AABC Commissioning Group
AIA Provider Number 50111116

Standard 211P: Taming the "Wild West" of Commercial Building Energy Audits

Course Number: CXENERGY1618

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April 12, 2016

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Course Description

Standard 211P will change the way that ASHRAE defines Level 1, 2 and 3 energy audits, including energy auditor qualifications and options for online audit delivery and data exchange formats. The chairman of the committee developing the standard provides vital insight for energy auditors and those with plans to hire one.

Learning Objectives

At the end of the this course, participants will be able to:

1. Understand the basic purpose for each of the ASHRAE Audit Levels 1, 2 and 3.
2. Identify new reporting procedures that will likely be part of the new ASHRAE Energy Audit Standard.
3. Describe how BuildingSync can be used to communicate energy audit results.
4. Identify common credentials that have been used to qualify energy auditors.

First, a little history

Energy Audits are like photography

- Everybody thinks they can do it
- Tools are cheap and available
- Producing a product is easy
- But results may vary…
- Lack of Standard Methods
- Lack of Consistent Reports

Need to maintain:
- Safety / IAQ
- Comfort
- Reliability

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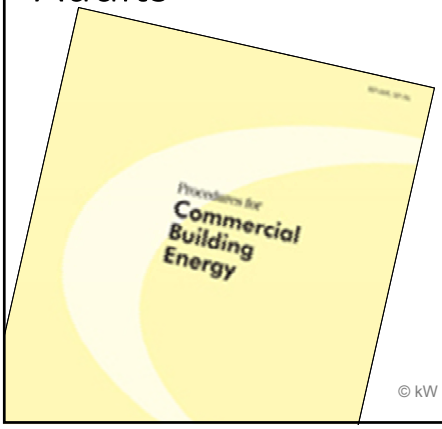
ASHRAE Procedures for Commercial Building Energy Audits



1st Edition emphasized:

- Levels of Effort
  - I, II, III
- Forms
  - Audit forms
  - Site use

Became de facto standard

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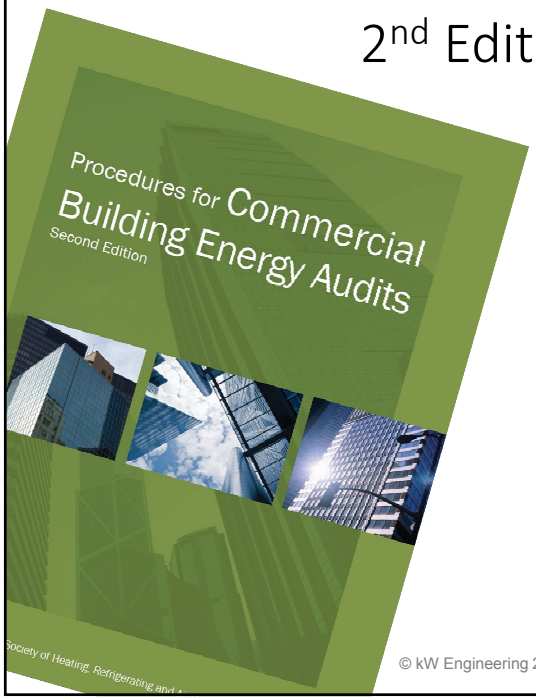
2nd Edition

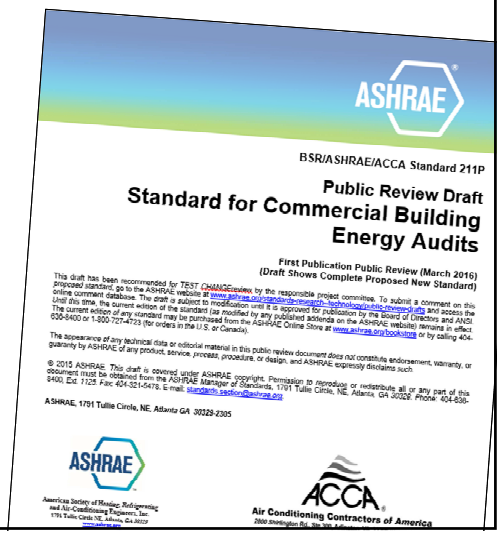


Added:

- Best Practice Methods
  - Site visit methods
  - Measurement methods
  - Economic evaluation
  - How to get a good bid
- Resources
  - Audit forms
  - EEM ideas
  - Simulation checklists

ASHRAE Standard 211 - Proposed

- Lots of adoption by cities who are writing their own standards
- Clarify intent, remove ambiguity
- Set a bar for the minimum, legal standard (not best practice)



Purpose

The purpose of this standard is to establish consistent practices for conducting and reporting energy audits for commercial buildings.

This standard:

a. defines the procedures required to perform Energy Audits Levels 1, 2 and 3,
b. provides a common scope of work for these audit levels for use by building owners and others,
c. establishes consistent methodology and minimum rigor of analysis required, and
d. establishes minimum reporting requirements for the results from energy audits.

Scope – Standard 211

This standard applies to all buildings except single-family houses, multifamily structures of three stories or fewer above grade, manufactured houses (mobile homes), and manufactured houses (modular).

- Commercial
- Multifamily

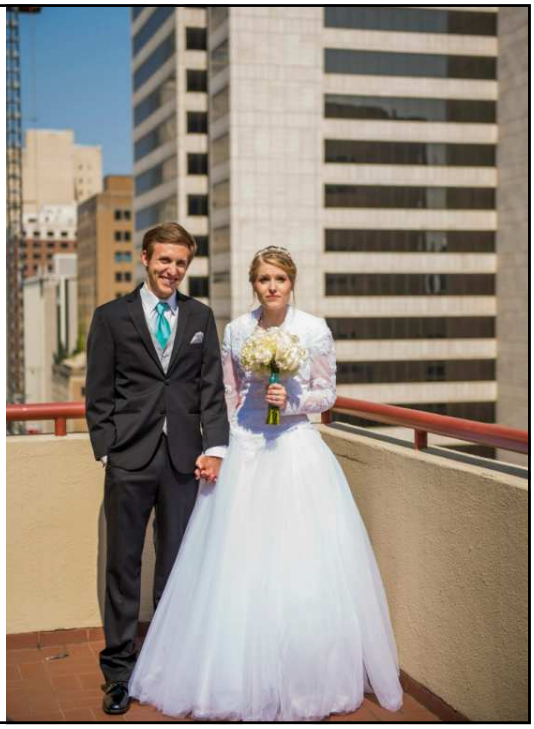
Not included:

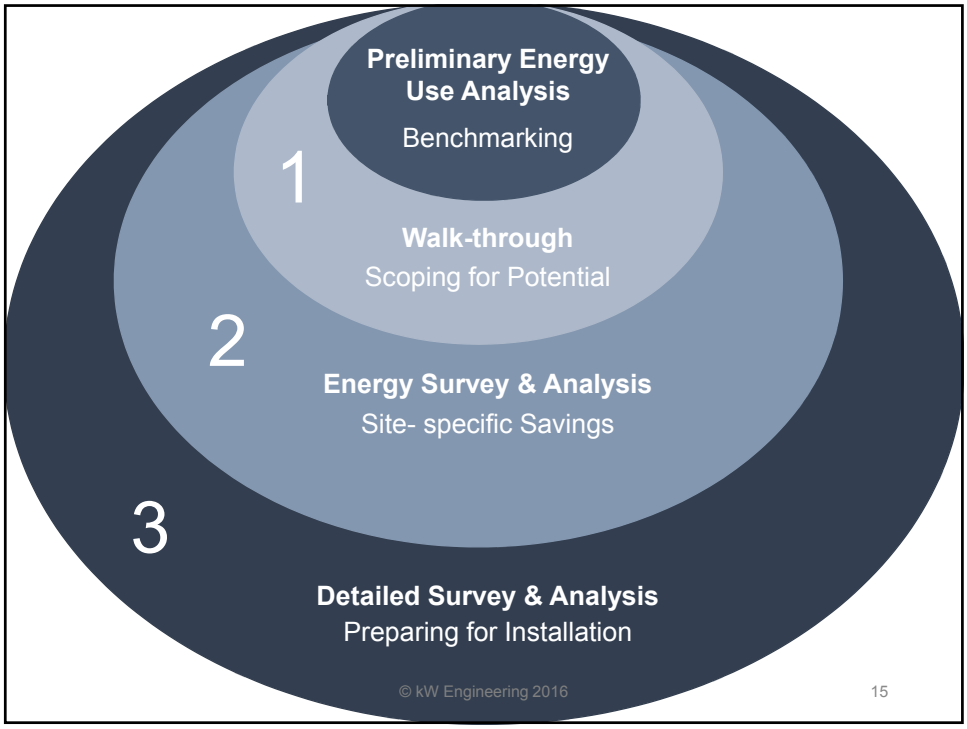
- Industrial processes
- Agricultural processes
- Irrigation

Mandatory Audits

An “awkward wedding”?

- Cities want to encourage energy savings
- Puts regulatory pressure on building owners
- Downward pressure on price
- Can lose sight of value




Preliminary Energy Use Analysis
Benchmarking
1
Walk-through
Scoping for Potential
2
Energy Survey & Analysis
Site- specific Savings
3
Detailed Survey & Analysis
Preparing for Installation
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What they're not: versions of the same thing
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What they're not: continuously adjustable scale

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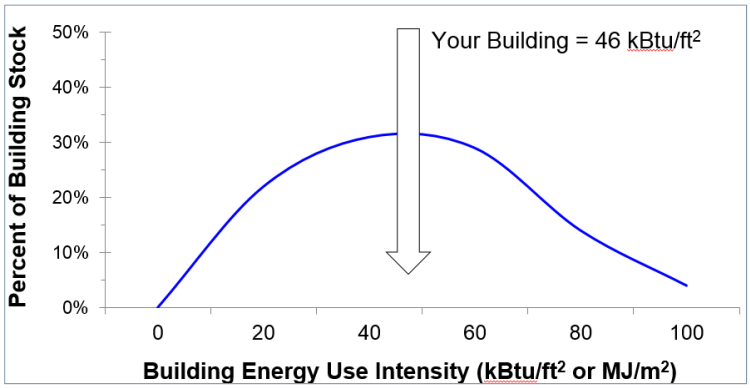
Prelim - Benchmarking

- ENERGY STAR
- CBECS
- Others (documented)
- ASHRAE bEQ
- DOE BPD
- ASHRAE Applications Handbook (Chap 36)



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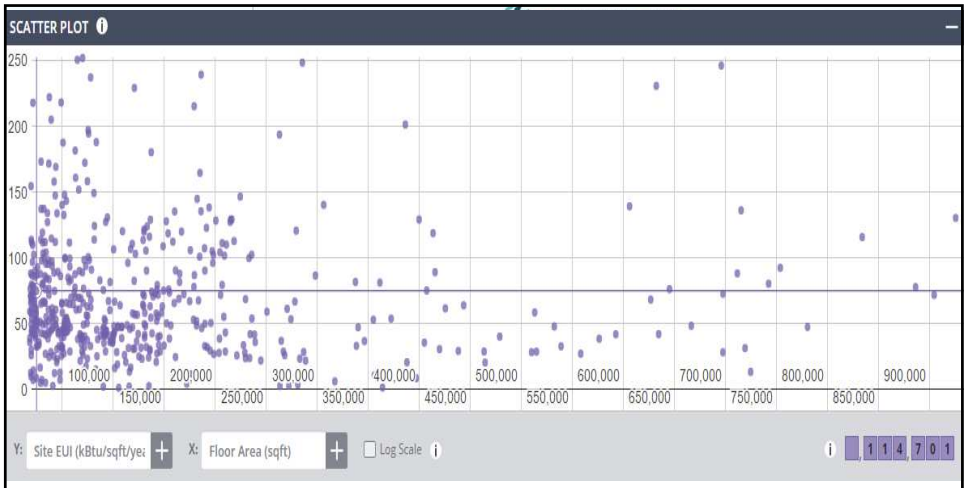


DOE Building Performance Database

bpd.lbl.gov

Level 1 – Scoping

OLD	NEW
• "Walk-thru Analysis"	• "Level 1 Audit"
• Utility summary	• STET
• Check correct rate	• STET
• Savings to target	• STET
• Quantified no-cost and low-cost EEMs	• Qualitative only.

Utility Summary

Level 1 Audit - Metered Energy

(use multiple copies to show prior years)

Building Name	Test Building Input Data	Date	user input
Gross floor area	20880		calculated

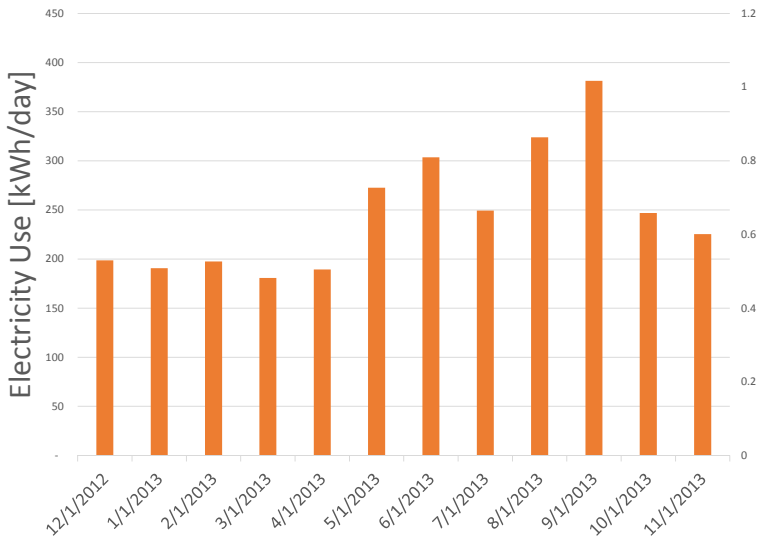
Energy Type X (if applicable)

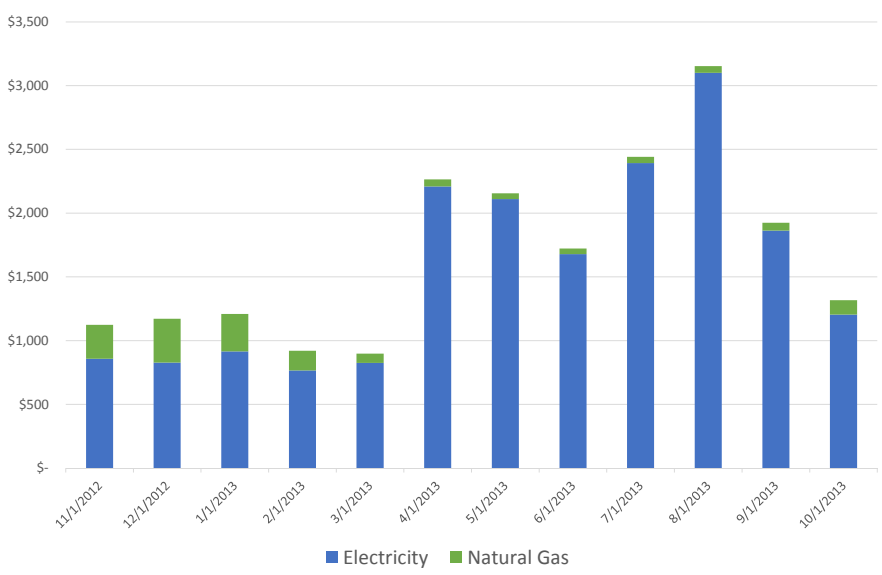
Start Date	End Date	Days	Electricity Use (kWh)	Electricity Peak (kW)	Electricity Load Factor [-]	Electricity Cost ($)	Natural Gas Use (Therms)	Natural Gas Cost ($)	Energy Type X* Use (ton-hrs)	Energy Type X* Cost ($)	Total Cost ($)
10/25/2013	11/23/2013	30	6,760			$ 1,204	207	$ 113			$ 1,317
9/26/2013	10/24/2013	29	7,160			$ 1,863	94	$ 61			$ 1,924
8/27/2013	9/25/2013	30	11,440			$ 3,100	69	$ 53			$ 3,153
7/27/2013	8/26/2013	31	10,040			$ 2,393	52	$ 48			$ 2,441
6/27/2013	7/26/2013	30	7,480			$ 1,679	43	$ 43			$ 1,722
5/29/2013	6/26/2013	29	8,800			$ 2,110	52	$ 46			$ 2,156
4/27/2013	5/28/2013	32	8,720			$ 2,209	73	$ 56			$ 2,265
3/28/2013	4/26/2013	30	5,680			$ 825	121	$ 73			$ 898
2/27/2013	3/27/2013	29	5,240			$ 766	288	$ 154			$ 920
1/26/2013	2/26/2013	32	6,320			$ 916	604	$ 293			$ 1,209
12/27/2012	1/25/2013	30	5,720			$ 827	759	$ 345			$ 1,172
11/27/2012	12/26/2012	30	5,960			$ 858	540	$ 266			$ 1,124
Annual Total		362	89,320	-		$ 18,750	2,902	$ 1,551	-	$ -	$ 20,301

Unit X: Definition kBtu/unit 12

Units ton-hrs

Notes:





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Level 1 Audit - Recommended Energy Efficiency Measure Summary

Recommendations	Modified System	Savings Source	Impact on Occupant Comfort	Effect on Building Systems	Cost	Savings Impact	Typical ROI	Priority
Add VFD to Chilled Water Pumps	CHW Distribution	Reduced CHW pumping energy	- none -		–	▲	▲	▲
Convert manual radiator valves to thermostatic models	Steam Radiators	Reduced excess steam heat	Improved temperature control in zones		▲	–	–	–
Demand Controlled Ventilation	Air Distribution	Reduced outside air when not needed	Improved ventilation during min OA hours		–	–	–	–

Key	▲ high	– med	▼ low

Changes: L1 Simplifications

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Level 1 Audit - Building Characteristics

Building Name	Test Building Input Data	user input
Energy Auditor	John Doe	calculated
Street	9999 Tulie Circle	
City	Atlanta	
State	GA	
Postal Code	99999-9999	
Date of site visit(s)	7/4/2015	
Primary Building use type	Office	

			Base		
Heating Degree Days (HDD)	9999.0	°F	65.0	Year of construction	1888
Cooling Degree Days (CDD)	9999.0	°F	65.0	Last Renovation	2001
Base	65.0	°F		Year of Prior Energy Audit	2001
Year of Data	2010			Year Last Commissioned	2010
				Building automation system? (Y/N)	Yes
Gross floor area	20,880	sq ft		Historical landmark status? (Y/N)	No
Spaces excluded from gross floor area	Parking areas				
Total conditioned area	198,000	sq ft		Percent owned (%)	100%
Conditioned area (heated only)	99,000	sq ft		Percent leased (%)	0%
Conditioned area (cooled only)	99,000	sq ft			
Conditioned Floors					
Above grade	99				
Below grade	99				

Primary building use

Typical occupancy	60	hours/week
Typical occupancy	52	weeks/year
Typical number of occupants (occ hours)	99,999	

Energy Sources

Energy Source	Accont #	Type	Rate schedule
Electricity	999-9999	Direct metering	WSE 999-999
Electricity	999-9999	Master meter without sub-metering	
Natural gas	999-9999	Master meter with sub-metering	
Chilled Water	999-9999	Combination	
Hot Water	999-9999	Unknown	
Fuel Oil	999-9999		
Steam	999-9999		
Renewable Energy	999-9999		
Other	999-9999		

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Level 2 – Recommendations

Probably the most-cited audit level

OLD	NEW
• "Energy Survey Analysis"	• "Level 3 Audit"
• Detailed Measure Evaluation	• STET
• "Financial evaluation"	• Simple PB and ROI
• Meet w/ owners rep	• STET
• The end use "pie"	• STET (for > 5% of use)
• Recommended M&V	• [Removed]
• Cost estimates	• Consider specific factors.

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Level 2 Audit - HVAC System

(check all that apply)

Cooling Distribution Equipment Type	☐ Air Handler Unit (AHU) ☐ Constant Volume ☐ VAV ☐ Hydronic to zone equipment (e.g. fan coil units, packaged terminal units or radiators) ☐ Refrigerant to zone equipment (e.g. fan coil units, packaged terminal units or radiators) ☐ None (i.e. electrically driven PTAC, baseboards) ☐ Other		
Heating Distribution Equipment Type	☐ Air Handler Unit (AHU) ☐ Constant Volume ☐ VAV ☐ Hydronic to zone equipment (e.g. fan coil units, packaged terminal units or radiators) ☐ Steam to zone equipment (e.g. fan coil units, packaged terminal units or radiators) ☐ None (i.e. electrically driven PTAC, baseboards) ☐ Other		
Cooling Source	☐ No cooling ☐ DX cooling ☐ Central plant ☐ Chiller ☐ District chilled water ☐ Other (specify)	Chiller Input	☐ Electricity ☑ Gas Absorption ☐ Gas ☐ Steam Absorption ☐ Oil (specify grade) ☐ Steam Turbine ☑ Other
		Compressor	☐ Reciprocating ☐ Scroll/Screw ☐ Centrifugal ☐ Other
		Condenser	☐ Air ☑ Water ☐ Ground ☑ Indirect Evaporative ☐ Direct Evaporative
Heating Source	☐ No heating ☐ Central furnace ☐ Heat pump ☐ Central plant ☐ District steam or hot water ☐ Other	Heating fuel	☐ Electricity ☐ Gas ☐ Oil (specify grade) ☐ Other
			☐ Steam boiler ☐ Mechanical draft ☑ Other ☐ Hydronic boiler ☑ Mechanical draft ☑ Other
	☐ No SHW		☐ Electricity

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Level 2 Audit - Lighting

(group by lighting types / fixtures that collectively make up the largest fraction of gross floor area)

Lighting Source Type(s)	Ballast Type(s)	Control(s)	Space Type(s)	Approx % Area Served

Lighting type(s)
(CFL, Fluorescent T5/High output T5; Fluorescent T8/Super T8; Fluorescent T12/High output T12; High pressure sodium; Incandescent/Halogen; LED; Mercury vapor; Metal halide)
Ballast Type(s) (Electronic, magnetic, N/A)
Control(s) (none, manual, occupancy sensor, photocell, timer, BAS, advanced, other)
Space Type(s) (Office, hallways, mech. spaces, exterior)
Approx % Area Served (>10, 10, 25, 50, 75, 90, 100)

"For each Practical EEM, the energy audit report shall include built-up cost estimates and assumptions made in developing the measure cost estimates including, as applicable:"

Cost factors*

- Material costs
- Labor costs
- Design fees
- Construction management
- Site-specific installation factors
- Permits
- Temporary services
- Utility service upgrades
- Commissioning
- Location(s),
- Equipment capacity(ies), and
- Year of basis of reference
- Any additional adjustments that, in the judgment of the energy auditor, would significantly impact the cost estimate for the measure.

* As applicable

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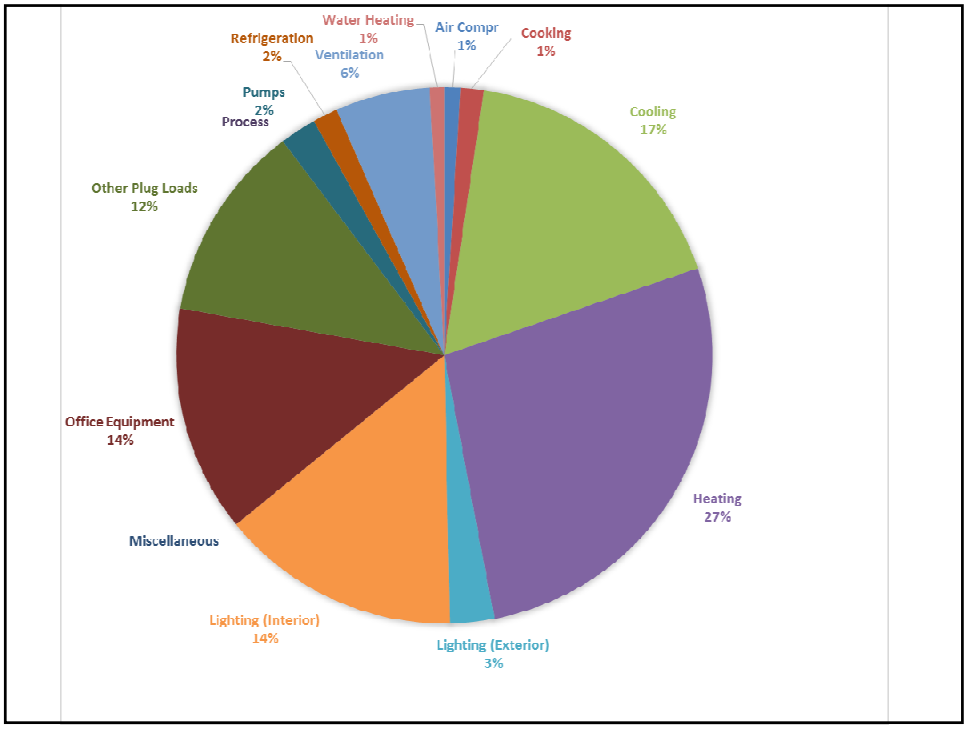
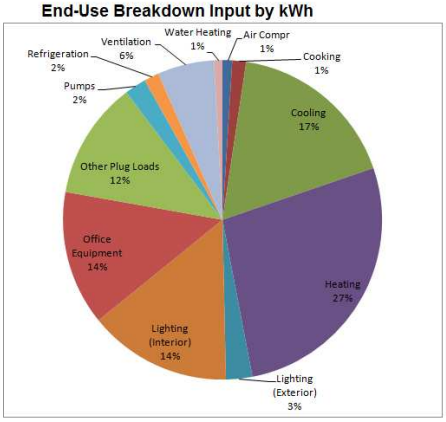
Savings Calcs

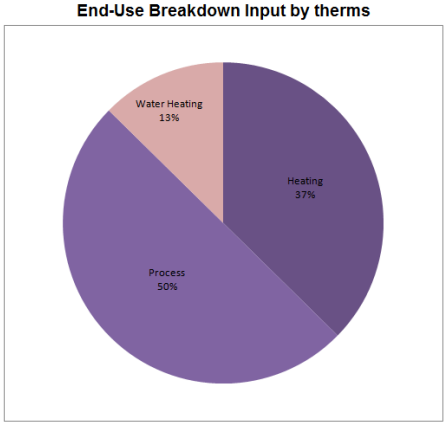
- State assumptions
- "…same energy analysis method shall be used for pre-retrofit and post-retrofit calculations. "
- State changes
- EEM interaction
- No "black boxes"
- Simulation inputs

Base Case		
CFM	36,040	
SP	1.75	
Fan Eff	70%	
Fan BHP	14.2	
Motor Eff	85.5%	
Fan kW	12.4	
hours	3,128	
Annual use	38,705	kWh
Proposed Case		
Fan kW	12.4	
hours	2,607	
Annual use	32,255	kWh
Savings		
Base Annual use	38,705	kWh
Proposed Annual use	32,255	kWh
Annual Savings	6,451	kWh



Separate Fuels





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	Input Energy Units			Combined Energy Use	
End Use	kWh	therms	gallons (propane)	kBtu	%
Air Compressors	25,000	-		85,304	1%
Cooking	36,000	-	9,800	1,017,870	6%
Cooling	445,996	-		1,521,800	10%
Heating	699,993	20,640		4,452,455	28%
Lighting (Exterior)	68,455	-		233,578	1%
Lighting (Interior)	371,996	-		1,269,304	8%
Miscellaneous	-	-	5,600	511,448	3%
Office Equipment	350,856	-		1,197,170	8%
Other Plug Loads	305,997	-		1,044,105	7%
Process	-	27,620		2,761,972	18%
Pumps	56,525	-		192,871	1%
Refrigeration	38,500	-		131,367	1%
Ventilation	146,999	-		501,580	3%
Water Heating	22,000	6,970		772,059	5%
Total Estimated	**2,568,316**	**55,229**	**15,400**	**15,692,885**	**100%**
Historical Billing	**2,575,020**	**56,800**	**15,500**	**15,881,949**	
Percent of Actual	**99.7%**	**97.2%**	**99.4%**	**98.8%**	
Total per ft^2	**25.7**	**0.6**	**0.2**	**156.9**	

Example QC Table

Energy Efficiency Measure	Annual Savings [kWh]	End Use Consumption [kWh]	% of End Use
Lighting Upgrade	55,000	372,000	15%
Economizer Repair	36,000	446,000	8%
Air Compressor Replacement	26,000	25,000	104%

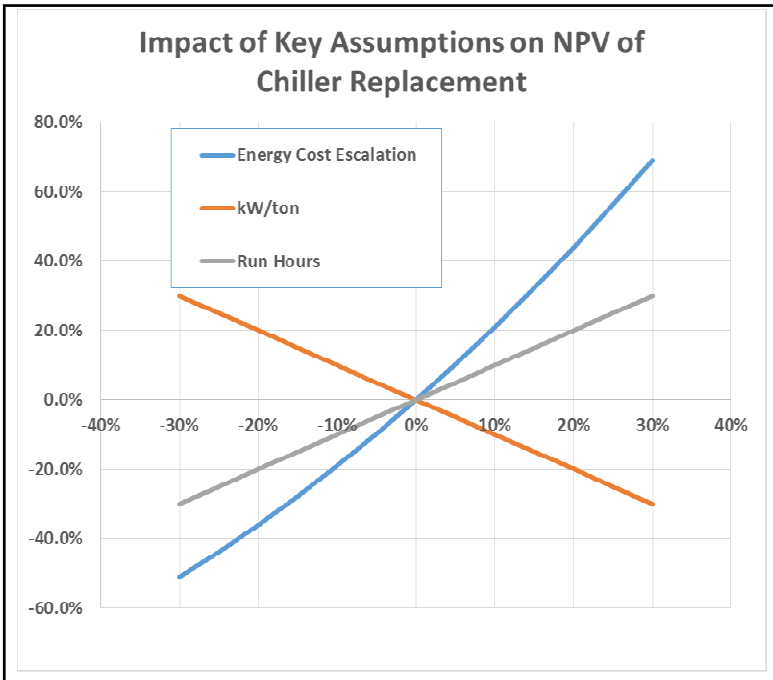
Level 3 – Development

OLD	NEW
• "Detailed Analysis of Capital Intensive Modifications"	• "Level 3 Audit"
• Interactions	• STET
• Additional measurement/analysis	• Yes, for EEMs > 15% of total savings
• Schematic layouts	• STET
• Life-cycle Cost Analysis	• STET.

Level 3 Additions

- Risk Assessment
- Hourly models for envelope measures
- Modeling calibration

L3+



Risk Assessment (e.g.)

Modeling calibration

Data	$CVRMSE_{MAX}$	$NMBE_{MAX}$
Monthly	15%	5%
Hourly	30%	10%

$$CVRMSE = 100 * \frac{\sqrt{\frac{\sum(y_i - \hat{y}_i)^2}{n-1}}}{\bar{y}}$$

$$NMBE = 100 * \frac{\sum(y_i - \hat{y}_i)}{(n-p) * \bar{y}}$$

Where:

CVRMSE = coefficient of variation of the root mean square error

NMBE = normalized mean bias error

y = measured value

y^ = model predicted value

ybar = mean value of the measured data

n = number of data points in sample

p = P-value; for this purpose p = 1

Who should do an audit?

ASHRAE Std 100 example

qualified energy auditor: a person having training and expertise in building energy auditing; any one of the following:

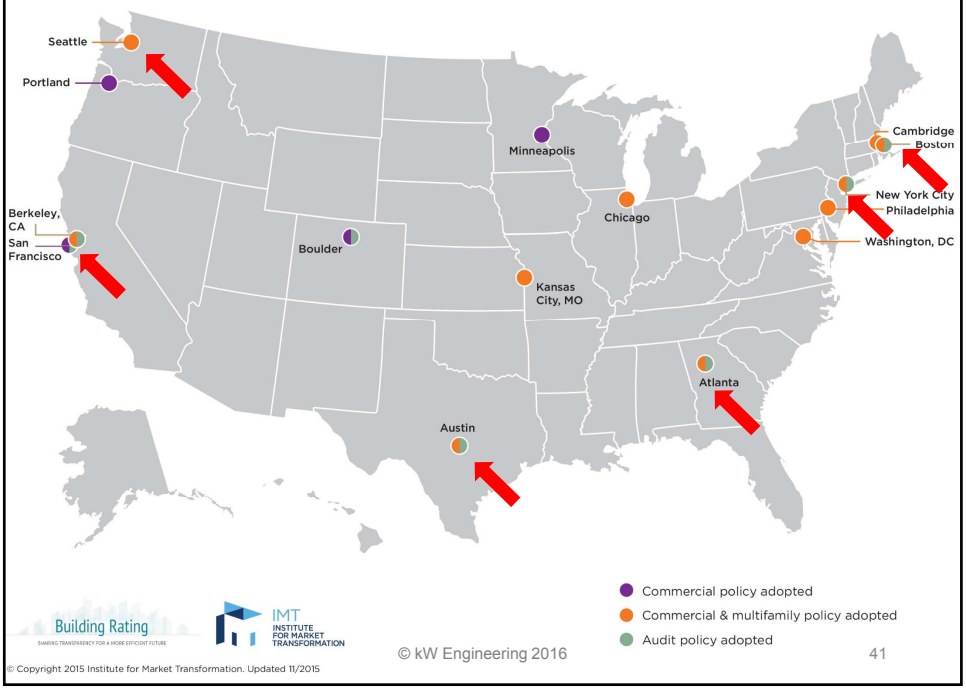
a. A licensed professional architect or engineer in the jurisdiction where the project is located
b. An energy auditor/assessor/analyst certified by ASHRAE or AEE for all building types, or certified by BPI or RESnet for residential buildings
c. A person qualified by the AHJ

Working Definition

qualified energy auditor: an energy solutions professional who assesses building systems and site conditions; analyzes and evaluates equipment and energy usage; and recommends strategies to optimize building resource utilization. Experience must include completion of five commercial (non-residential) energy audits within the past three years, and be one of the following:

a) A Building Energy Assessment Professional (BEAP), Certified Energy Manager (CEM), or Certified Energy Auditor (CEA) as certified by ASHRAE or AEE respectively,
b) A person who holds a certification from a credentialing program approved by the U.S. Department of Energy Better Buildings Workforce Guidelines for Building Energy Auditors.
c) A licensed Professional Engineer or a Licensed Contractor specifically approved to perform energy audits by the authority having jurisdiction.
d) A person qualified by the authority having jurisdiction.

U.S. City Building Benchmarking, Transparency, and Audit Policies



Building Rating

IMT INSTITUTE FOR MARKET TRANSFORMATION

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Qualifications

City/State	AEE CEA	AEE CEM	AEE EBCP	AEE CBCP	ASHRAE BEAP	ASHRAE CPMP	ASHRAE HBDP	PE	Reg. Arch.	EMC (Northwest)	MFBA	NYSERDA FlexTech	AABC TBE	PhD Mech Eng	BOC	Op. Eng. CES	Auditing Exp. Only	ESCO	Pre-Qual List
New York City	Y	Y			Y		Y				Y	Y							
San Francisco		Y+2	Y+2	Y+2	Y+2	Y+2		Y+2		Y+2				Y+2	Y+5	Y+5			
Atlanta	Y+2				Y+2			Y+2	Y+2				Y+2				Y+5		
Boulder	Y+3	Y+3			Y+3			Y+3	Y+3	Y+3									
Austin																			Y
Berkeley	Y	Y			Y			Y											Y
Washington																		Y	

Y+N = Yes, with N years of auditing experience

Thanks to Andrew Parker at NREL for this list!

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Qualification Thresholds Used by Cities

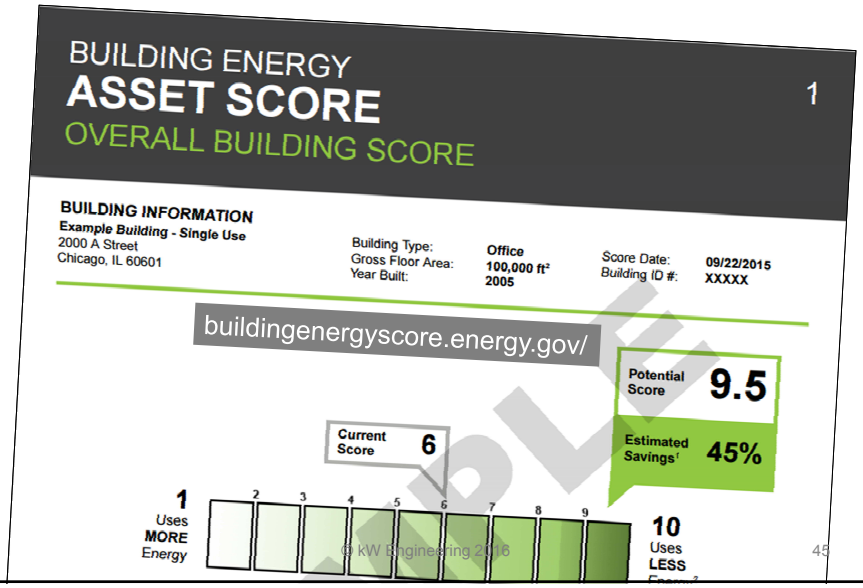
AEE CEA	AEE Certified Energy Auditor
AEE CEM	AEE Certified Energy Manager
ASHRAE BEAP	ASHRAE Building Energy Assessment Professional
ASHRAE HBDP	ASHRAE High Performance Building Design Professional
MFBA	Multi Family Building Analyst
NYSERDA FlexTech	NYSERDA FlexTech
PE	Professional Engineer
Reg. Arch.	Registered Architect
AABC TBE	Associated Air Balance Council Test & Balance Engineer
PhD Mech Eng	PhD Mechanical Engineering
ASHRAE CPMP	ASHRAE Commissioning Process Management Professional
AEE EBCP	AEE Existing Building Commissioning Professional (EBCP)
AEE CBCP	AEE Certified Building Commissioning
EMC (Northwest)	Northwest Energy Management Certification
BOC	Int'l Building Operator Certification Level II
Op. Eng. CES	Int'l Union of Operating Engineers Cert. Energy Specialist
Auditing Exp. Only	Energy Auditing Experience without any qualifications
ESCO	Energy savings performance contractor
Pre-Qual List	City provides a list of qualified auditors

Suggested Outlines (not required)

1. EXECUTIVE SUMMARY
    a. Overall Assessment of Benchmarking and Energy Performance
    b. Aggregated Savings and Costs of Recommended Measures
    c. Table of Recommended Measures with Savings and Costs
2. INTRODUCTION
    a. Audit Scope
    b. Key Dates
    c. Contact Information
3. FACILITY DESCRIPTION
    a. Building Information
    b. Building Envelope
    c. HVAC
    d. DomesticService Hot Water
    e. Lighting
    f. Electrical
    g. Process and Plug Loads, Vertical Transportation
4. HISTORICAL UTILITY DATA
    a. Data Summary and Rate Structure
    b. Benchmarking
    c. Target and Savings Estimate
    d. End-Use Breakdown
5. ENERGY SAVING OPPORTUNITIES
    a. Low Cost/No Cost Savings Measures
    b. Capital Projects
    c. EEMs Considered but Not Recommended
    d. O&M Measures
6. SPECIAL CONDITIONS

APPENDICES
- Tabulated Utility Data
- Utility Rate Schedules
- Calculation Methodology
- Savings Calculations
- Cost Estimates
- Equipment Inventory Tables
- O&M Logs
- Equipment Specifications

Links to DOE Asset Score


BUILDING ENERGY
ASSET SCORE
OVERALL BUILDING SCORE
1

BUILDING INFORMATION
Example Building - Single Use
2000 A Street
Chicago, IL 60601

Building Type: Office
Gross Floor Area: 100,000 ft²
Year Built: 2005

Score Date: 09/22/2015
Building ID #: XXXXX

buildingenergyscore.energy.gov/

Potential Score 9.5

Estimated Savings[1] 45%

Current Score 6

1 Uses MORE Energy

10 Uses LESS

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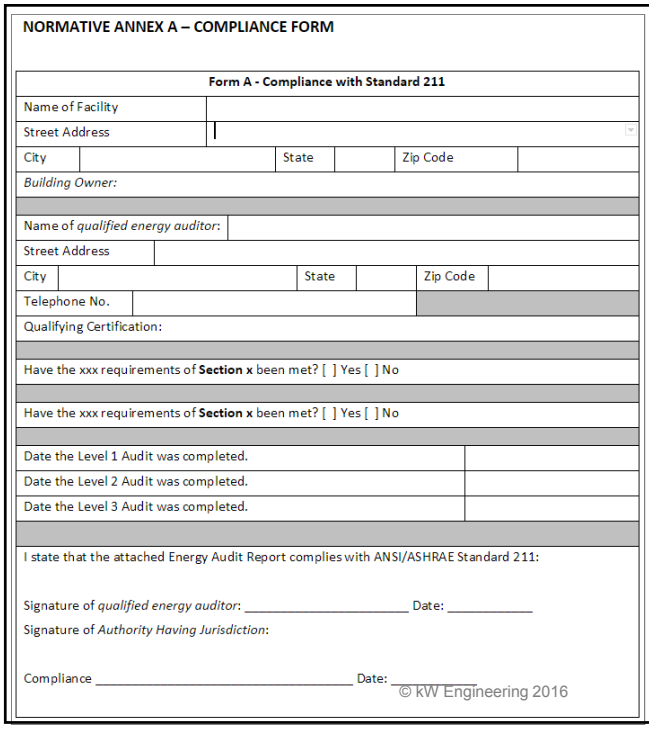
NORMATIVE ANNEX A – COMPLIANCE FORM

Form A - Compliance with Standard 211

Name of Facility					
Street Address					
City		State		Zip Code	
Building Owner:					
Name of *qualified energy auditor*:					
Street Address					
City		State		Zip Code	
Telephone No.					
Qualifying Certification:					
Have the xxx requirements of **Section x** been met? [ ] Yes [ ] No					
Have the xxx requirements of **Section x** been met? [ ] Yes [ ] No					
Date the Level 1 Audit was completed.					
Date the Level 2 Audit was completed.					
Date the Level 3 Audit was completed.					

I state that the attached Energy Audit Report complies with ANSI/ASHRAE Standard 211:

Signature of *qualified energy auditor*: _____ Date: _____

Signature of *Authority Having Jurisdiction*:

Compliance _____ Date: _____

Compliance Form

- You will need to submit a form that says you comply
- If AHJ requires a license to submit …

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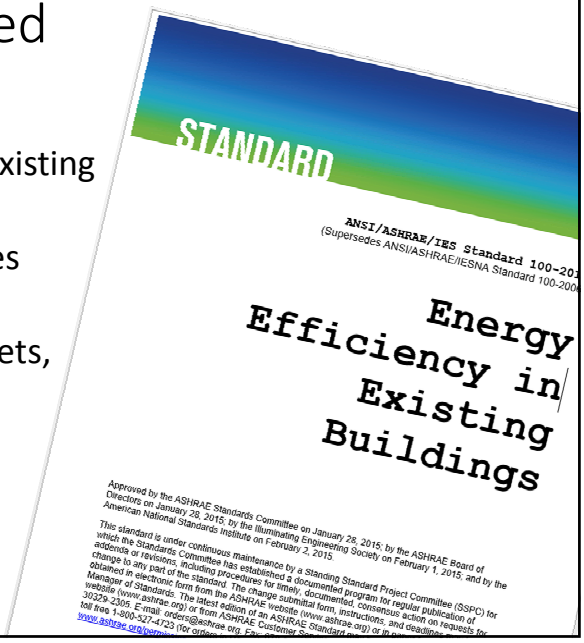
What next?

- Next Public Review this spring (I hope)
- Comments by June
- Edits in the Fall
- Vote for publication Jan 2017

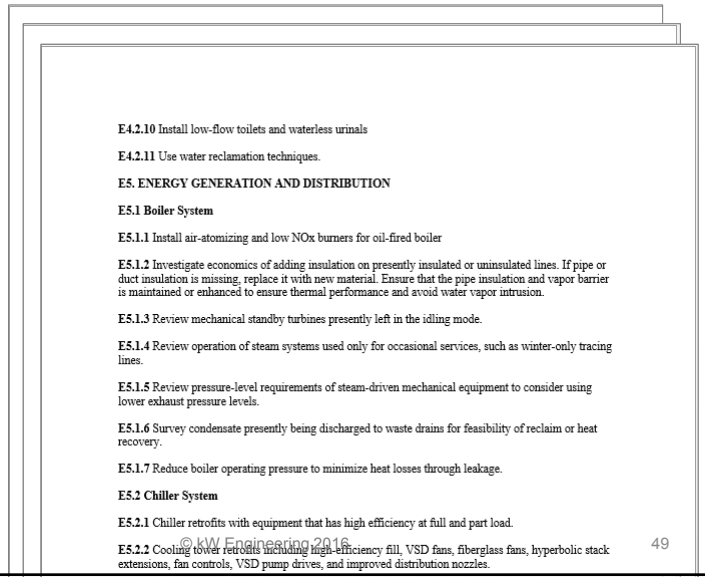
Now Published

ASHRAE Standard 100

- Energy Efficiency for Existing Buildings
- For most buildings uses energy targets
- For buildings w/o targets, requires ASHRAE Level 2 Energy Audits (within 10% annual spend cost cap)



Std 100
Measure Recommendations



E4.2.10 Install low-flow toilets and waterless urinals

E4.2.11 Use water reclamation techniques.

E5. ENERGY GENERATION AND DISTRIBUTION

E5.1 Boiler System

E5.1.1 Install air-atomizing and low NOx burners for oil-fired boiler

E5.1.2 Investigate economics of adding insulation on presently insulated or uninsulated lines. If pipe or duct insulation is missing, replace it with new material. Ensure that the pipe insulation and vapor barrier is maintained or enhanced to ensure thermal performance and avoid water vapor intrusion.

E5.1.3 Review mechanical standby turbines presently left in the idling mode.

E5.1.4 Review operation of steam systems used only for occasional services, such as winter-only tracing lines.

E5.1.5 Review pressure-level requirements of steam-driven mechanical equipment to consider using lower exhaust pressure levels.

E5.1.6 Survey condensate presently being discharged to waste drains for feasibility of reclaim or heat recovery.

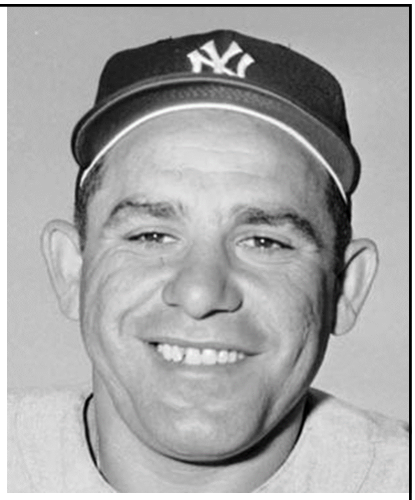
E5.1.7 Reduce boiler operating pressure to minimize heat losses through leakage.

E5.2 Chiller System

E5.2.1 Chiller retrofits with equipment that has high efficiency at full and part load.

E5.2.2 Cooling tower retrofits including high-efficiency fill, VSD fans, fiberglass fans, hyperbolic stack extensions, fan controls, VSD pump drives, and improved distribution nozzles.

Trends in Audits



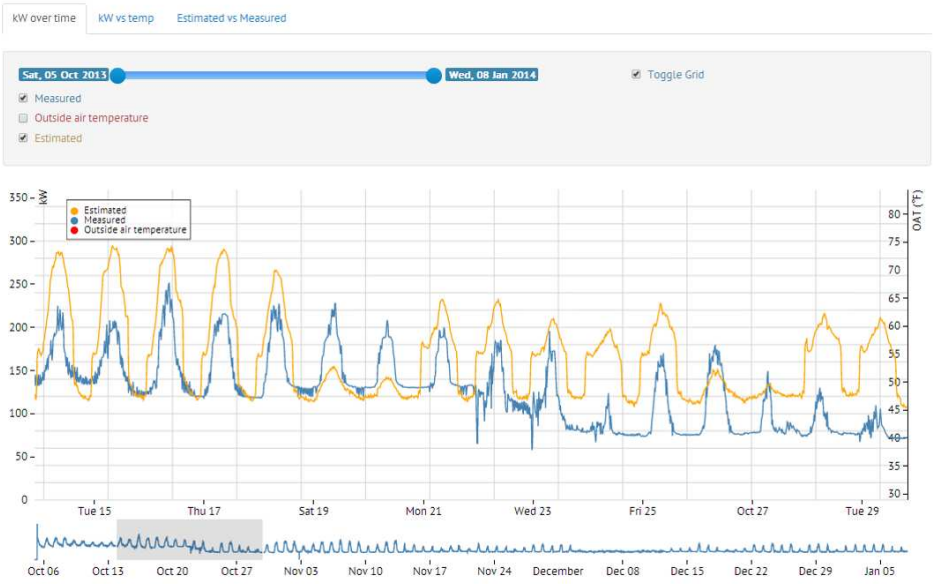
"The future ain't what it used to be."

- Yogi Berra

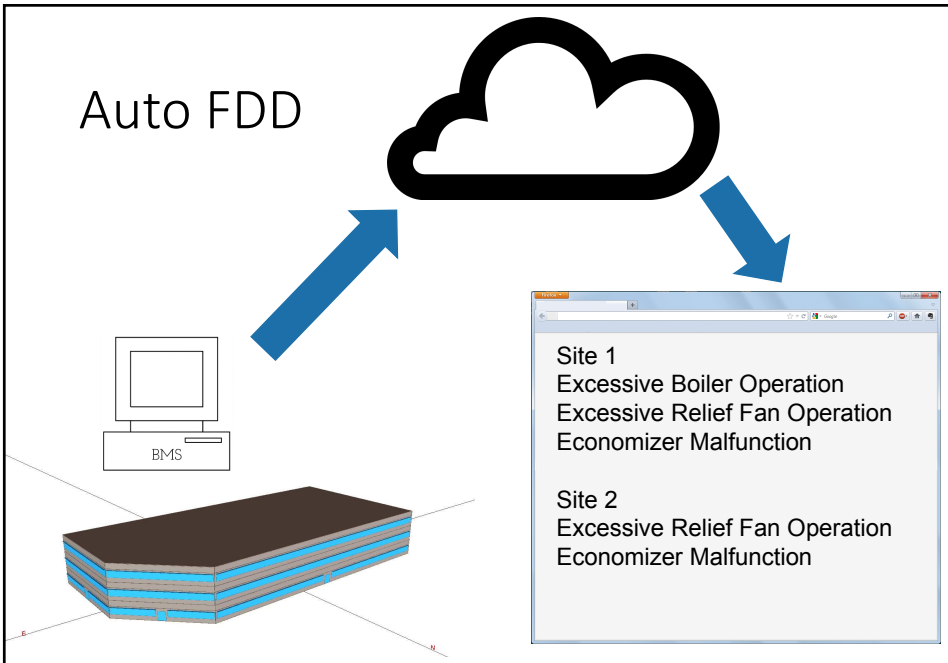
Software Innovation Impact on Energy Audits

- Visualizations
- M&V
- Automated Fault Detection & Diagnostics (Auto FDD)
- “No-touch” or “remote audits”
- Data Collection
- Reporting

Measurement & Verification

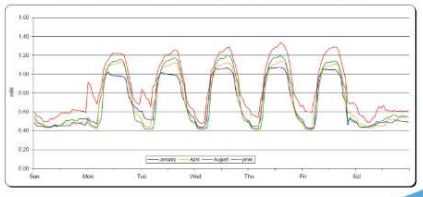


Auto FDD



Data Collection

Interval Data



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EEMs

- Schedule Hot Water Pumps
- Schedule AHU's
- Sequence HHW valve, economizer and CHW valve
- Install dead-band thermostats
- SAT reset
- SP reset
- Occupancy controlled zones

"No Touch" Audits

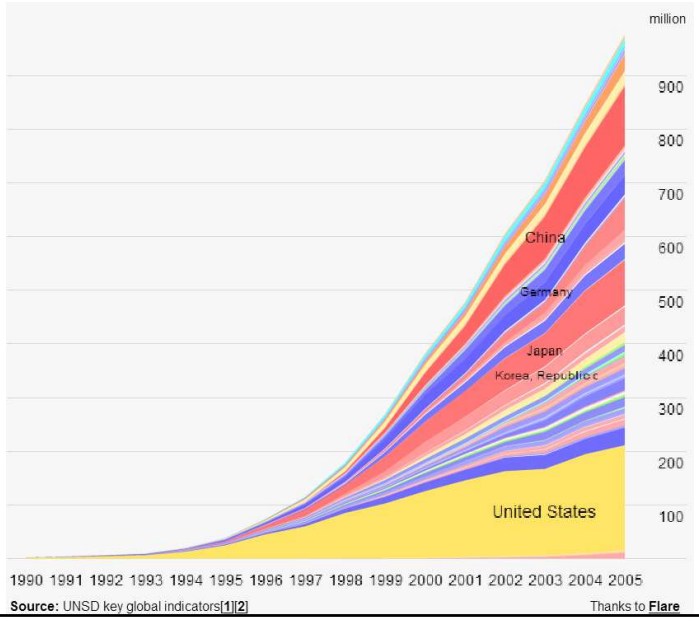
Disruptive Innovation - Clayton Christensen

www.claytonchristensen.com/key-concepts/ ▾ Clayton M. Christensen ▾

Disruptive innovation, a term of art coined by Clayton Christensen, describes a process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors.

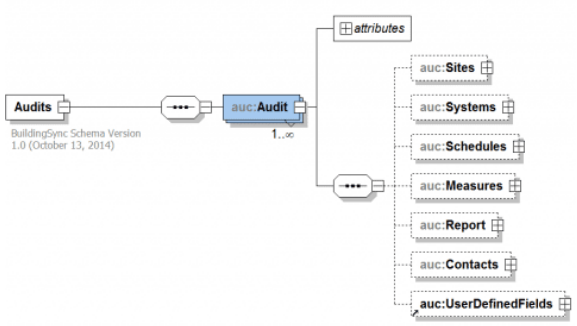
- Typically initially lower quality
- Offers other features that consumers like
- Quality improves over time

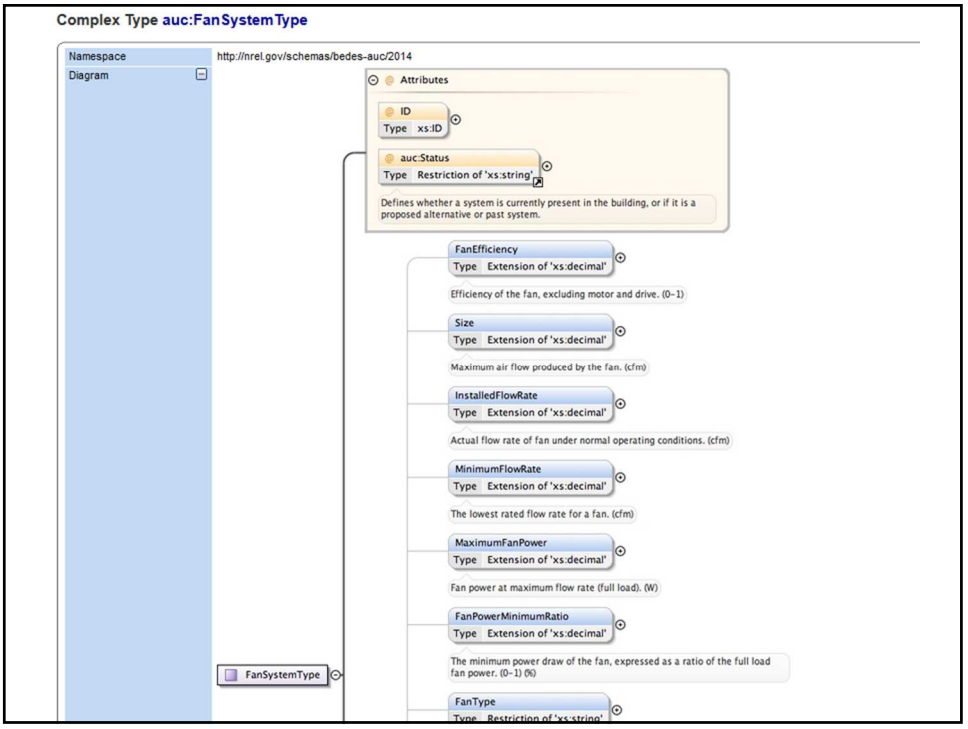
Learn to say "interoperability"



BuildingSync

BuildingSync® is a standardized language for commercial building energy audit data to facilitate data exchange between audit tools and data storage platforms.



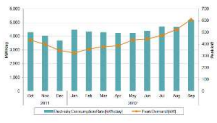


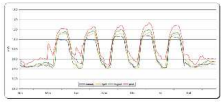
Interoperability & Audits

There is no reason to support analytics that are data "dead ends"

Instead:

- BuildingSync
- GreenButton Connect
- Missiondata.org
- OpenEI.org
- Open Energy Data Initiative (EDF)





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What BuildingSync is not

- A Tool
- Energy Management System (EMS) data
- Building Information Modeling (BIM).

Conclusions

- Proposed Std 211 attempts to make approaches higher quality and more consistent
- Still it's a minimum bar – not best practice
- Interoperability increasingly important
- Ignore innovation at your peril
- Auditor credentials remains a thorny issue

Thanks!

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