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# Introduction to Commercial Building Audits

Course No. ENRG 50

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# Introduction to Commercial Building Audits

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## 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

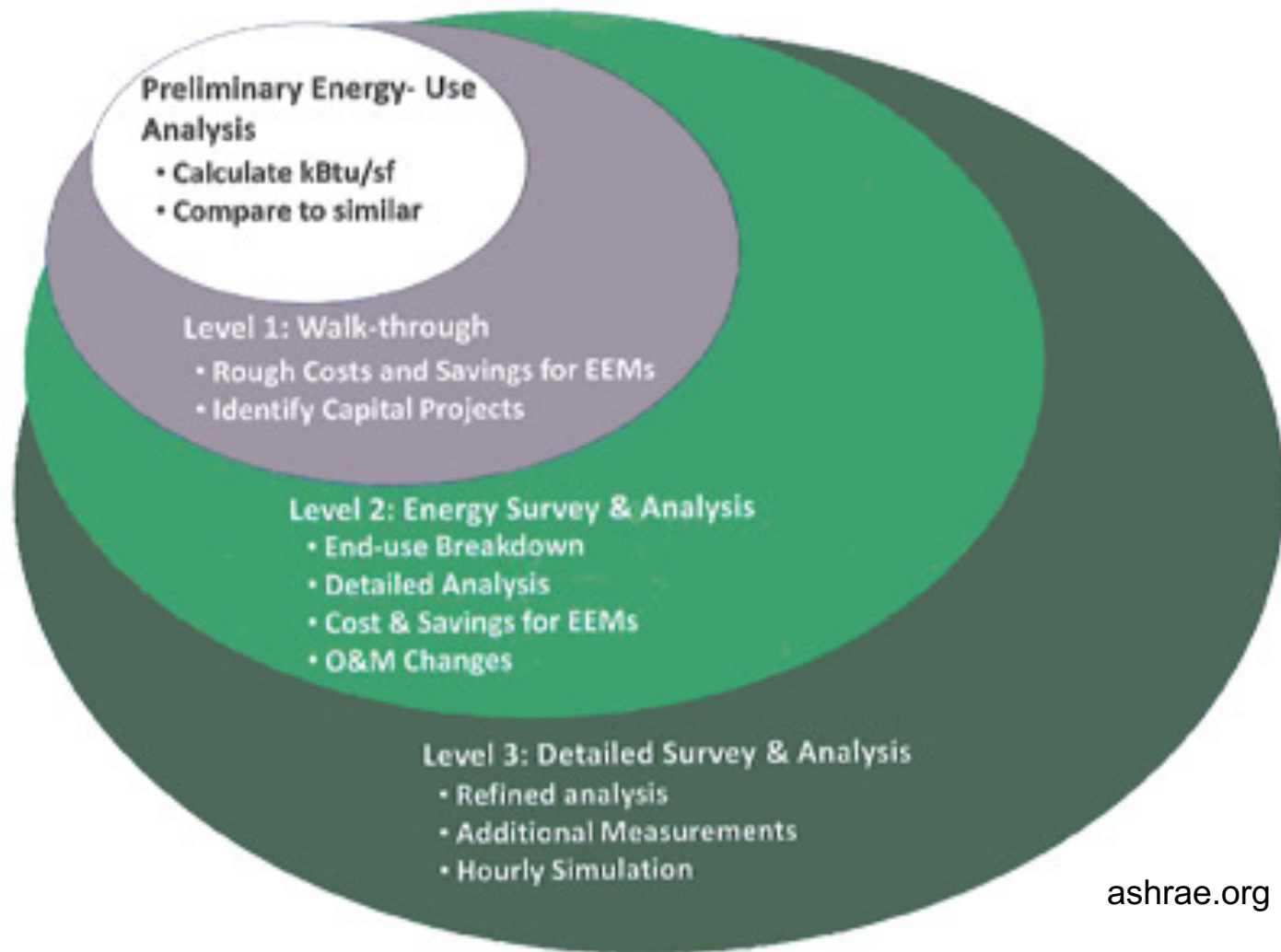
1. Prepare and present written report
2. Assist with development of implementation plan

### C. Three ASHRAE audit levels

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

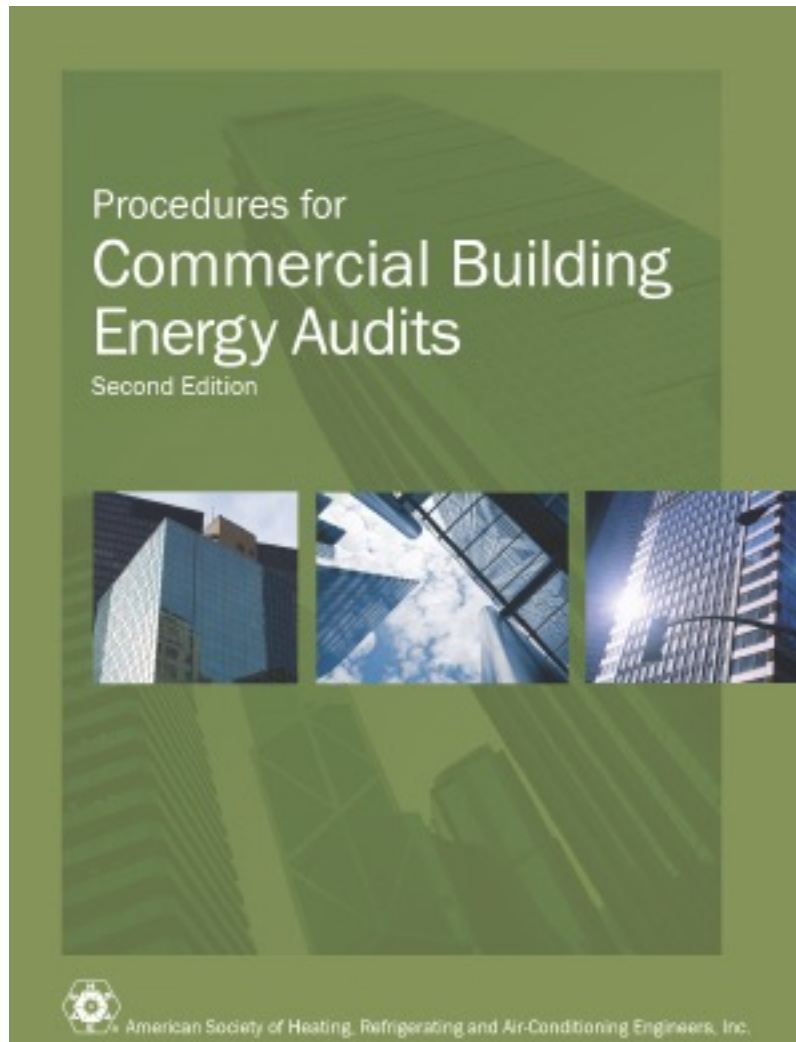
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## Introduction to Commercial Building Audits

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[ashrae.org](http://ashrae.org)

### C. Three ASHRAE audit levels

1. Preliminary energy use analysis
2. Level 1, Walk-through analysis
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# Summary - Preliminary energy use analysis

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- Analyze historic utility use and cost
- Develop the Energy Utilization Index (EUI)
- Compare the building EUI to similar buildings
  - Energy Star/ CBECs
  - Energy IQ ([www.energyiq.lbl.gov](http://www.energyiq.lbl.gov))
- Determine if further engineering study and analysis are likely to produce significant energy savings
- EUI: annual energy use per square foot (kBtu/ft<sup>2</sup>/yr)
- reading material: <http://cms.ashrae.biz/EUI/>  
<http://www.energystar.gov/index.cfm?fuseaction=buildingcontest.eui>

# Steps - Preliminary energy use analysis

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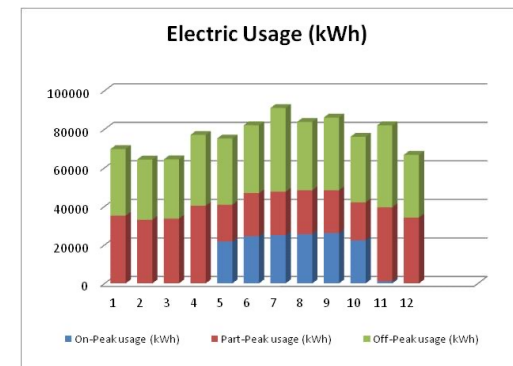
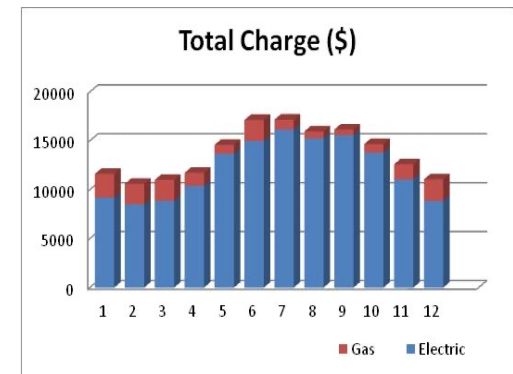
1. Potential customer interface and information
  - Customer goals
  - Previous energy conservation projects
  - Schedule of facilities
  - Maintenance policies
  
2. Determine the gross conditioned square footage, classify the primary use

# Steps - Preliminary energy use analysis

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## 3. Review of utility data (12-36 months)

- Analyze data and trend
- Compare the EUI and cost index with similar buildings
- Determine potential of EEMs
- Determine potential local utility rebate programs



# Steps - Preliminary energy use analysis

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## EUI

Energy Use Indices for Quincy House New Residence Hall					
Metric	2006 (baseline used for 30% GHG Reduction Goal)	Current EUI based on FY2010 Data	Annualized with all ECRs	Savings Potential from FY10	Equivalent to meet 30% GHG reduction goal
kBtu per sq. ft.	88.16	75.49	34.9	54%	61.6*
Total Utility Cost per square foot	\$2.69	\$2.19	\$1.03	\$1.16	\$1.53
* The University-wide 30% GHG reduction goal is not intended to be interpreted as a strictly school or building-based target.					

[http://www.uos.harvard.edu/fmo/building\\_maintenance/quincy\\_house\\_energy\\_audit.pdf](http://www.uos.harvard.edu/fmo/building_maintenance/quincy_house_energy_audit.pdf)

# EPA Portfolio Manager – Energy Star ratings

## • Baseline



## • Level 1 Improvements



## • Level 2 Improvements



## • Level 3 Improvements



# Report - Preliminary Energy Use Analysis

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- Provide description of facility, occupancy, floor area, usage and scheduling etc
- Present graph of utility bills, analysis and summary tables
- Present results of benchmarking
- Present preliminary list of potential EEMs for further analysis

## C. Three ASHRAE audit levels

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

## Summary - Level 1: Walk-through analysis

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- Assess a building's energy cost and efficiency by analyzing energy bills and conducting a brief on-site survey
- Identify and provide a savings and analysis of low-cost/no-cost measures.
- Provide a list of potential capital improvements that merit further consideration

# Steps - Level 1: Walk-through analysis

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1. Complete steps of a Preliminary energy use analysis
2. Potential customer interface and information
  - compare drawing to actual facility conditions
  - ask customer goals/concerns
  - equipment replacement history and plans
  - operation and scheduling
  - maintenance procedures

## Steps - Level 1: Walk-through analysis

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3. Perform a brief walk-through survey of the facility
  - occupancy information
  - envelope components (wall, roof, windows, doors, skylights, floor, etc)
  - HVAC systems inventory and control strategies
  - lighting fixtures and controls
  - other energy usage systems
4. Perform a rough estimate to determine the approximate breakdown of energy use for significant end-use categories

## Steps - Level 1: Walk-through analysis

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### 5. Identify savings and cost analysis for low-cost/no-cost measures

- lighting retrofits having fastest payback
- better control systems or strategies
- obvious energy wasting operation and poor scheduling
- utility and local government rebates in cost analysis

## Steps - Level 1: Walk-through analysis

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6. Provide a list of potential capital improvement EEMs for further analysis

- building envelope features (tinting or installing insulated windows, roof insulation)
- HVAC retrofits including higher efficiency equipment, VFD for fans/pumps
- lighting retrofit requiring significant investment such as LED, system controls
- building automation controls

## Report - Level 1: Walk-through analysis

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- contents in preliminary energy use analysis
- preliminary end use energy breakdown estimation
- discussion of irregularities found in the energy use patterns
- summary of special problems or needs identified for operational or maintenance procedures
- list of low-cost/no-cost EEMs and estimate of savings
- list of potential capital improvement EEMs with initial estimate of energy savings and costs.

# Report - Level 1: Walk-through analysis

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## Sample report

<http://campusops.uoregon.edu/files/pdf/admin/knight-law-ashrae-level-1-june-11.pdf>



### C. Three ASHRAE audit levels

1. Preliminary energy use analysis
2. Level 1, Walk-through analysis
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## Summary - Level 2: Intermediate

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- includes a more detailed building survey and energy analysis
- provide a breakdown of the energy use
- Identify and provide the savings and cost analysis of all practical measures, along with a discussion of any changes to operation and maintenance procedures
- Provide a list of potential capital-intensive improvements that require more thorough data collection and engineering analysis, and a judgment of potential costs and savings
- This level of analysis will be adequate for most buildings and measures

## Steps - Level 2: Intermediate

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1. Complete steps of a Level 1 walk-through analysis services
2. Potential customer interface and information
  - corporate financial criteria and guidelines
  - discuss potential energy conservation projects to compliment equipment replacement plans, anticipated changes to operation and schedule of equipment and facilities
  - status of current equipment, validation of operational controls, existing problems areas, actual maintenance level of implementation

## Steps - Level 2: Intermediate

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### 3. Existing building survey information

- occupancy information, equipment schedules and operations
- envelope components (wall, roof, windows, doors, skylights, floor, etc)
- HVAC systems inventory and control strategies
- lighting fixture types, quantities and controls
- other energy usage systems

## Steps - Level 2: Intermediate

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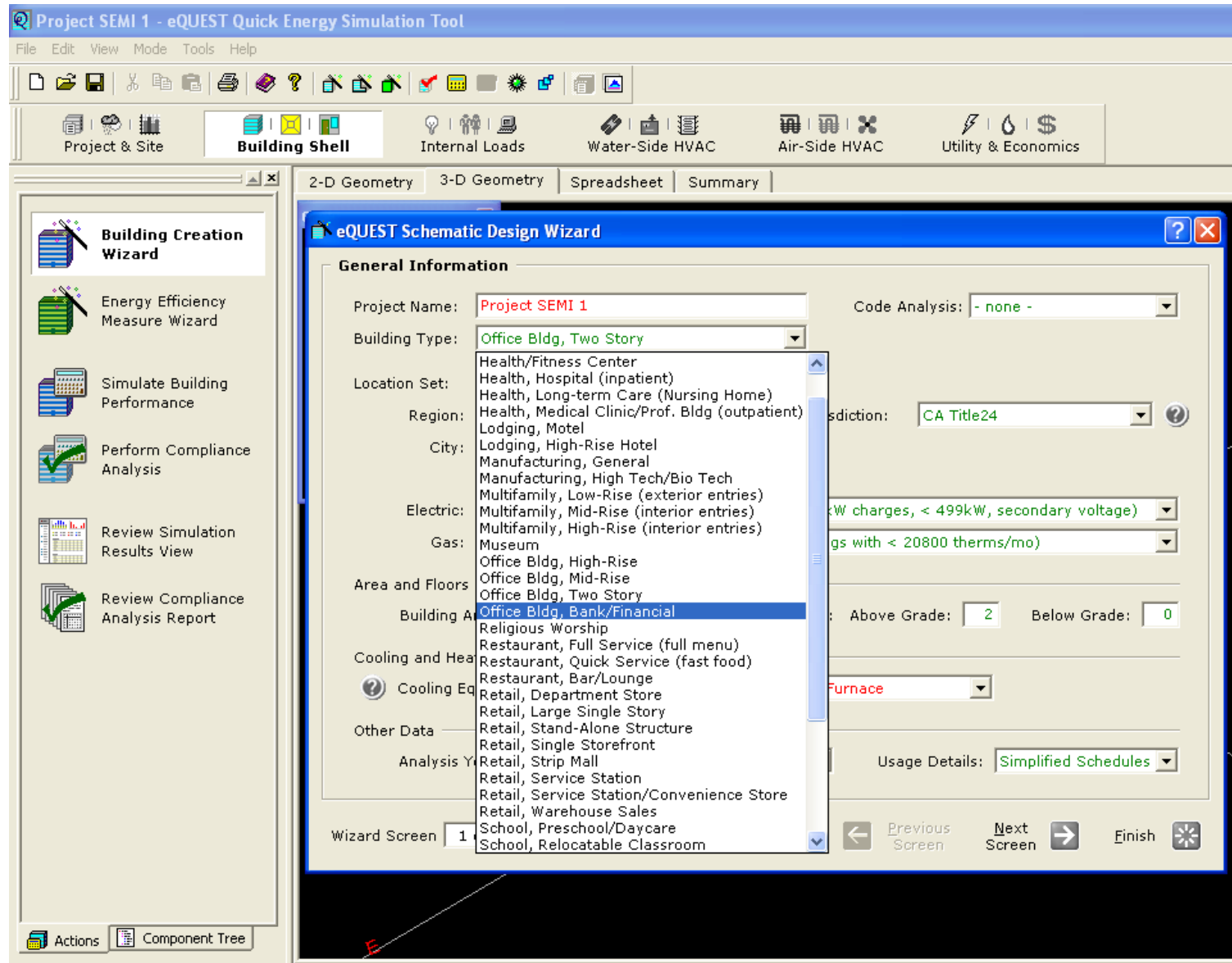
### 4. Breakdown of energy use within building

- provide estimate based on California Commercial End-use Survey
- conduct preliminary energy analysis with energy simulation software (eQuest, Trane Tracer or Carrier HAP-Wizard level, etc)

Selection of energy analysis software

[http://www1.eere.energy.gov/buildings/qualified\\_software.html](http://www1.eere.energy.gov/buildings/qualified_software.html)

# eQuest demo



# eQuest demo

**eQUEST Schematic Design Wizard**

**Building Footprint**

Footprint Shape:  ...

Zoning Pattern:  ...

Building Orientation: \_\_\_\_\_

Plan North:  ...

Footprint Dimensions: \_\_\_\_\_

Zone Names and Characteristics

38.0% Perc

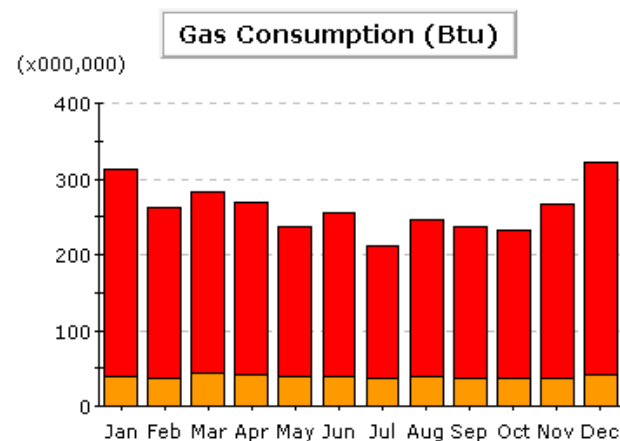
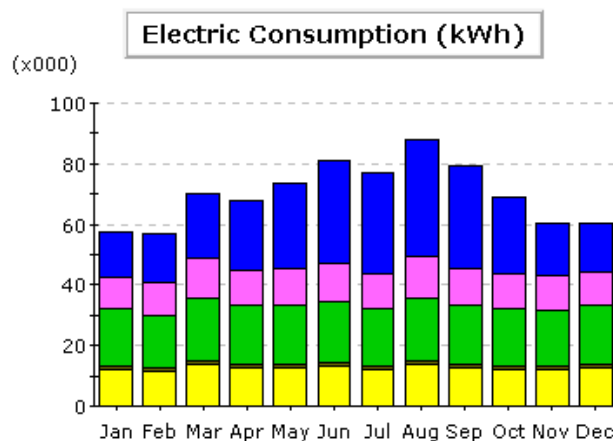
1 of 41 - General Information  
3 of 41 - Building Footprint  
4 of 41 - Building Envelope Constructions  
5 of 41 - Building Interior Constructions  
6 of 41 - Exterior Doors  
7 of 41 - Exterior Windows  
8 of 41 - Exterior Window Shades and Blinds  
9 of 41 - Roof Skylights  
13 of 41 - Activity Areas Allocation  
14 of 41 - Occupied Loads by Activity Area  
16 of 41 - Unoccupied Loads by Activity Area (% of occupied load)  
17 of 41 - Main Schedule Information  
19 of 41 - HVAC System Definitions  
20 of 41 - HVAC Zones: Temperatures and Air Flows  
21 of 41 - Packaged HVAC Equipment  
24 of 41 - HVAC System Fans  
25 of 41 - HVAC System #1 Fan Schedules  
26 of 41 - HVAC System #2 Fan Schedules  
27 of 41 - HVAC Zone Heating, Vent and Economizers  
28 of 41 - HVAC System Hot/Cold Deck Resets  
36 of 41 - Non-Residential Domestic Water Heating  
41 of 41 - Project Information

Wizard Screen 3 of 41

Help Previous Screen Next Screen Finish

Number of Floors: 32,000 ft<sup>2</sup>  
Above: 29,696 ft<sup>2</sup>  
Flr-To-Ceil: 12.0 ft

# eQuest demo



**Electric Consumption (kWh x000)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	14.96	16.39	20.93	22.83	28.02	34.01	33.18	38.30	33.87	25.41	17.31	16.07	301.29
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	10.35	10.39	13.12	11.73	12.18	12.57	11.82	13.48	12.10	11.48	11.01	10.89	141.14
Pumps & Aux.	0.03	0.02	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.17
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	18.79	17.62	20.86	19.32	19.48	20.01	18.79	20.86	19.32	18.79	18.63	19.48	231.96
Task Lights	1.09	1.04	1.25	1.14	1.14	1.20	1.09	1.25	1.14	1.09	1.09	1.14	13.69
Area Lights	12.13	11.47	13.78	12.64	12.68	13.19	12.13	13.78	12.64	12.13	12.09	12.68	151.36
<b>Total</b>	<b>57.35</b>	<b>56.94</b>	<b>69.96</b>	<b>67.69</b>	<b>73.51</b>	<b>80.98</b>	<b>77.02</b>	<b>87.68</b>	<b>79.08</b>	<b>68.91</b>	<b>60.16</b>	<b>60.29</b>	<b>839.60</b>

## eQuest demo

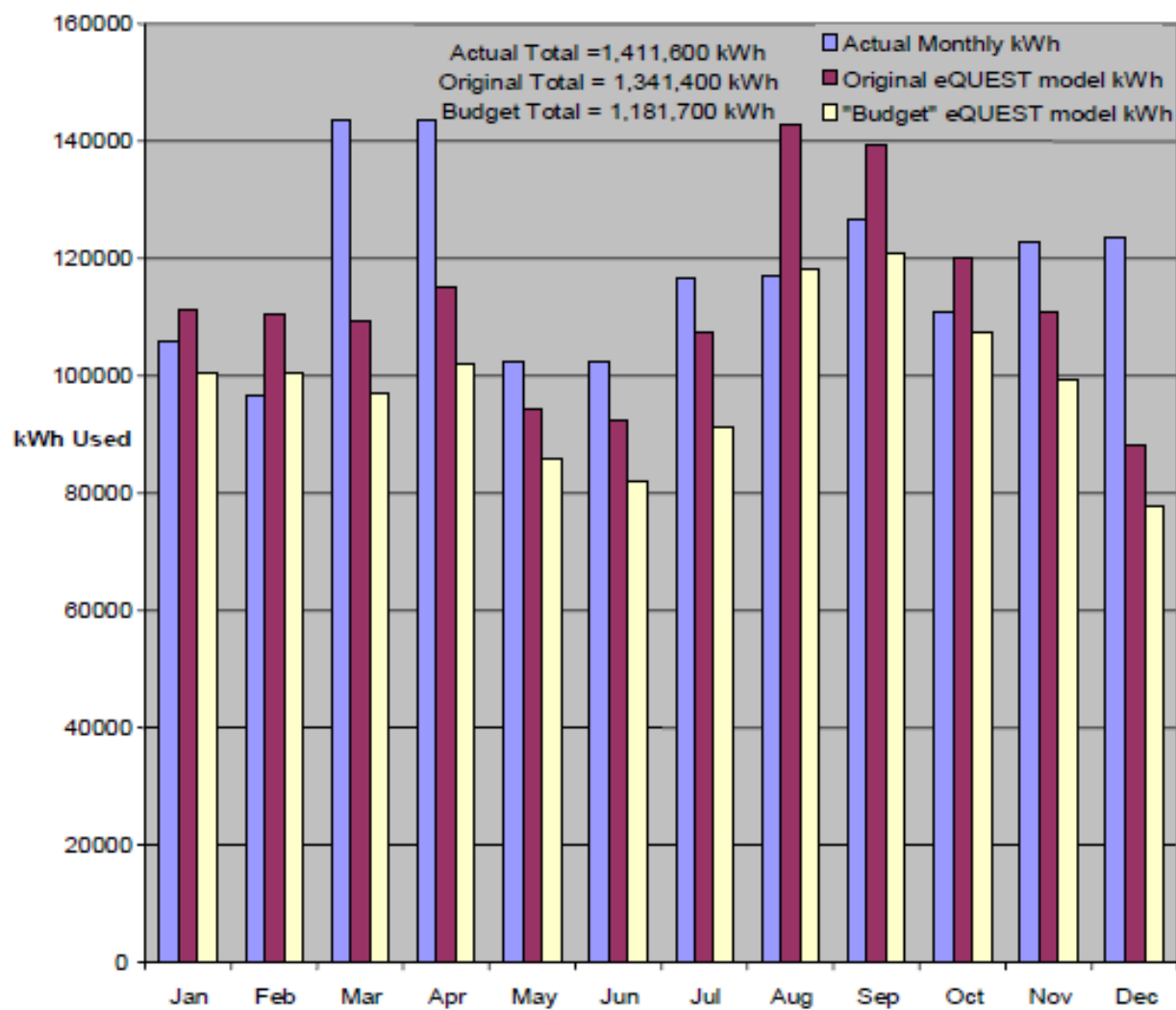


Figure 2 – Energy Modeling Comparison to Actual Electric Meter Readings

Take eQuest intro-  
and intermediate  
training classes at the  
Pacific Energy Center,  
they are FREE!

## Steps - Level 2: Intermediate

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5. Identify recommended changes to equipment, operation and maintenance activities, cost/savings estimates.
6. Provide energy savings and cost analysis of practical EEMs that meet customer's constraints and capital improvement criteria
  - building envelope features (windows, skylights, etc)
  - HVAC retrofits – replacement of existing systems by higher efficiency equipment, VFD, building automation controls
  - Lighting retrofits – re-lamping, de-lamping

**Include utility rebates in cost analysis**

## Steps - Level 2: Intermediate

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7. Provide a list of capital-intensive improvements that require further data and analysis
  - building envelope features (better wall, cool roof etc)
  - HVAC retrofits – complete replacement of existing systems, significant upgrade to building automation controls
  - Lighting retrofits requiring significant investment such as LED light sources for high bay and light poles
  - renewable energy generation systems like solar PV, solar thermal, etc

**Include utility rebates in cost analysis**

## Report - Level 2: Intermediate

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1. Provide summary of energy use and cost associated with major components
2. Specify computer software analysis utilized, compare actual total utility usage and calculated energy estimates
3. Provide description of building including floor plans, and inventories of major equipment

## Report - Level 2: Intermediate

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4. Provide discussion of recommended energy conservation measures.
  - existing situations that are wasting energy
  - required repairs of existing equipment
  - impact of measures on health, safety and comfort
  - impact on occupants, O&M procedures and staff
  - useful life of equipment
  - an outline of any new skills required for existing employees or new hires as a result of EEM implementation

## Report - Level 2: Intermediate

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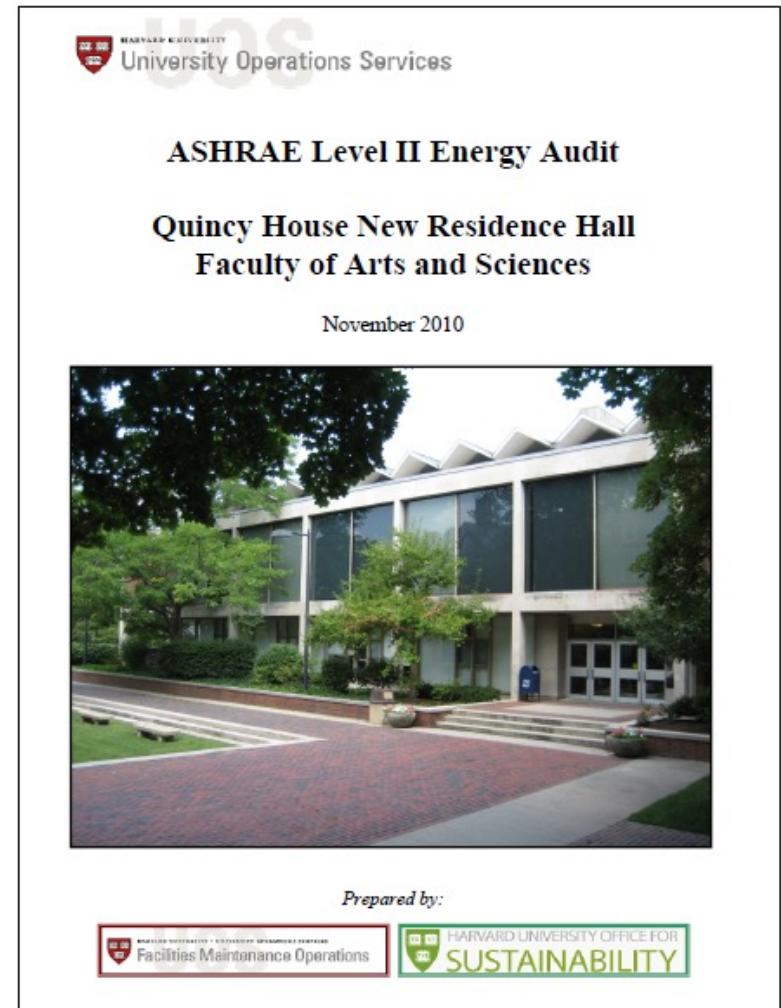
5. Provide summary (tables) with:
  - name of EEMs
  - estimated annual energy savings
  - estimated installation cost, simple payback period
  - implementation plan for all recommendation EEMs
6. Recommend EEMs and verification methods to validate performance of projects
7. Discuss potential capital-intensive measures requiring a level 3 analysis

# Report - Level 2: Intermediate

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Sample Level 2 report:

[http://www.uos.harvard.edu/fmo/building\\_maintenance/quincy\\_house\\_energy\\_audit.pdf](http://www.uos.harvard.edu/fmo/building_maintenance/quincy_house_energy_audit.pdf)



# Report Demo – Executive Summary

[http://www.uos.harvard.edu/fmo/building\\_maintenance/quincy\\_house\\_energy\\_audit.pdf](http://www.uos.harvard.edu/fmo/building_maintenance/quincy_house_energy_audit.pdf)

Quincy House New Residence Low Cost Energy Conservation Recommendations							
ECR no.	ECR Title	Reason for Evaluation	Building Budget Savings	Net University Savings	Net Costs	SIR	Simple Payback Years
1	Replace existing 32W linear T8 fluorescent lamps with 25W alternative	Inefficient lighting	\$1,374	\$1,130	\$898	19.30	0.65
2	Replace outdoor canopy lamps with LED alternatives	Inefficient lighting	\$1,774	\$1,458	\$30,684	0.63	17.30
3	Install occupancy in dorms, restrooms, offices, and conference rooms.	Inefficient lighting	\$1,004	\$825	\$9,300	2.18	9.27
4	Replace 50W MR 16 With LED alternative	Inefficient lighting	\$729	\$599	\$280	75.26	0.38
5	Install vending misers on vending machines	Plug load	\$444	\$365	\$900	7.60	2.03

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Quincy House New Residence Low Cost Energy Conservation Recommendations							
ECR no.	ECR Title	Reason for Evaluation	Building Budget Savings	Net University Savings	Net Costs	SIR	Simple Payback Years
26	Seal unused fireplaces in dining hall and common rooms	Insulation & air infiltration	\$78	\$21	\$300	5.96	3.82
27	Cover permanently installed window AC units in winter	Insulation & air infiltration	\$440	\$116	\$1,440	6.96	3.27
Low Cost ECR Total			<b>\$94,953</b>	<b>\$51,472</b>	<b>\$212,287</b>	<b>-</b>	<b>2.24</b>
Quincy House New Residence Capital Cost Energy Conservation Recommendations							
28	Add gas powered water heaters to supply building domestic hot water	Inefficient HVAC Operation	\$14,979	(\$11,734)	\$115,000	3.05	7.68
29	Install heat recovery loop in main building supply and return air plenum	Inefficient HVAC Operation	\$3,716	\$982	\$62,000	1.17	16.68
30	Add thermostatic control valves to fin tube heating in dorm rooms	Inefficient HVAC Control	\$9,031	\$2,387	\$174,600	1.01	19.33
31	Install Insulating Window Quilts® all dorm room windows	Insulation & air infiltration	\$23,919	\$6,322	\$89,625	6.08	3.75
Consolidated Total			<b>\$146,599</b>	<b>\$49,429</b>	<b>\$653,512</b>	<b>-</b>	<b>4.46</b>

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### C. Three ASHRAE audit levels

1. Preliminary energy use analysis
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## Summary - Level 3: Detailed analysis

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- Focuses on capital-intensive projects identified during Level 2 analysis
- Involves more detailed field data gathering as well as a more rigorous engineering analysis
- Provides detailed project cost and savings calculations with a high level of confidence sufficient for major capital investment decisions

## Steps - Level 3: Detailed analysis

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1. Complete steps of a Level 2 energy survey and analysis
2. Potential customer interface and information
  - customer provide detail financial criteria for life cycle cost analysis and 3<sup>rd</sup> party financing as applicable
  - discuss potential construction contractor and maintenance contractors that can assist with cost estimated for detailed analysis

## Steps - Level 3: Detailed analysis

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3. Existing building on-site survey information, validate drawings and other documentation

- envelope components (wall, roof, windows, doors, skylights, floor, etc)
- HVAC systems components and control strategies
- lighting fixtures and controls
- equipment schedules, space and occupancy information
- other energy usage systems

## Steps - Level 3: Detailed analysis

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### 4. Conduct more rigorous energy analysis

- conduct energy simulation analysis (i.e. Trane Tracer or Carrier HAP-Detail level)
- requires well defined building envelope information
- detail HVAC systems components and control strategies
- accurate lighting and other electrical equipment levels and schedules

## Steps - Level 3: Detailed analysis

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5. Detail construction costs estimates or contractor price quotes are obtained
6. Equipment O&M and replacement costs are determined from service contractors
7. Complete life cycle cost analysis of alternatives are conducted
  - Life Cycle Costing Manual – Federal
  - Energy Management Program

## Report - Level 3: Detailed analysis

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1. Include text, schematics and equipment list necessary to completely describe the EEMs.
2. Preliminary engineering information and detailed estimates or firm price quotes should support cost estimates.
3. Prepare a financial evaluation of the estimated capital improvement projected energy savings
4. Use the owner's chosen techniques and criteria as requested in final presentation

## Difference between levels

Process	1	2	3
Conduct Preliminary Energy Analysis (PEA)	√	√	√
Conduct walk-through survey	√	√	√
Identify low-cost/no-cost recommendations	√	√	√
Identify capital improvements	√	√	√
Review M&E design, condition and O&M practices		√	√
Measure key parameters		√	√
Analyze capital measures (savings & costs including interaction)		√	√
Meet with owner/operators to review recommendations		√	√
Conduct additional testing/monitoring			√
Perform detailed system modeling			√
Provided schematic layouts for recommendations			√

Source from kW Engineering

## Difference between levels

Report	1	2	3
Estimate savings from utility rate change	√	√	√
Compare EUI to that of similar sites	√	√	√
Summarize utility data	√	√	√
Estimate savings if EUI met target	√	√	√
Estimate low-cost/no-cost savings		√	√
Perform detailed end-use breakdown		√	√
Estimate capital project costs and savings		√	√
Complete building description and equipment inventory		√	√
General description of considered measures		√	√
Recommended M&V method		√	√
Financial analysis of recommended EEMs		√	√
Detailed description of recommended measures			√
Detailed EEM cost estimates			√

Source from kW Engineering

## Homework:

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Read through sample auditing reports

# 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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