Energy Exchange

Federal Sustainability for the Next Decade

U.S. Department of Energy

The Basics of Energy Auditing

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The Energy Audit

- What they are
- Audit concept review
- When to use them
- What to expect
- How to use the reports
- Why they are important
- The difference between Audits, EBCx, and RCx

What is Energy Auditing?

- Defined by ASHRAE in the Procedures for Commercial Building Energy Audits as:

  "The objectives of an energy analysis or audit are to identify and develop modifications that will reduce the energy use and/or cost of operating a building. The results should be presented in a format that will provide the information needed by an owner/ operator to decide if any, some, or all of the recommended modifications should be implemented."

- How do we do that?

What is Energy Auditing?

Steps of an Energy Audit*

1. Collect and analyze historical energy use.
2. Study the building and its operational characteristics.
3. Identify potential modifications that will reduce the energy use and/or cost.
4. Perform an engineering and economic analysis of potential modifications.
5. Prepare a rank-ordered list of appropriate modifications.
6. Prepare a report to document the analysis process and results.

*Procedures for Commercial Building Energy Audits, ASHRAE, 2004

Types of Energy Audits

- ASHRAE – Different Levels of Effort
  - Preliminary Assessment
  - Level 1 – Walk Through Assessment
  - Level 2 – Energy Survey and Analysis
  - Level 3 – Detailed Analysis of Capital Intensive Modifications
- Customize each energy audit depending on your building's needs and the funding available
- Each audit level may lead to the next

Levels of ASHRAE Energy Audits

Preliminary Energy Use Analysis

- "Analyze historic utility use and cost. Develop the Energy Utilization Index (EUI) of the building. Compare the building EUI to similar buildings to determine if further engineering study and analysis are likely to produce significant energy savings."

- Similar to benchmarking – more to come later
- Helps to figure out the baseline energy use
- Identifies how well the building is doing in general

Levels of ASHRAE Energy Audits

Level I—Walk-Through Analysis

- "Assess a building's energy cost and efficiency by analyzing energy bills and conducting a brief on-site survey of the building. A Level I energy analysis will identify and provide a savings and cost analysis of low-cost/no-cost measures. It will also provide a listing of potential capital improvements that merit further consideration, and an initial judgment of potential costs and savings."

- Usually one day or less of field work for the auditors
- Easy to achieve, "low hanging fruit" measures are identified with these audits

Levels of ASHRAE Energy Audits

Level II—Energy Survey and Analysis

- "More detailed building survey and energy analysis. A breakdown of the energy use within the building is provided. A Level II energy analysis will identify and provide the savings and cost analysis of all practical measures that meet the owner's constraints and economic criteria, along with any changes to O&M procedures. May also provide a listing of potential capital-intensive improvements that require more thorough data collection and engineering analysis, and a judgment of potential costs and savings."

- Most common type of energy audit, good balance of detail and useful information for most facilities

Levels of ASHRAE Energy Audits

Level III—Detailed Analysis of Capital-Intensive Modifications

- "This level of engineering analysis focuses on potential capital-intensive projects identified during the Level II analysis and involves more detailed field data gathering as well as a more rigorous engineering analysis. It provides detailed project cost and savings calculations with a high level of confidence sufficient for major capital investment decisions."

- Good to do before any major investments are made
- Whole building energy model is required for detailed savings analysis (eQUEST, Carrier HAP, etc.)

Audit Concepts – Power and Energy

- Power – Instantaneous Energy Use, Rate
  - Rating of a lighting bulb (40W, 100W, etc.)
  - Total capacity of a power plant (100MW)
  - Demand component of the utility bill (kW)
  - Size of an AC unit (5000BTU/h)

- Energy – Total Energy Used over Time, Amount
  - Total use of light bulb in one day
  - Daily output of a power plant
  - Usage component of the utility bill (kWh)
  - Usage of a window AC in a day (kWh)

Audit Concepts – Power and Energy

• I-P (English)

- Energy
  - **Kilowatt-Hour (kWh)**
  - **British Thermal Unit (Btu)**
  - **Therms**
  - **Tons of Cooling**
- Power
  - **Kilowatt (kW)**
  - **Btu/h**
  - **Horsepower (Hp)**

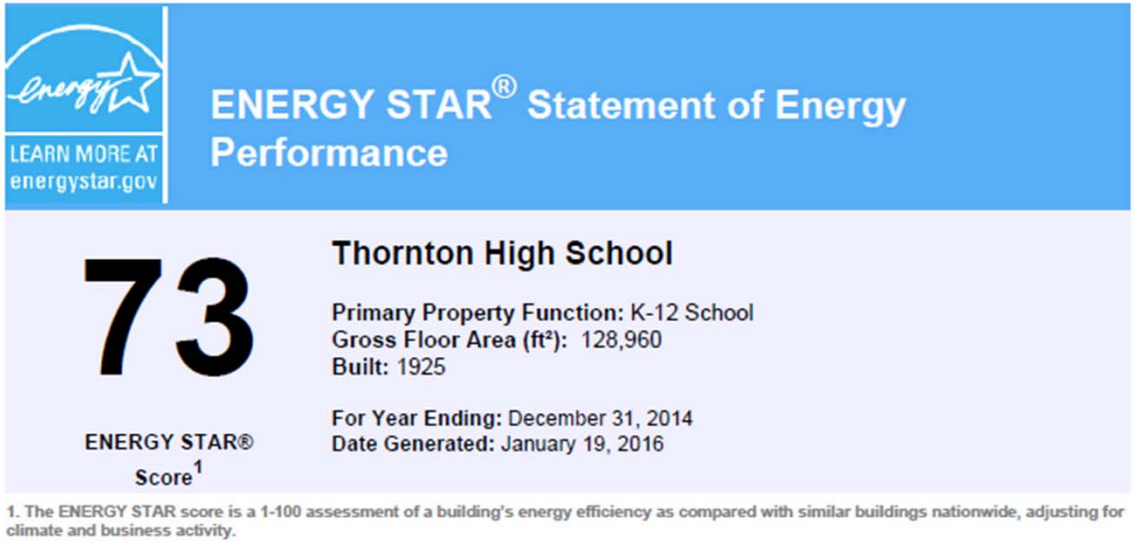
• SI (Metric)

- Energy
  - **Joules (J)**
- Power
  - **Joules/second (J/s)**
  - **Watt (W)**

***However, sometimes these terms and units are interchanged because of old conventions, so be careful… Btu vs Btu/h**

Audit Concepts - Terms

- ENERGY STAR® Score
  - 1 to 100 rating comparing your building to similar ones around the county.
  - Corrected for climate and building type.
  - Must get a 75 or above to apply for ENERGY STAR® certification. Must apply annually.



Audit Concepts - Terms

- EUI = Energy Use Intensity (kBtu/ft^2/yr)
  - Also known as Energy Utilization Index
  - Site and Source EUI

Energy Consumption and Energy Use Intensity (EUI)				
Site EUI	**Annual Energy by Fuel**		**National Median Comparison**	
67.4 kBtu/ft²	Fuel Oil (No. 2) (kBtu)	2,938,006 (34%)	National Median Site EUI (kBtu/ft²)	84.6
	Electric - Grid (kBtu)	2,069,037 (24%)	National Median Source EUI (kBtu/ft²)	129.8
	Natural Gas (kBtu)	3,679,300 (42%)	% Diff from National Median Source EUI	-20%
Source EUI			**Annual Emissions**	
103.3 kBtu/ft²			Greenhouse Gas Emissions (Metric Tons CO2e/year)	585

- EUI simply shows total energy per square foot
- A data center or hospital will have a much higher EUI than a school or warehouse…

Audit Concepts - Units

- MBtu = 1,000 Btu
  - M = thousand (roman numeral)
- MMBtu = 1,000,000 Btu
  - MM = thousand, thousand (roman numeral)
- Therm = 100,000 Btu

- 1 Ton of Cooling = 12,000 Btu/h
- 1 Watt = 3.41214 Btu/h
- 1 Hp = 2545 Btu/h

This barrel of oil contains:

- **42 gallons of crude oil**
- **5.8 MMBtu**
- **5800 Mbtu**
- **58 therms**

Audit Concepts - Units

- kW = 1,000 W
  - k = kilo, thousand (metric)
- MW = 1,000,000 W
  - M = mega, million (metric)
- GW = 1,000,000,000 W
  - G = giga, billion (metric)

- 0.746 HP = 1kW
- 3412 Btu = 1kW
- Volts x Amps = W
  - 100W bulb, at 120V, uses ~0.83A

This LED bulb uses:

- **10 Watts**
- **0.01 kW**
- **0.00746 hp**

And lasts for over 20 years!

When to Use an Energy Audit

- Decide on Level I, II, or III after Benchmarking or a Preliminary End Use Analysis has taken place
- Use metrics such as the ENERGY STAR® Score or EUI to compare your building to other similar building
- Buildings with a lower ENERGY STAR® Score or higher EUI will have more potential for energy savings. Usually….

What to Expect with an Energy Audit

- A report will be provided from the audit team
- What are the basic report outputs?
  - Utility Bill/Energy Analysis (Benchmarking)
  - O&M Practices Review
  - Facility Description
  - End Use Analysis
  - Table of Energy Conservation Measures (ECMs)
    - Can also be known as Facility Improvement Measures

What to Expect – Facility Description

Photo 9: Boiler #6

Photo 10: Burner Control Panel

- Facility Photos with Descriptions
- Narrative of Building Systems
- Description of Energy Using Systems

- Space Function Breakdown
- List of Hours of Occupancy

Space Type	Sq. Ft	% of Total
Office	169,092	29%
Garage	125,067	22%
Storage	70,219	12%
Machine Workshop	41,309	7%
Mechanical Equipment Rooms	33,883	6%
Locker Rooms	23,950	4%
Stairwell	22,662	4%
Electrical Rooms	17,116	3%
Residence Hall	17,115	3%
Unused	20,024	3%
Other (not identified)	14,368	2%
Tenant Leased	9,341	2%
Data Center / Computer Rooms	11,250	2%
Total	**575,396**	**100%**

What to Expect – End Use Analysis

- The End Use Analysis helps to show what uses what in your building:

	Existing Annual Energy Use				
End Use Type	**Electricity kWh**	**Natural Gas Therm**	**Steam kLbs**	**Fuel Oil Gal**	**Total Site Energy Use kBtu**
Space Heating	272,695	157,721	100,059		136,172,774
Domestic Hot Water/Cooking	222,688	144,724	3,613		19,546,260
Space Cooling	4,142,233				14,133,298
Ventilation/Fans	4,918,527				16,782,014
Lighting	4,094,976				13,972,058
Pumps	871,224				2,972,616
Process and Plug Loads/Misc.	503,444				1,717,750
Total Estimated	15,025,787	302,445	103,671.93	0	205,296,770
Total per Sq. Ft	21.5	0.4	0.1	0.0	293.5

What to Expect – Energy Conservation Measures

- Energy conservation measure summary table
- Measures ranked by simple payback, low to high

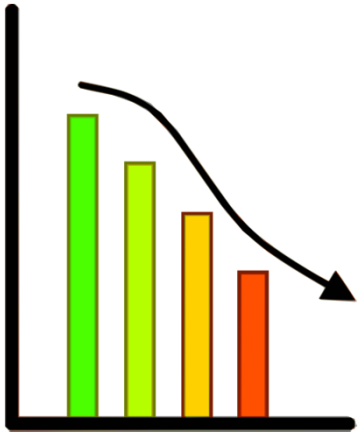
#	Energy Conservation Measure Description	Annual Energy and Cost Savings						
		Peak Demand Savings (kW)	Electricity Savings (kWh)	Steam Savings (kLbs)	CO2e Savings (kg)	Total Annual Energy Cost Savings	Material & Labor Cost	Simple Payback
1	Lighting Upgrade: Exterior Lighting LED	131	1,348,410	-	413,026	$ 161,809	$ 527,315	3.3
2	Lighting Upgrade: Interior T12 to LED	264	2,045,513	-	626,553	$ 245,462	$ 1,989,830	8.1
3	West Buildings DHW upgrade	-	-	2,298	128,213	$ 17,672	$ 166,898	9.4
4	Solar Photovoltaic Installation	-	2,119,986	-	649,364	$ 254,398	$ 4,322,620	17.0
5	Integrated Building Management System	-	-	-	-	$ -	$ 847,742	N/A
TOTALS (Recommended Measures)		**395**	**5,513,909**	**2,298**	**1,817,157**	**$ 679,341**	**$ 7,854,405**	**11.6**

Estimated Utility Rates		
Blended Electricity	$0.12	$/kWh
Natural Gas	$0.98	$/Therm
Steam	$7.69	$/kLb

How to Use the Reports

- Report should present economic analysis of measure in metric usable for owner to take action:
  - ROI = Return on Investment
  - Simple Payback
  - SIR = Savings to Investment Ratio
  - IRR = Internal Rate of Return

- Implement ECMs or FIMs!
- Track energy use over time
  - Metering
  - Benchmarking



Common Low/No Cost Measures

- Implement a Preventative Maintenance Program including tune/calibrate existing control system (DDC & pneumatic)
- Incorporate HVAC schedules (on/off & night setback)
- Adjust heating/cooling set-points & eliminate simultaneous heating & cooling
- Seal leaking ductwork
- Turn off plug loads when not in use (computers, printers, and other equipment)

Common Capital Improvement Measures

- HVAC
  - New direct digital HVAC controls
  - Steam trap survey & replacement
  - Testing, adjusting, and balancing
  - Boiler upgrades - condensing boilers or new burners
  - Thermostatic radiator valve installation (TRV's)
  - Variable frequency drive installation (VFD's)

- Electrical
  - Lighting retrofits to LED lamps/fixtures
  - Lighting controls, occupancy and daylighting sensors
  - Install digital metering

Common Energy Conservation Measures

- LED Lighting Upgrade
  - Lamps and fixtures are dropping in price rapidly
  - Paybacks are often between 1-3 years for direct replacement lamps, shorter if run 24/7
  - T8 fluorescent tube replacements have become very popular in the last 1 – 2 years, easy to install

Common Energy Conservation Measures

- Variable Frequency Drive Installation
  - Retrofit inlet guide vanes to full variable flow
  - Implement demand controlled ventilation
  - Install static pressure control for chilled/hot water pumps instead of bypassing the water
  - Upgrade cooling tower fan motors and implement variable speed control

Why are Energy Audits Important

Facility Improvement	• Resolve O&M Issues • Improve IAQ • Identify Staff Training Needs
Energy Savings	• Reduce Utility Bills • Reduce Overall Operating Costs
Sustainability	• Reduce Carbon Footprint • Improve Energy Star Rating Or Other Benchmarks

The Difference Between Audits and EBCx or RCx

	EBCx	Audit
Walkthrough	X	X
Document Review (As built, Tenant Interviews, TAB reports, CFR, Submittals, Previous System Manuals, review O&M work request, Energy Audits/Facility Assessment documents, etc.)	X	
Utility Bill Analysis	X	X
O&M Practices: Interviews & Reviews	X	X
Facility Improvement Measurements (FIM) Identified	X	X
Identifying Capital Improvement Opportunities	X	X
System Sequence Testing	X	
System Functional Testing	X	
Data & Trend Logging & Analysis	X	

- Energy audits have no functional testing
- Audits are focused on potential future system improvements
- Many new state and city laws require RCx or EBCx to be performed

Thank You

Questions