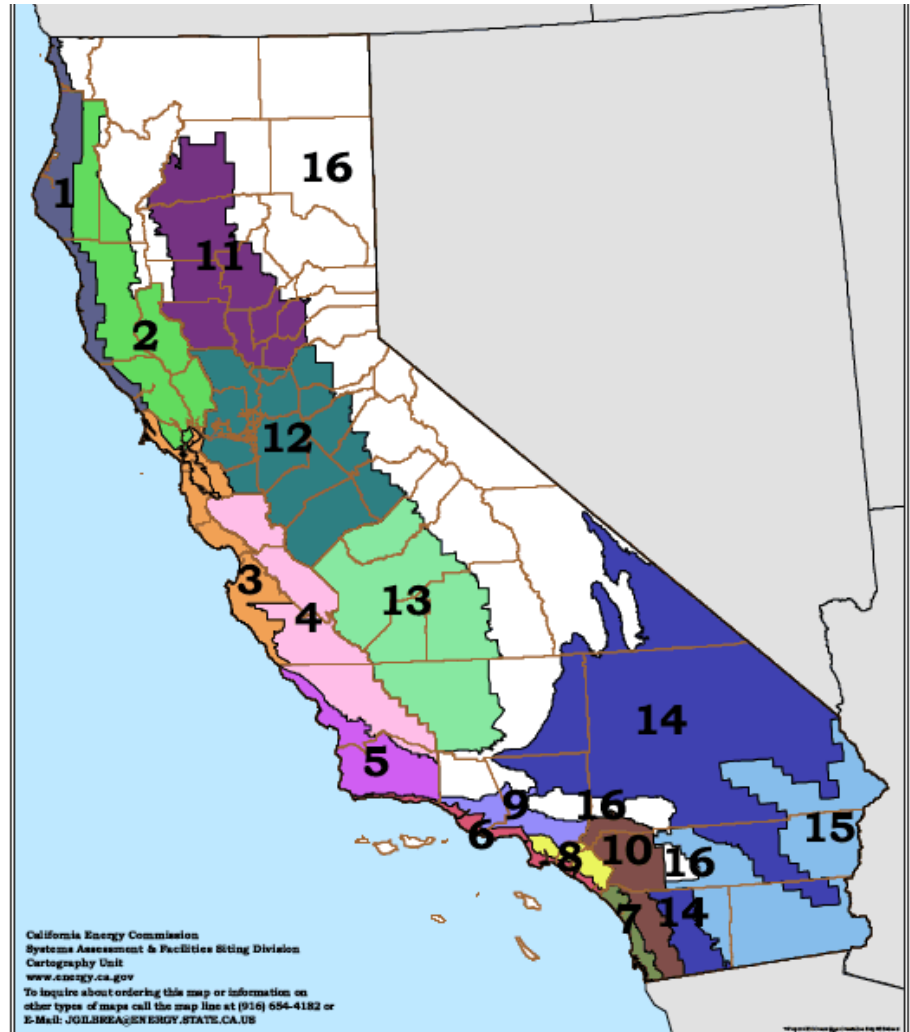
http://www.pge.com/tariffs/tm2/pdf/GAS_SCHS_G-NR1.pdf

California building climate zones

http://www.energy.ca.gov/maps/renewable/building_climate_zones.html

CZ 1: Arcata
CZ 2: Santa Rosa
CZ 3: Oakland
CZ 4: Sunnyvale
CZ 5: Santa Maria
CZ 6: Los Angeles
CZ 7: San Diego
CZ 8: El Toro
CZ 9: Pasadena
CZ10: Riverside
CZ11: Red Bluff
CZ12: Sacramento
CZ13: Fresno
CZ14: China Lake
CZ15: El Centro
CZ16: Mount Shasta

http://www.energy.ca.gov/maps/renewable/Climate_Zones_by_City.pdf



Homework

Assuming you are going to audit the college building, generate a questionnaire to collect needed data & information.

Initial walk-through visit

- Meet with executive, energy and/or facility manager(s)
- Interview facility staff if necessary and possible
- Become familiar with the facility
- Establish a common understanding of the audit process
- Observe the existing control strategies
- Determine the processes that will need a detailed audit later

D. Developing the scope of work in a commercial building audit

1. Objectives of the audit, including needed data and resources
- 2. Assessment management**
3. Responsibilities of audit team members

Assessment management

- preliminary walk-through, analysis
- instrument inventory and functions
- collect / monitor usage data
- analyzing energy use patterns
- Benchmarking and comparative analysis
- Identifying energy efficiency potentials
- Cost benefit analysis

Instrument inventory and functions

- Demo: Motor inventory
 - Site ID
 - Motor application
 - Motor location
 - Maker
 - Model#
 - Size (HP)
 - Name plate speed (RPM)
 - Measured speed (RPM)
 - % full-load
 - efficiency
 - Motor kW
 - % on
 - Operation hours/yr
 - Analyst

Collect/monitor usage data

- *The data collection is carefully matched to the goals of the analysis and the study questions to avoid the common pitfalls of too little or too much data.*

- A. Select performance metrics to be measured.
- B. Identify data required for each metric.
- C. Specify physical location of each measurement.
- D. Specify frequency of each measurement.
- E. Specify measurement equipment.
- F. Determine practicality of measurements.
- G. Estimate cost of DAS equipment and operation.
- H. Calculate uncertainty of measurements.
- I. Resolve cost and uncertainty with expectations

Select performance metrics to be measured

- NREL Tier 2 measurement planning forms: <http://www.nrel.gov/docs/fy06osti/38601.pdf>

#	Performance Metric	Necessary Data	Measurement/ Source of data	Record Freq.	Measurement equipment	
					Devices	Quantity
1	Gross interior floor area			1 time	N/A	N/A
2	Functional Area			1 time	N/A	N/A
3	Installed lighting energy use			series		
4	Plug-in lighting energy use					
5	Façade lighting energy use			series		
6	Building lighting energy use			series		
7	Heating energy use			series		
8	Cooling energy use			series		
9	Air distribution energy use			Series		
10	Cold storage transfer			series		

Select performance metrics to be measured – ctnd.

- NREL Tier 2 measurement planning forms: <http://www.nrel.gov/docs/fy06osti/38601.pdf>

#	Performance Metric	Neces- sary Data	Measure ment/ Source of data	Record Freq.	Measurement equipment	
					Devices	Quantity
11	Other HVAC energy use			series		
12	HVAC energy use			series		
13	DHW energy use			series		
14	DHW load			series		
15	DHW system efficiency			monthly		
16	Plug loads energy use			series		
17	People-Mover energy use			series		
18	Other building energy use			series		
19	Building energy use			Series		
20	Building energy use intensity		N/A	annual	N/A	N/A

Select performance metrics to be measured – ctnd.

- NREL Tier 2 measurement planning forms: <http://www.nrel.gov/docs/fy06osti/38601.pdf>

#	Performance Metric	Necessary Data	Measurement/ Source of data	Record Freq.	Measurement equipment	
					Devices	Quantity
21	Building purchased energy cost		bills	monthly	N/A	N/A
22	Building purchased energy cost intensity		N/A	annually	N/A	N/A
23	Building electrical demand		N/A	monthly	N/A	N/A
24	Building electrical demand intensity		N/A	monthly	N/A	N/A
25	Process energy use			Series		
26	Outdoor energy use			series		
27	Cogeneration fuel use			series		
28	Cogeneration electrical energy output			series		
29	Cogeneration thermal energy output			Series		
30	Cogeneration losses		N/A	Series	N/A	N/A

Select performance metrics to be measured – ctnd.

- NREL Tier 2 measurement planning forms: <http://www.nrel.gov/docs/fy06osti/38601.pdf>

#	Performance Metric	Neces- sary Data	Measure ment/ Source of data	Record Freq.	Measurement equipment	
					Devices	Quantity
31	PV energy production			series		
32	Wind energy production			series		
33	Other electrical energy production			series		
34	Electrical generation system losses			series		
35	Thermal energy production			Series		
36	Produced energy storage transfer			series		
37	Facility energy production			series		
38	Total facility energy use			series		
39	Net facility energy use			Series		
40	Net facility purchased energy cost		bills	Monthly	N/A	N/A

Select performance metrics to be measured – ctnd.

- NREL Tier 2 measurement planning forms: <http://www.nrel.gov/docs/fy06osti/38601.pdf>

#	Performance Metric	Necessary Data	Measurement/ Source of data	Record Freq.	Measurement equipment	
					Devices	Quantity
41	Total facility electrical demand			monthly	N/A	N/A
42	Net facility electrical demand			monthly	N/A	N/A
43	Net facility load factor			monthly	N/A	N/A
44	Indoor zone temperature			Series		
45	Outdoor ambient temperature			Series		
	User-defined metrics					

10 Common problems in Energy Audits

http://home.comcast.net/~tureston2011/BES/Audit_Tool/10_CommonProblemsInEnergyAudits.pdf

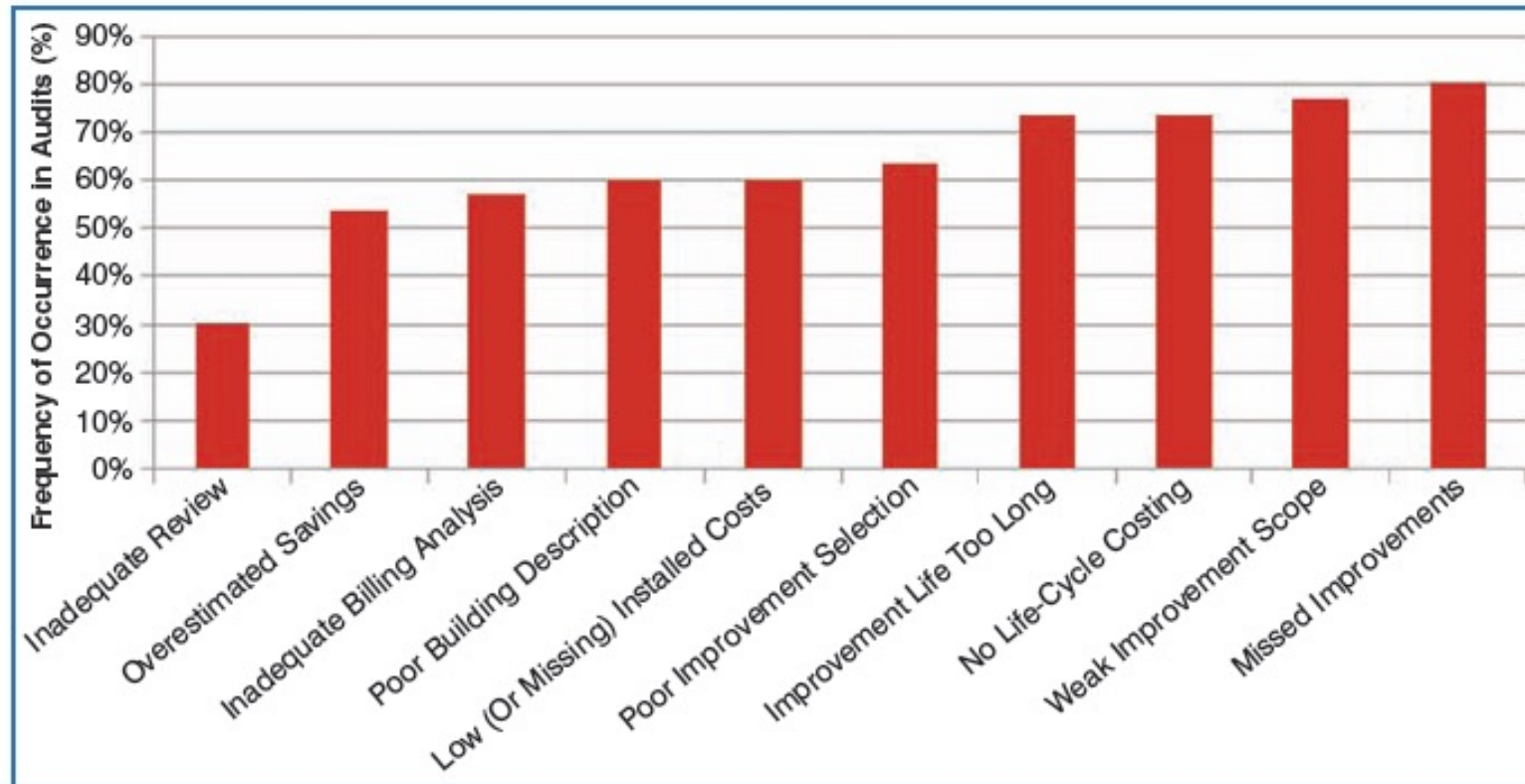


Figure 1: Ten most common problems identified in a survey of 300 energy audits.

D. Developing the scope of work in a commercial building audit

1. Objectives of the audit, including needed data and resources
2. Assessment management
3. Responsibilities of audit team members

Responsibilities of audit team members

- Project manager
 - communicate with customers
 - plan and keep the project on track
 - organize installation of data-loggers and data collection
 - integrate EEMs and report together
 - write executive summary and summarize financial section

Responsibilities of audit team members

- Lighting analysis
- HVAC systems and controls
 - This area is highly technical; well-trained personnel are essential
- Building envelope
 - Civil engineering and architecture background are preferred.
- Simulation analysis
- Other specialties: such as kitchen EE experts for restaurants

One may conduct more than one task.
Each one needs to finish analysis and writing for his/her own sections.

BEST Center Curricula, Resources & Recordings

Academic Programs

Georgia Piedmont Technical College - Building Automation Systems

Milwaukee Area Technical College - Sustainable Facilities Operations

Laney College - Commercial HVAC Systems

City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos

National Institutes

Building Automation Systems Instructor Workshops

Webinars (e.g., BEST Talks)

Faculty Profile Videos

Reports & Case Studies

Marketing Resources

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