Essential Techniques and Calculations for Energy Managers and Cx Authorities

September 19, 2019

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POINTGUARD
An Abundant Power Company

Overview

- Introduction – Importance of Energy Management
- Energy Planning
- Establishing an Energy Baseline
- Energy Performance Benchmarks
- Analyzing Utility Invoices
- Energy Auditing - Procedures
- Identifying / Evaluating Savings for ECMs / FIMs
- Economic Analysis
- Implementing Energy Measures
- Importance of Documentation / Training
- Persistence of Savings
- Energy Management Association

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Learning Objectives

- Importance of Energy Management and its synergy with commissioning
- Key qualifications and services for an Energy Manager
- Energy Planning, Auditing and Savings Persistence – Process and Strategies
- Why technical certificates, like Energy Management Professional (EMP) are important

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Introduction

Report: Energy Demand Skyrockets …

Energy Manager Today – March 26, 2019

- Energy Demand Grew 2.3% last year, fastest pace this decade
- 45% of the increase accommodated by natural gas
- 70% of the growth accommodated by fossil fuels
- Wind and solar grew at double digits / solar by 31%
- U.S. generated 4.18 trillon kWh of electricity in 2018
- Global electricity demand grew by 4% in 2018 – 23,000 TWh

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Report: Energy Demand Skyrockets …

Energy Manager Today – March 26, 2019

- Rapid growth pushes electricity to 20% share in final consumption of energy
- Renewables were a major contributor – accounting for almost half of electrical demand growth
- One fifth of the increase in global energy demand attributed to higher demand for heating and cooling
- China, the United States and India accounted for nearly 70% of the rise in energy demand

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Energy Manager's Qualifications

- Understands utility rate structures, evaluates bills and benchmarks building performance
- Understands various mechanical and electrical building systems and associated controls
- Performs energy and water auditing, identifying opportunities for improvement measures with associated energy reduction and associated savings
- Performs calculations and conversions related to energy; related to consumption, savings, payback and life cycle costs
- Applications and use of various energy conservation strategies, including renewable energy conversions and controls

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Energy Manager's Services / Deliverables

- Energy Audits and Studies
- Facility Condition Assessments / Existing Building (Retro-) Commissioning / Ongoing Cx
- Energy Roadmap / Masterplan
- Renewable energy consulting – feasibility studies & utility coordination
- Sustainability / Resiliency Consulting
- Energy Modeling
- Energy Feasibility Studies / Utility Masterplans
- Energy Service Company (ESCO) Consulting
- Management of Energy Project Implementation
- Measurement and Verification
- Negotiate Energy Procurement Contracts

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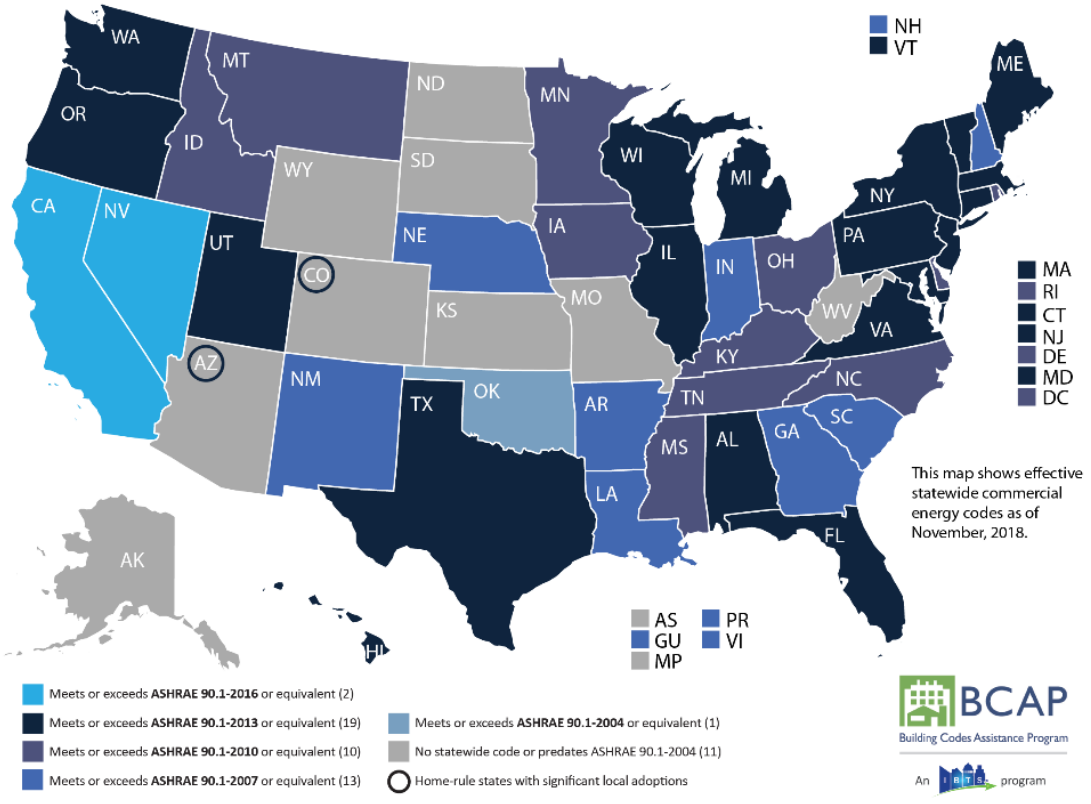
Applicable Codes and Standards

- ASHRAE 90.1 – 2016 - Energy Standard for Buildings, except Low-Rise Residential Buildings
- ASHRAE 211-2018 – Standard Procedures for Commercial Building Energy Audits
- ASHRAE 100 - 2018 - Energy Efficiency in Existing Buildings
- ASHRAE 189.1 – 2017 Standard for Design of High Performance Green Buildings (incorporates IgCC)
- Federal Executive Orders and State Energy Codes
- City / Municipal Energy Benchmarking and RCx Ordinances
- IECC-2018 – International Energy Conservation Code
- ASHRAE 202 - 2018 – Commissioning Process for Building and Systems
- ANSI/ASHRAE Standard 135-2016 BACnet™ - A Data Communication Protocol for Building Automation and Control Networks .
- ASHRAE Guideline 0.2 - 2015 – Commissioning Process for Existing Building Systems and Assemblies
- Leadership in Energy and Environmental Design (LEED) – U.S. Green Building Council

Building Codes Assistance Project

COMMERCIAL ENERGY CODE ADOPTION



http://bcapcodes.org/code-status/commercial/

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Energy Planning

Strategic Energy Plan

1. **Executive Summary** – outline's the client's short-term and long-term energy goals
2. **Introduction** – summarizes the energy management process and describes the facility's energy consumption
3. **Goals and Objectives** – defines metrics to measure progress and provides a timeline
4. **Resource Use Management** – provides a detailed description of project results to date and ECMs/FIM

Strategic Energy Plan

(continued)

5. **Resource Supply Management** – summarizes the facility's utility supply and local rate structures

6. **Resource Data Management** – provides an overview of the benchmarking process and M&V tools to be put in place

7. **Financial Analysis** – describes project funding strategies and financial metrics for individual ECMs and FIMs

8. **Roles and Responsibilities** – outlines project roles and responsibilities for team members and other stakeholders

Strategic Energy Plan

(continued)

9. **Measure Results** – describes how the effectiveness of ECM / FIM implementation will be measured and progress tracked

10. **Cost Allocation** – provides a project cost outline that includes schedule, timeline, task cost, and responsibilities

11. **Resources** – identifies useful references and sources to support the SEP

12. **Appendices** – include additional project documentation and reports, and can be updated with current material

Energy Roadmap

Energy Roadmap / Masterplan

Intended to assist Client's facilities' operations in **forecasting, prioritizing, and budgeting** with respect to their equipment, systems, buildings and vehicles. It also helps **establish policies and procedures** for their employees, and those of its partners and tenants, ensuring greater energy and process efficiency, and encouraging behaviors that save energy and money. Typically includes:

- **Energy Forecast / Security**
- **Energy Benchmarking and Analysis**
- **Potential ECMs / FIMs**
- **Integration with Sustainability Management Plan / Goals**
- **Feasibility of Renewable Energy Systems**

Establishing an Energy Baseline

Develop an Energy Use Baseline

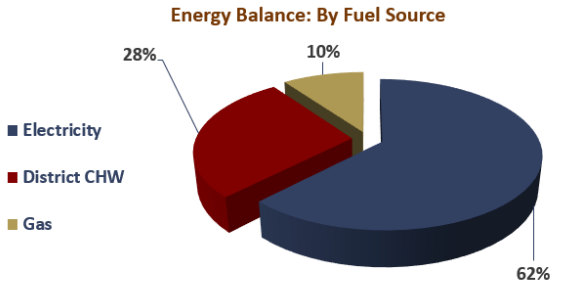
- Decide on boundaries – building, campus, company
- Choose a Baseline Year – Calendar , Fiscal
- Gather energy use data – by fuel source
- Decide on product grouping / units of output
- Calculate energy use intensity (EUI)
- Track and report progress

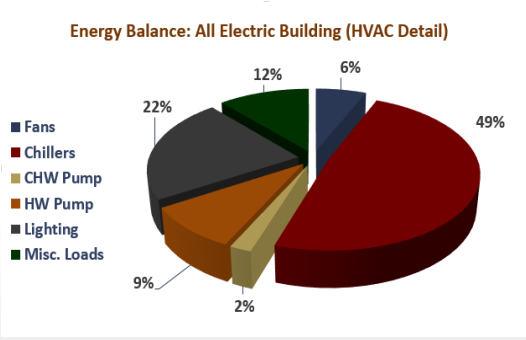
Energy Usage Assessment

- **Gather Historical Utility Bill Data**
  - Monthly energy utility bills
  - Monthly energy supplier bills, if applicable
  - Energy supply contracts, if applicable
- **Energy data tracked by the building**
  - Submetering / power monitoring
  - BAS trend logs
  - Dataloggers

Energy Balance - Four-part Process

1. Identify baseline energy usage by fuel source
2. Define the energy balance for each energy source
3. Subdivide the largest energy-consuming systems

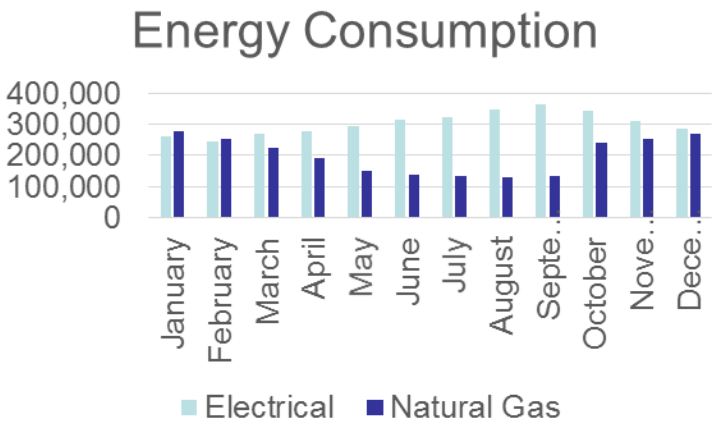




Energy Balance - Four-part Process

4. Establish a baseline

Develop a baseline against which estimated energy consumption can be measured going forward.



Influences on Energy Consumption

- Climate / weather
- Efficiency of the envelope (tightness and insulation)
- Seasonal Activities (retail, education, etc.)
- Occupancy and occupant's behaviors
- Energy intense operations (labs, data centers, manufacturing)
- Internal load schedules

Energy Performance Benchmarks

Baselining vs. Benchmarking

Baselining – comparing plant or process performance over time, relative to its measured performance in a specific (i.e. baseline) year.

Benchmarking – comparing performance to average or established best practice level of performance against an appropriate peer group.

Performance Metrics

Energy Use Intensity (Index) (EUI) is the energy consumed (kBtu) within a building divided by its total square feet.

$$\text{EUI – Energy Use Intensity (Index)} = \frac{\text{Annual Building Energy Use}_{\text{(kBtus)}}}{\text{Building Area}_{\text{(sq. ft.)}}}$$

Energy Performance Benchmarks

Many state and local governments are requiring commercial building owners to benchmark their buildings using ENERGY STAR's Portfolio Manager, and submit the results for public disclosure.

These disclosure laws are driving demand for both benchmarking services as well as efficiency projects to help building owners improve properties' performance levels.

Recently, EMA and ENERGY STAR Cohosted a Webinar: "State and Local Energy Policies: Trends in Energy Benchmarking and Disclosure"

https://www.energymgmt.org/webinars/

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Energy Performance Benchmarks

ENERGY STAR® PortfolioManager®

Technical Reference

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft²)	Site EUI (kBtu/ft²)	Reference Data Source - Peer Group Comparison
Healthcare	Ambulatory Surgical Center		155.2	63.0	CBECS - Outpatient Healthcare
	Hospital	Hospital (General Medical & Surgical)*	389.8	196.9	CBECS - Inpatient Healthcare
		Other/Specialty Hospital			
	Medical Office*		116.7	44.4	CBECS - Medical Office
	Outpatient Rehabilitation/Physical Therapy		155.2	63.0	CBECS - Outpatient Healthcare
	Residential Care Facility		243.2	125.7	CBECS - Nursing
	Senior Care Community*		243.2	125.7	CBECS - Nursing
	Urgent Care/Clinic/Other Outpatient		182.7	66.8	CBECS - Clinic/Outpatient
Lodging/Residential	Barracks*		114.9	73.9	CBECS - Dormitory
	Hotel*		162.1	73.4	CBECS - Hotel & Motel/Inn
	Multifamily Housing*		127.9	59.6	Fannie Mae Industry Survey
	Prison/Incarceration		169.9	93.2	CBECS - Public Order and Safety
	Residence Hall/Dormitory*		114.9	73.9	CBECS - Dormitory
	Residential Care Facility		243.2	125.7	CBECS - Nursing
	Senior Care Community*		243.2	125.7	CBECS - Nursing
	Single Family Home		N/A	N/A	None Available
	Other - Lodging/Residential		155.5	73.4	CBECS - Lodging
Manufacturing/Industrial	Manufacturing/Industrial Plant		N/A	N/A	None Available
Mixed Use	Mixed Use Property		123.1	78.8	CBECS - Other
Office	Medical Office*		116.7	44.4	CBECS - Medical Office
	Office*		148.1	67.3	CBECS - Office & Bank/Financial
	Veterinary Office		182.7	66.8	CBECS - Clinic/Outpatient
Parking	Parking		N/A	N/A	None Available

Energy Performance Benchmarks

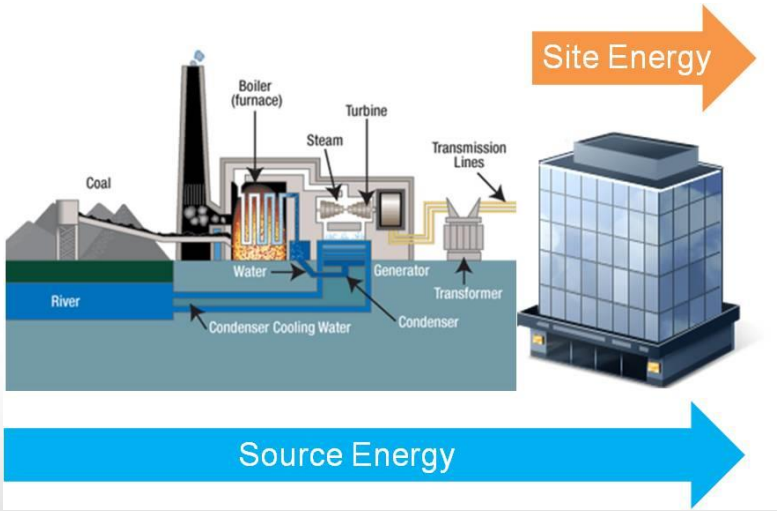
ASHRAE Building Energy Quotient (bEQ)

- A building energy rating program that provides information on a building's energy use
- Two separate workbooks, one evaluating **As Designed potential** and the other assessing **In Operation performance**, form the foundation of bEQ
- bEQ rests on ASHRAE methodologies and standards and the experience of qualified practitioners.
- Only select individuals can submit completed workbooks to ASHRAE for review and receive ASHRAE issuance of a building rating.
    - Professional Engineers (PE) licensed in the jurisdiction where the building to be rated is located
    - ASHRAE Building Energy Modeling Professionals (BEMP)
    - ASHRAE Building Energy Assessment Professionals (BEAP)

Source Energy vs. Site Energy

Site energy is what your utility meter would read -- it is the energy used on the site.

Source energy takes into account energy loss for production and transmission -- so it is the raw energy entering the power plant.



Source Energy vs. Site Energy

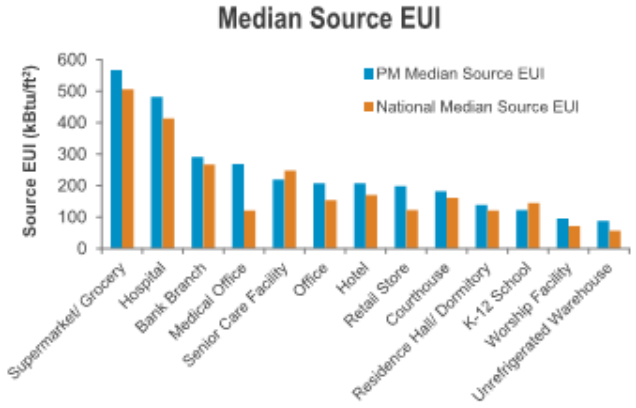


Table 1 Source-Site Ratios for all Portfolio Manager Fuels	
Fuel Type	Source-Site Ratio
Electricity (Grid Purchase)	3.34
Electricity (on-Site Solar or Wind Installation)	1.0
Natural Gas	1.047
Fuel Oil (1,2,4,5,6,Diesel, Kerosene)	1.01
Propane & Liquid Propane	1.01
Steam	1.21
Hot Water	1.28
Chilled Water	1.05
Wood	1.0
Coal/Coke	1.0
Other	1.0

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EUI - Sample Problem

An 80,000 SF office building includes gas boilers for heating and has a 'demand response' agreement with the local utility to utilize its on-site generator during high demand periods. Its annual metered energy usage, per fuel, is as follows:

- Electricity: 859,000 kWh
- Natural Gas: 1,499,641 cu. ft.
- Diesel oil: 2,000 gallons

1. What is the Site EUI?
2. What is the Source EUI?

EUI – Site Energy

Convert all inputs into kBtu

- 859,000 kWh/yr x 3.412 kBtu/kWh = 2,930,908 kBtu/yr
- 1,499,641 cu. ft./yr x 1,023 Btu/cu. ft. x 1 kBtu/1000 Btu = 1,534,133 kBtu/yr
- 2,000 gallons/yr x 138,690 Btu/gal x 1 kBtu/1000 Btu = 277,380 kBtu/yr

$$\text{Site EUI} = \frac{(2{,}930{,}908 + 1{,}534{,}133 + 277{,}380)\ \text{kBtu/yr}}{80{,}000\ \text{SF}} = 59.28\ \text{(kBtu/yr) per SF}$$

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EUI – Source Energy

Use Portfolio Manager's Source-Site Ratios

- 2,930,908 site kBtu/yr x 3.34 = 9,789,233 source kBtu/yr
- 1,534,133 site kBtu/yr x 1.047 = 1,606,237 source kBtu/yr
- 277,380 site kBtu/yr x 1.01 = 280,154 source kBtu/yr

$$\text{Source EUI} = \frac{(9{,}789{,}233 + 1{,}606{,}237 + 280{,}154)\ \text{kBtu/yr}}{80{,}000\ \text{SF}} = 145.95\ \text{kBtu/yr}$$

Alternate Output (EUI) Metrics

Other Metrics Used to Establish Benchmarking Goals

- Btu per Square Foot – Any Building
- Btu per Employee – Office Building
- Btu per Unit of Product – Assembly Plant
- Btu per Pound of Product - Manufacturer
- Btu per Number of Beds Occupied – Hotel or Hospital
- Kilowatt-hours (kWh) per Square Foot - Lighting

Analyzing Utility Invoices

Terminology

- **Energy (Consumption) - kWh (Kilowatt-hours) -** the amount of electrical energy that is used over time by the consumer
- **Energy Demand - kW (Kilowatt) -** the amount of power that a customer's facility or operation is pulling (demanding) from the utility electrical system at a given period (15 min.) in time
- **Power Factor (PF) - Reactive Power -** basically it is a measure of how effectively the customer is utilizing the electrical energy the utility provides
- **Distributed Generation (DG) -** also distributed energy, on-site generation (OSG) or district/decentralized energy is generated or stored by a variety of small, grid-connected devices referred to as distributed energy resources (DER) or distributed energy resource systems

Terminology

- **Flat Rate Structure –** Fixed cost of energy that does not vary except for fuel cost adjustments and other fees
- **Seasonal Flat Rates –** Flat rates that vary by season. A typical seasonal flat rate structure has a lower fixed rate for winter months and a higher rate for summer months
- **Time of Use Rate (TOU) –** time-of-use or time-of-day rate structures usually vary two to four times a day. The term “on peak” or “peak” is generally used to describe hours with higher prices while “off peak” is used to describe hours with lower prices
- **Tiered Energy Charge -** Some utilities charge less per kWh the more you use (some utilities may charge more). Regardless, this “tiered” or “block” structure will show up on your rate schedule

Utility Rate Structures

Typically utility rate structures are divided between three categories:

Customer Charges

- Recover costs associated with making service available to the customer

Demand Charges

- Costs associated with the demand charge include: capital and operating costs for production, transmission, equipment (transformers) and storage costs that vary with demand requirements

Supply Charges

- Consists of the costs associated with capital and operating costs to produce the energy, such as fuel costs and production supplies. These costs change only with the consumption of energy

Audit Utility Invoices

Validate bills with meter data (monthly and interval)

Meter Accuracy

- When was meter last calibrated / checked?
- Per the National Utilities Refund, “on average, 80% of companies are overcharged on utility expenses through calculation errors and discrepancies billed by the utility providers.”

Real time utility account access

- Coordinate with Utility Company

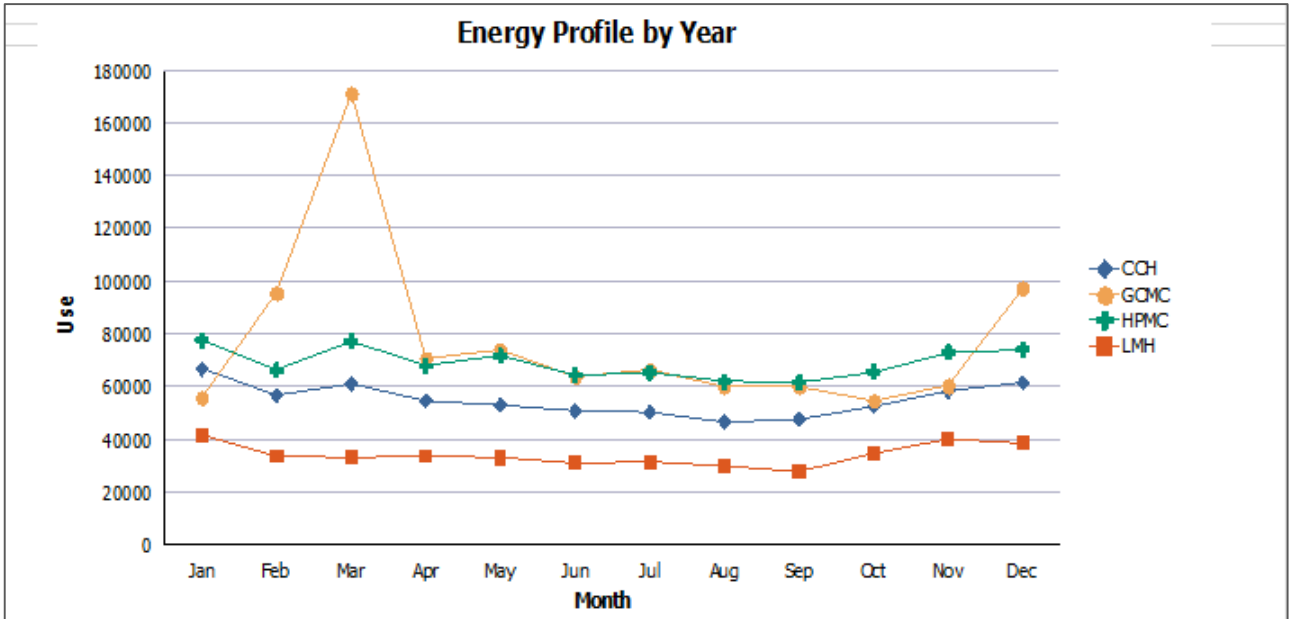
Sub-metering

- Permits identification of large energy-consuming loads

Electric meter location

- If the power company meters are located on the line side of the service meters, charges may be 3-5% higher than actual consumption due to losses in the transformers.

Audit Utility Invoices



Use in THERM

Place	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
CCH	66,778	56,828	61,134	54,732	53,060	50,787	50,301	46,800	47,711	52,554	58,224	61,442	660,351
GCMC	55,935	95,374	171,326	70,632	73,791	63,907	66,205	59,883	60,084	54,563	60,335	97,317	929,352
HPMC	77,711	66,263	77,285	67,910	71,611	64,406	65,406	62,017	61,648	65,585	73,070	74,161	827,073
LMH	41,595	33,763	33,401	33,784	32,936	31,270	31,416	29,757	27,708	34,695	40,027	38,692	409,043
Totals	242,019	252,228	343,147	227,058	231,397	210,370	213,329	198,456	197,151	207,396	231,655	271,612	******

Utility Invoice Audit – Sample Problem

Month	Electrical Consumption (kWh)	Electric Demand (kW)	Natural Gas (MCF)
Jan	300,000	12,000	1100
Feb	298,000	16,000	900
Mar	355,500	14,500	901
Apr	425,200	16,800	899
May	555,500	17,000	750
Jun	688,800	18,200	612
Jul	825,000	19,300	599
Aug	900,000	20,000	536
Sep	855,000	19,500	602
Oct	769,000	16,900	751
Nov	627,900	14,900	827
Dec	550,000	13,200	1050
Total	7,149,900	198,300	9,527

Consumption (Charge) = $0.074/kWH

T&D = $0.083/kWH

Demand = $5.00/kW

What are the demand charges for August?

What is the total electrical cost for August?

What is the blended electrical energy rate?

Utility Invoice Audit – Sample Problem

Calculate demand charges in August

- Demand = 20,000 kW
- Demand: 20,000 kW x $5.00 / kW = $100,000

Calculate total electrical cost for August

- Consumption: 900,000 kWh x $0.074 / kWh = $66,600
- Demand: 20,000 kW x $5.00 / kW = $100,000
- T&D = 900,000 kWh x $0.083 kWh = $74,700
- **Total: $241,300**

Calculate the blended electrical rate

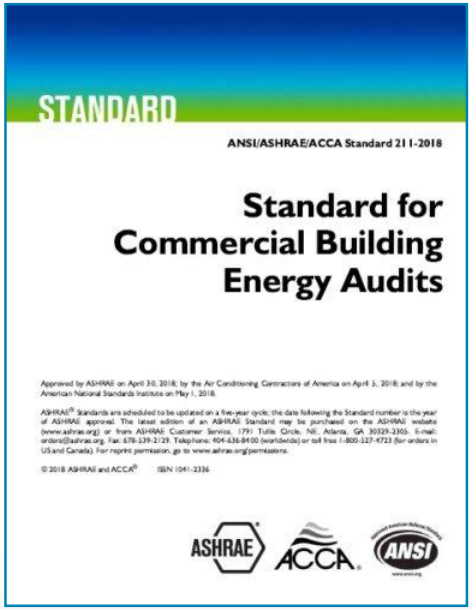
- Consumption = 7,149,900 kWh x $0.074 / kWh = $529,092.60
- Demand = 198,300 kW x $5 = $991,500
- T&D = 7,149,900kWh x $0.083 / kWh = $593,441.70
- Cost = $2,114,034
- **Blended rate = $2,114,034 ÷ 7,149,900 = $0.296**

Energy Auditing - Procedures

ANSI / ASHRAE / ACCA Standard 211-2018, Standard for Commercial Building Energy Audits

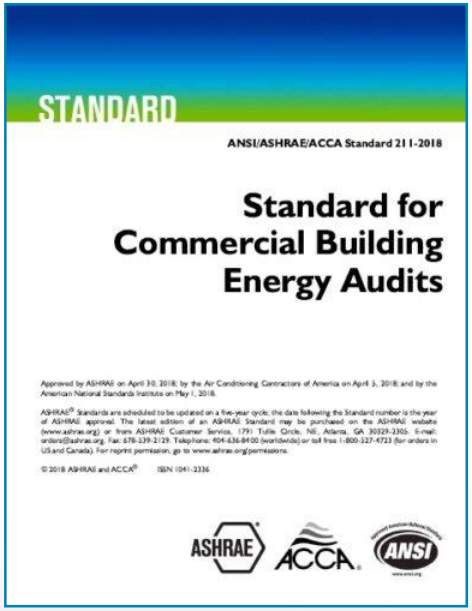
Includes:

- Requirements for **energy auditor qualifications**
  (ANSI accredited, DOE BBWG recognized, EMP complies)
- Specific guidance around the energy audit quality control process
- Guidance to be more audit customer-oriented
- References ANSI/ASHRAE/IESNA Standard 100 for energy efficiency measure recommendations
- Guidance for Building Energy Model Calibration



ANSI / ASHRAE / ACCA Standard 211-2018, Standard for Commercial Building Energy Audits

- Defines the procedures required to perform ASHRAE Level 1, 2 and 3 energy audits
- Provides a common scope of work for these audit levels for building owners and others
- Establishes standardized industry practices and minimum reporting requirements for the results



Planning Energy Audits

Define the Scope

- Level of effort – Level 1 (Preliminary), Level 2 (Standard) Level 3 (Investment Grade)
- Building Systems – Energy-consuming
- Process Systems – Industrial, Institutional
- Building envelope

Different from a Facility Condition Assessment (FCA)

Performing the Audit

Level 1 Procedures

- Review Historical Utility Data
- Review Utility Rate Structure (as applicable)
- Perform Facility Site Assessment / Survey (accompanied by staff)
- Identify O&M Problems and Needs
- Identify important energy-using systems / processes

Performing the Audit

Level 1 Procedures (continued)

- Interview key stakeholders – Owner, Operators, Occupants
- Determine Space Function Analysis
- Determine Key Operating Parameters
- Identify Low-Cost / No-Cost Energy Conservation Measures
- Identify Potential ECM Capital Recommendations

Performing the Audit

Level 2 Procedures

Follows Level 1 Audit, or includes those tasks plus:

- Develop the annual energy cost breakdown by cost component
- Review of current operations and maintenance procedures
- Determine key operating parameters: set-points, schedules, load conditions
- Conduct end-use breakdown for each system and fuel type
- Identify potential energy savings opportunities with savings analysis

Performing the Audit

Level 2 Procedures (continued)

Follows Level 1 Audit, or includes those tasks plus:

- Bundle interactive measures
- Calculate energy savings
- Provide Quality Assurance review
- Estimate ECM (EEM) costs
- Conduct Economic Analysis

Performing the Audit

Level 3 Procedures

Follows Levels 1 and 2 analyses, and includes the following:

- Additional analyses on all EEMs that meet Owner's criteria
- Schematic diagram of new equipment, where appropriate
- Analysis conducted using either measured data, building energy modeling, or engineering calculations. Energy modeling required for envelope analysis
- Evaluate impact of proposed HVAC modifications on seasonal HVAC requirements and building occupants

Performing the Audit

Level 3 Procedures (continued)

Follows Levels 1 and 2 analyses, and includes the following:

- Estimate initial and recurring costs, energy costs savings, and non-energy cost savings of each measure
- Perform Life Cycle Cost Analysis (LCCA) of each recommended EEM for a timeframe that spans, at a minimum, the life of the measure with the longest service life
- A risk analysis shall be conducted with a minimum level of rigor as defined under paragraph 5.5.4 Risk Analysis

Identifying / Evaluating Savings for ECMs / FIMs

ECM (EEM) vs. FIM

Energy Conservation Measure (ECM) or Energy Efficiency Measure (EEM) – a project conducted, an initiative or technology implemented that reduces the consumption of energy in a facility. The measures can affect a variety of resources mainly water, electricity and gas for commercial and industrial facilities.

Facility Improvement Measure (FIM) – a project or initiative to improve building and system performance, system reliability / resiliency, reduce O&M costs, improve IEQ, etc. The measure may or may not reduce energy consumption and related costs.

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Identify Energy Opportunities

- Provide initial screening assessing potential Energy Conservation Measures
- Includes site assessment and discussions with Facilities' staff
- Based upon experience
- Recommend utilizing a checklist

8.0 ECM Checklist		
Measure - Controls	**Screen**	**Comments**
1. Reduce operating time of major HVAC equipment	☐ Yes ☐ No	
2. Reduce outdoor air during Unoccupied mode	☐ Yes ☐ No	
3. Demand control ventilation	☐ Yes ☐ No	
4. Enthalpy Economizer	☐ Yes ☐ No	
5. Condenser water reset	☐ Yes ☐ No	
6. Chilled water reset	☐ Yes ☐ No	
7. Heating hot water reset	☐ Yes ☐ No	
8. Supply air temperature reset	☐ Yes ☐ No	
9. Reset hot/cold deck temperatures	☐ Yes ☐ No	
10. Eliminate simultaneous heating and cooling	☐ Yes ☐ No	
11. Variable air volume tracking	☐ Yes ☐ No	
12. Occupancy sensor control of HVAC	☐ Yes ☐ No	
13. Chiller sequencing	☐ Yes ☐ No	
14. Cooling tower sequencing	☐ Yes ☐ No	
15. Boiler sequencing	☐ Yes ☐ No	
16. Optimize chilled water temperatures	☐ Yes ☐ No	
17. Optimize condenser water temperatures	☐ Yes ☐ No	
18. Demand control / peak shaving	☐ Yes ☐ No	
19.	☐ Yes ☐ No	
20.	☐ Yes ☐ No	
Measure – HVAC Equipment	**Screen**	**Comments**
21. Convert CAV air handling system to VAV	☐ Yes ☐ No	
22. Convert Dual Duct air handling system to VAV	☐ Yes ☐ No	
23. Convert Multi-zone air handling system to VAV	☐ Yes ☐ No	
24. Reduce outdoor air through increased filtration	☐ Yes ☐ No	
25. Packaged equip. replacement with high eff. units	☐ Yes ☐ No	
26. Addition of air-side economizer	☐ Yes ☐ No	
27. Variable flow pumping (CHW or HW)	☐ Yes ☐ No	
28. Low leakage dampers	☐ Yes ☐ No	
29. Air-to-Air heat recovery	☐ Yes ☐ No	
30. Water to-air heat recovery (run around coil)	☐ Yes ☐ No	
31. Re-zone HVAC system(s)	☐ Yes ☐ No	

Identify Energy Opportunities

- Screening identifies potential measures requiring further investigation / analysis
- Depending upon scope, review controls, HVAC systems, lighting, water, envelope, O&M procedures, renewable energy, etc.

32. Replace motors with energy efficient motors	☐ Yes ☐ No	
33. Add variable frequency drives (VFDs) for pumps	☐ Yes ☐ No	
34. Chiller replacement	☐ Yes ☐ No	
35. Cooling tower replacement	☐ Yes ☐ No	
36. Boiler replacement	☐ Yes ☐ No	
37. Boiler combustion efficiency improvements	☐ Yes ☐ No	
38. Boiler stack economizers	☐ Yes ☐ No	
39. Addition of baffle inserts in boilers	☐ Yes ☐ No	
40. Blow-down heat recovery	☐ Yes ☐ No	
41. Install a smaller (summer / 'pony') boiler	☐ Yes ☐ No	
42. Addition of water-side economizer	☐ Yes ☐ No	
43. Re-size chiller plant	☐ Yes ☐ No	
44. Provide smaller chiller for Off-peak loads	☐ Yes ☐ No	
45. Provide alt. cooling source to shutdown plant	☐ Yes ☐ No	
46. Proper pump sizing	☐ Yes ☐ No	
47. Add variable speed chiller control	☐ Yes ☐ No	
48. Add variable freq. drives (VFDs) – cooling tower	☐ Yes ☐ No	
49. Decentralize inefficient steam systems	☐ Yes ☐ No	
50. Steam trap maintenance	☐ Yes ☐ No	
51.	☐ Yes ☐ No	
52.	☐ Yes ☐ No	
Measure – Lighting	**Screen**	**Comments**
53. Reconfigure lighting fixtures (reduce levels)	☐ Yes ☐ No	
54. Occupancy sensors, timers, program controls	☐ Yes ☐ No	
55. New fluorescent lighting technology	☐ Yes ☐ No	
56. New HID (metal halide) lighting technology	☐ Yes ☐ No	
57. New LED lighting technology	☐ Yes ☐ No	
58. Daylight harvesting – de-lamping, dimming control	☐ Yes ☐ No	
59.	☐ Yes ☐ No	
60.	☐ Yes ☐ No	
Measure – Operations & Training	**Screen**	**Comments**
61. Preventative / predictive maintenance program	☐ Yes ☐ No	
62. HVAC Re-commissioning (scheduled)	☐ Yes ☐ No	
63. Coil cleaning	☐ Yes ☐ No	
64. Filter replacement	☐ Yes ☐ No	

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Evaluating Energy Opportunities

Evaluating Potential ECMs / EEMs

- Establish savings methodology, based upon:
  - Proposed change or modification
  - Unit energy cost (may be blended rate to accommodate consumption, demand and any additional charges)
- Establish cost estimating procedures
  - Cost data guides (Means, Dodge, etc.)
  - Contractor / vendor quotes
  - Internal costing for in-house implementation

Sample ECM Problem

During an energy audit, it is discovered that a laboratory has three (3) exhaust fans serving fume hoods that are operating continuously; 24 hours a day, 365 days a year.

In discussion with the Users of the building, it is determined that the fans only need to operate from 8:00 AM to 5:00 PM for five (5) days a week.

Each fan motor is ½ horsepower, single phase with a power factor of .85. The nameplate on the motor lists 4.9 amps at 230 volts.

The blended electricity rate is $.07 / kWh.

By reducing the run time of the fans, what is the approximate savings per year?

Sample ECM Problem

Each Fan:

0.85 (PF) x 230 (V) x 4.9 amps = 958 watts

(958 / 1000) x 15 hrs. / day x 5 days / week x 52 weeks / yr. = 3,736.2 kWhs saved

plus,

(958 / 1000) x 24 hrs. / day x 2 days / week x 52 weeks / yr. = 2,391.2 kWhs saved

6127.4 kWhs x $.07 / kWh = $428.92 per fan

Total Savings - 3 x $428.92 = **$1,286.76**

Economic Analysis

Evaluating Energy Opportunities

Evaluating Potential ECMs / EEMs

Establish financial analysis method(s) to be employed

Simple Payback

$$\text{Payback Period (years)} = \frac{\text{Initial cost of Measure}}{\text{Savings per year}}$$

Return on Investment (ROI)

$$\text{ROI (annual)} = \frac{\text{Return (savings) from investment (annual)}}{\text{Cost of Investment}}$$

Present Worth Analysis

Life Cycle Cost Analysis

Payback / ROI Problem

An EMP identifies three ECMs with the following estimated costs and projected annual savings.

	Cost ($)	Annual Savings ($)
ECM #1	5,400	1,200
ECM #2	3,500	800
ECM #3	8,900	2,700
ECM #4	6,400	1,800

The Owner decides to implement all four of the measures

What is the simple payback for the project?

What is the projected ROI for the project?

Payback / ROI Problem

Simple Payback

$24,200 / $6,500 = 3.72 years

Return on Investment (Annual)

$6,500 / $24,200 = .2685 = 26.85%

Payback Period vs. Present Worth

Payback Period

- Simple to use and understand
- Easy to Compute
- Preference to Liquidity
- Deals with risk
- Ignores time value of money
- Not all cash flows are covered
- Ignores profitability

Net Present Worth (Value)

- More flexible and meaningful
- Today's dollar value of potential investment
- Accommodates costs and savings over the life of the project
- Accommodates time value of money
- More difficult to calculate
- Present Value Annuity Factor – calculates present value of a series of equal payments over time

Present Worth Analysis

Equations to be used:

$$PW = \frac{\text{Future Value (F)}}{(1 + i)^n}$$

$$PW = \text{Annual Payment} * \frac{(1 + i)^n - 1}{i * (1 + i)^n}$$

i = annual interest rate
n = Period of analysis (years)

Evaluating Energy Opportunities

Life Cycle Cost Analysis

- Method of assessing the total cost of facility ownership; taking into account all costs associated with acquiring, owning and disposing of a building or building system
- Useful in comparing alternate systems that may fulfill performance requirements, but differ in first and operating costs
- Typical building-related costs include:
  - Initial Costs
  - Fuel Costs
  - Operation, Maintenance and Repair Costs
  - Replacement Costs
  - Residual Values, Resale or Salvage
  - Disposal Cost
  - Finance Charges
  - Non-monetary Benefits

Evaluating Energy Opportunities

Basic Life Cycle Cost Calculation

LCC = I + Repl – Res +E +W + OM&R +O

Where:

- LCC = Total life cycle costs in present-value (PV) dollars
- I = PV investment costs
- Repl = PV capital replacement costs
- Res = PV residual value (resale or salvage) less disposal costs
- E = PV of energy costs
- W = PV of water costs
- OM&R = PV of non-fuel operating, maintenance and repair costs
- O = PV of other costs (e.g. contract costs for ESPCs, etc.)

Evaluating Energy Opportunities

Evaluating Potential ECMs / EEMs

- Other Factors (besides cost and payback)
  - Regulatory or code compliance
  - Life Safety issues
  - Efforts to meet ‘green’ certifications (LEED, Green Globes, etc.)
  - Employee comfort / Indoor Environmental Quality
  - Increase productivity

Implementing Energy Measures

Prioritizing Energy Opportunities

Ranking ECMs / EEMs

- **ECMs with Shortest Payback / Return on Investment** – *Which ECMs offer the most "bang for the buck"?*
- **ECMs with the Largest Potential Savings** – *Which ECMs could potentially make the largest impact in terms of reduction in energy use?*
- **ECMs with the Lowest Implementation Costs** – *Which ECMs are the least expensive to implement?*

Prioritizing Energy Opportunities

Ranking ECMs (continued)

- **Potential Reduction in EUI Attainable by ECMs** – *Where can an ECM have the most impact, relative to the current energy usage of the building?*
- **EUI Deviation from Buildings of Similar Type / Use** – *Which building has energy use furthest above others of its type / size?*
- **Balanced Scoring Based Upon All of the Above** – *Which ECMs score the highest, taking into account all the factors described above (weighted scoring system)?*

Prioritizing Energy Opportunities

Beyond Energy - Other (Intangible) Benefits

- **Safety and Security** – Increase lighting (with more efficient source)
- **Preparation for Sale** – Demonstrate system performance / efficiency
- **Sustainability Initiatives** – Pursuing LEED or Green Globes certification
- **Code / Ordinance Compliance** – Municipalities enacting RCx requirements

Prioritizing Energy Opportunities

Final criteria for opportunity prioritization

- Owner's Objectives and Goals
- Energy Prioritization
  - First Cost / Budget
  - Payback / ROI
- Regulatory / code mandates
- Non-energy (intangible) benefits

Plan Project Implementation

Develop the Scope of Work

- Identify responsible parties and their roles
  - Who is responsible for ensuring performance?
- Create project program / Owner's Project Requirements
- Determine type and detail of documentation required
  - Detailed drawings and specifications vs. narratives and sketches
- Coordinate access requirements for Contractors

Plan Project Implementation

Develop the Scope of Work

- Establish and confirm project budget
  - Include contingency based upon level of unknowns
- Develop project schedule w/ measurable milestones
- Identify any constraints to implementation
  - Phasing requirements?
  - Limited work hours to maintain normal operations?

Plan Project Implementation

Determine procurement / delivery method

- Owner Managed – depends upon in-house expertise
  - In-house Facilities staff
  - On-call Contractors
- Construction Manager / General Contractor
- Design - Build
- Energy Savings Performance Contract (ESPC)

Importance of Documentation / Training

As-Built Documentation

Detailed documentation of all systems' modifications that were implemented.

- Illustrates differences between original building systems design and changes made during the project.
- Essential for helping resolve future systems and operational issues in the building.

Detailed documentation of all control system modifications that were implemented.

- Control system documentation will be produced by the controls' contractor.
- The Energy Manager or Construction Manager should verify accuracy of as-built control documentation.

Current Facility Requirements (CFR)

A written document that details the current functional requirements of an existing facility and the expectations of how it should be used and operated. This includes goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information to meet the requirements of occupants, users, and owners of the facility.

Recommended CFR contents include:

1. User/Occupant requirements
2. Owner directed requirements
3. Specific facility requirements such as environmental and energy goals, level of systems control, and/or sustainability certification
4. Training requirements
5. Sustainability requirements

Current Facility Requirements (CFR)

Suggested CFR contents also include:

6. Equipment and systems maintainability requirements
7. Capabilities of operators and maintenance team
8. Documentation requirements
9. Regulatory requirements
10. On-going commissioning requirements
11. Benchmarks
12. Financial requirements and investment criteria.

Systems Manual

ASHRAE Guideline 1.4 - 2014 – Procedures for Preparing Facility Systems Manuals

Systems manual addresses system level information while the O&M focuses on the individual pieces of equipment that make up the systems. Standard data contained within a Systems Manual includes:

- System Description
- System Configuration (Schematics, Drawings, Shop Drawings)
- Operation Data (Basis of Design, Operating Conditions, Performance Metrics, Sequences of Operations, Operating Modes
- Maintenance Data (Scheduled maintenance, materials required)
- Troubleshooting (System Level and Equipment Level)
- Parts List (Recommended spare parts, parts cost sheet, Lead times, consumables)

Operations and Maintenance Manual

ASHRAE GUIDELINE 4 - Preparation of Operating and Maintenance Documentation for Building Systems

- Physical Descriptions / Submittal Data
- Functional Descriptions
- Troubleshooting
- Preventative Maintenance (Procedures and Schedules)
- Corrective Maintenance (Repair Recommendations)
- Parts List
- Operation / Maintenance – Significant Drawings, Figures, Illustrations, Schedules

Operations and Maintenance Training

Guideline 1.3 - 2018 -- Building Operations and Maintenance Training for the HVAC&R Commissioning Process

- Methodologies and formats for developing training plans
- Conducting training programs
- Documenting training results for the operation and maintenance of building HVAC&R systems during the Commissioning (Cx) Process.

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Persistence of Savings

Measurement and Verification Plan

- Two Key Documents
  - **ASHRAE Guideline 14 - 2014 -- Measurement of Energy, Demand, and Water Savings**
  - **International Performance Measurement & Verification Protocol (IPMVP) – Vols. I - III**
- Plans typically consistent with Option D: Calibrated Simulation (Savings Estimation Method 2), or Option B: Energy Conservation Measure Isolation, as specified in the *IPMVP Volume III*
- Define period of coverage for M&V plan
  - Typically not less than one year of post-construction occupancy
  - Entire period for ESPC contracts.
- Provide a process for corrective action if the results of the M&V plan indicate that energy savings are not being achieved.

* **https://www.energymgmt.org/nibs-2019-mv-presentation/**

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M&V Reporting Strategy

When developing an M&V reporting strategy, the EMP should consider:

- **Metrics** – Energy saving metrics that are used for M&V should be consistent with those agreed upon and used during earlier phases of the project.
- **Specificity** - Performance measurements may apply to an entire system or an individual ECM, depending on the nature of the implemented measures and client preferences.
- **Format** - Graphs that illustrate current performance relative to baseline and anticipated energy performance are useful visuals for both the EMP and client to examine. While graphs convey a lot of information, they should be supplemented with brief narratives that characterize the performance and explain unexpected results

Existing Building (Retro-) Commissioning

- Scope / Methodology
  - **ASHRAE Guideline 0.2-2015**
  - **Six phase process from Planning through Ongoing Cx**
- Reporting Requirements
  - Current Facility Requirements (CFR)
  - Final EBCx report (evolves over time through Implementation and Hand-Off)
- Ongoing Commissioning (OCx) Plan (updated periodically)

Ongoing Commissioning (OGCx)

In spite of initial commissioning and M&V…..

- A facility's performance will degrade over time
- New issues may arise

To maintain performance, implement a strategy for ongoing monitoring and adjustment – **Ongoing Commissioning (OGCx)**

- Prevents degradation
- Lays out procedures for dealing with systems issues

Ongoing Commissioning Program

An **Ongoing Commissioning Program** includes planning, point monitoring, system testing, performance verification, corrective action response, ongoing measurement, and documentation to proactively address operating problems in the systems being commissioned.

- Defines roles and responsibilities;
- Establishes measurement requirements (meters, points, metering systems, data access);
- Defines the points to be tracked, with frequency and duration for trend monitoring;
- Defines the limits of acceptable values for tracked points and metered values;

Ongoing Commissioning Program (cont'd)

An **Ongoing Commissioning Program** also includes:

- Define the review process that will be used to evaluate performance;
- Define an action plan for identifying and correcting operational errors and deficiencies
- Establish planning for repairs needed to maintain performance;
- Define the frequency of analyses in the first year (at least quarterly); and
- Define the subsequent analysis cycle (at least every 24 months).

Continuous monitoring requirements:

- List of monitored equipment
- Specific data points for each system
- Baselines used for comparison
- List of meters and submeters
- Calibration schedule for meters and submeters
- Reporting structure and schedule
- Methods of tracking EUI and energy usage data
- Testing procedures and schedule
- Description of sampling protocol

Energy Management Association

Commissioning-Based Energy Management

- Created in 2012 by the AABC Commissioning Group (ACG)
- Developed **Energy Management Professional (EMP)** certification program – Cx-based approach to energy management
- Became an Independent Subsidiary of ACG Operating as the **Energy Management Association** in 2014
- EMP received **ANSI Accreditation** in 2018
- Received **DOE Better Building Workforce Guidelines (BBWG)** recognition in 2018

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Synergy of Cx and Energy Management

- Process focus – Investigative / Problem Solving
- Experience with a variety of building systems – equipment operation and optimization
- Knowledge of Building Management Systems and control sequences
- Investigative and assessment skills for existing facilities and their systems
- Functional testing and monitoring to verify integrated systems' performance
- Related expertise in sustainability and resiliency

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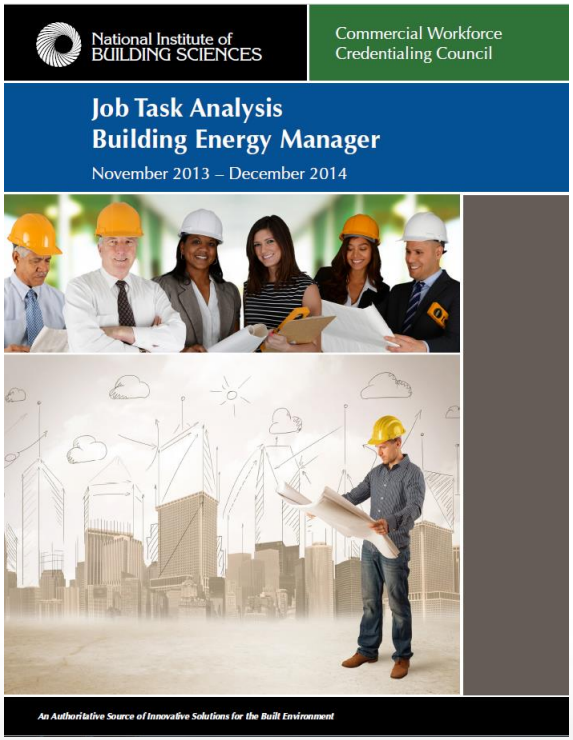
DOE Better Buildings Workforce Guidelines

- Created by The National Renewable Energy Laboratory (NREL), in conjunction with the National Institute of Building Sciences (NIBS) and the U.S. Department of Energy (DOE),

- **Building Energy Manager:** Responsible for managing and continually improving energy performance in commercial buildings by establishing and maintaining an energy program management system that supports the mission and goals of the organization.



Closing

Why Technical Certifications are Important

- **Demonstrates Commitment** – both Corporate and Individual to clients
- **Recognized Proficiency** – important step in professional development
- **Continuing Education** – supports CEU / PDH requirements for licensed individuals
- **RFQ Requirements** – more RFQs / RFPs include certification requirements for respondents
- **Codes and Ordinances** – more codes, standards and standards are defining the qualifications required to perform specific activities
- **Government Initiatives** – more government contracts will require individuals meet the DOE / BBWG requirements

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ENERGY MANAGEMENT PROFESSIONAL

The Gold Standard in Energy Management

Register for the EMP Seminar & Exam in Orlando, FL

EMA's Energy Management Professional (EMP) program provides a complete framework for a commissioning-based energy management process that achieves what building owners demand: maximum energy efficiency and optimum building performance.

Exclusive opportunities to attain this coveted certification:

November 12-13, 2019 in Orlando, FL at NFMT Orlando

April 6-7, 2020 in San Diego, CA at CxEnergy 2020

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- Learn to lower your operating costs and sustain them.
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