

## Energy Auditing of Buildings



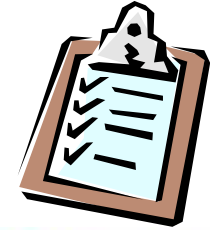
*Dr. Sam C. M. Hui*

Department of Mechanical Engineering

The University of Hong Kong

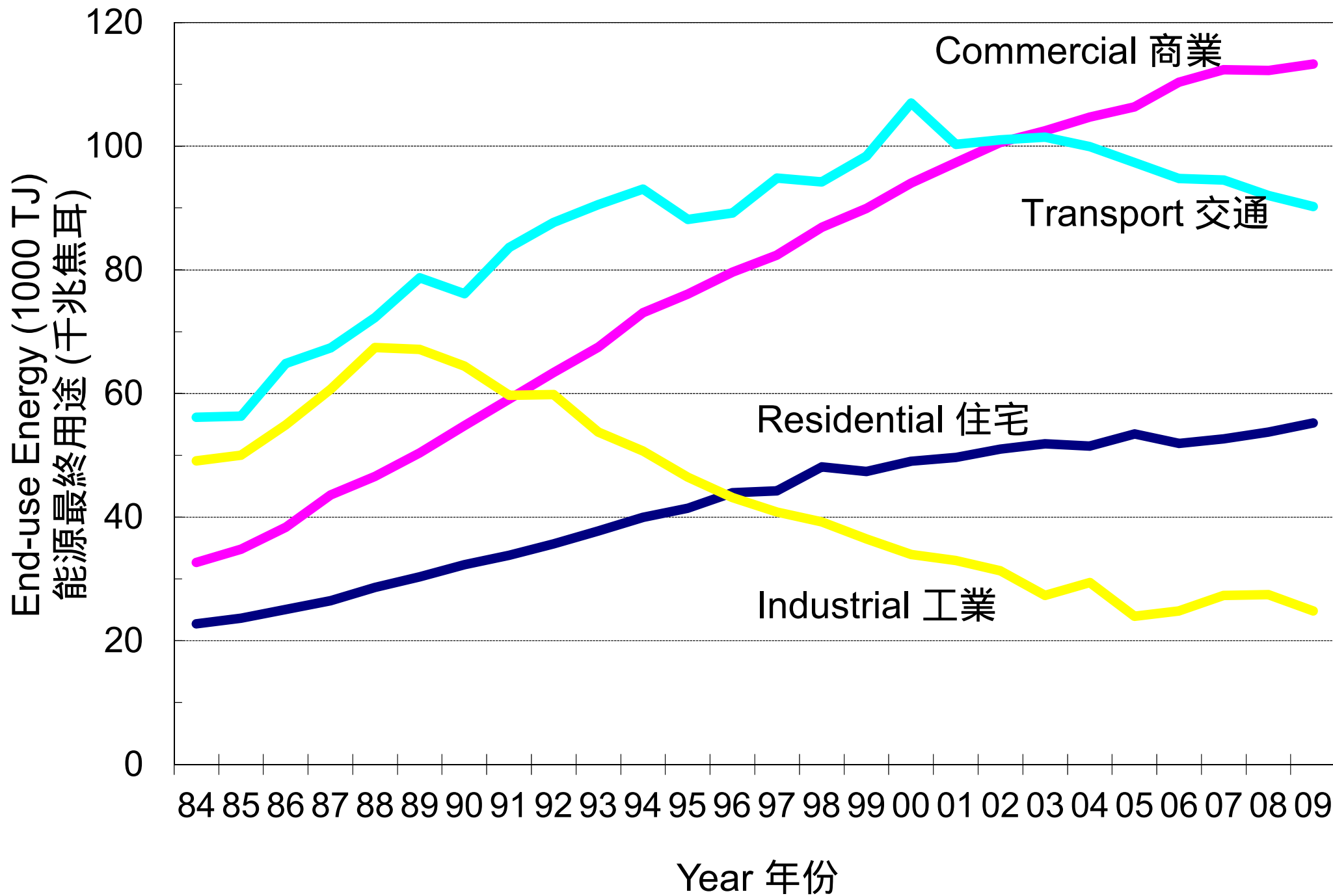
E-mail: [cmhui@hku.hk](mailto:cmhui@hku.hk)

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(Data source: EMSD) Energy end-use in Hong Kong by sectors, 1984-2009

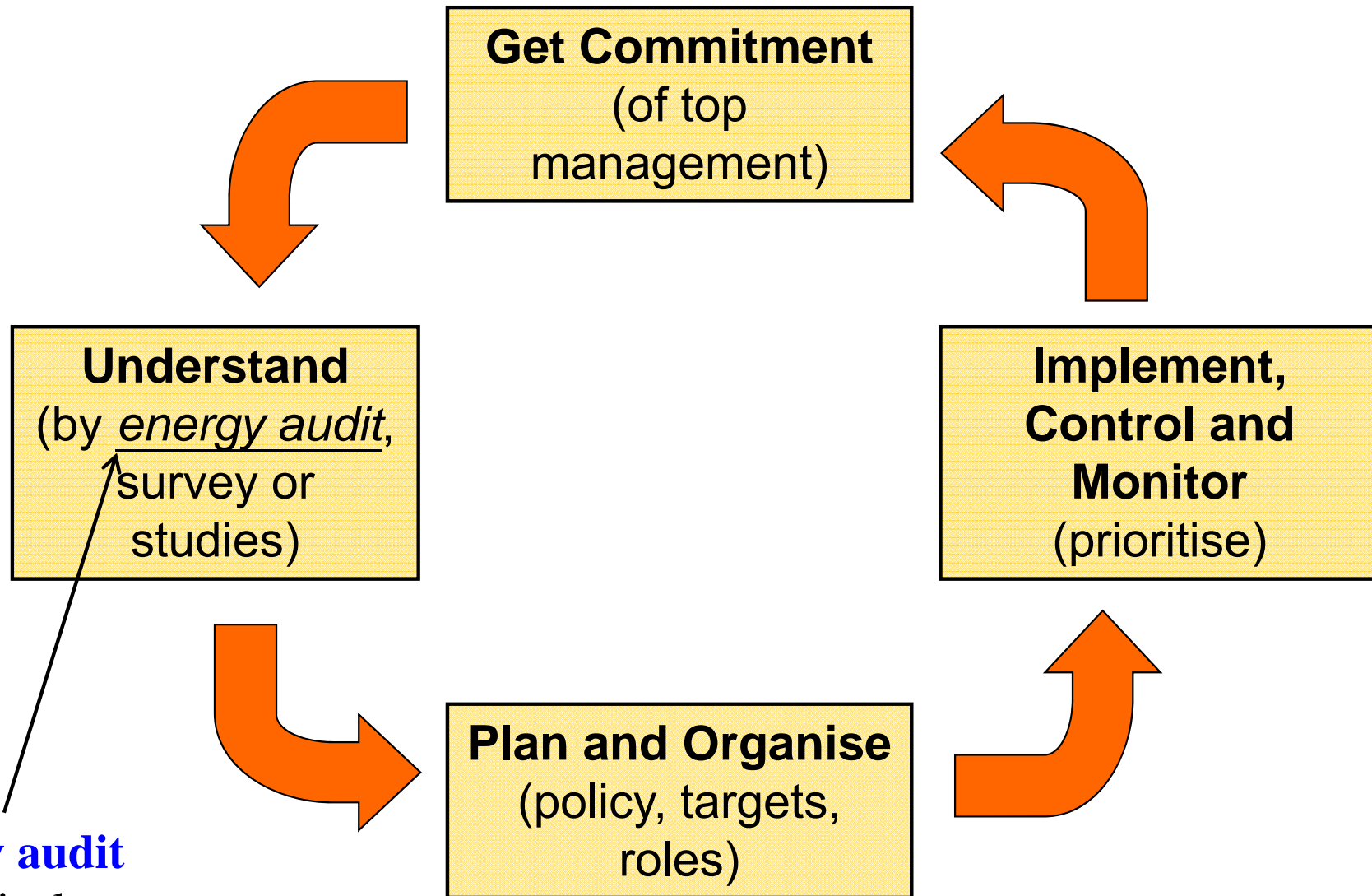


# Basic Concepts

- Energy end-use in HK (trend in 1984-2010)
  - Commercial sector: increases at 5% per year
  - Residential sector: increases at 3.5% per year
- Average consumption: (examples)
  - Office: 265 kWh/m<sup>2</sup>/year
  - Hospital: 200 kWh/m<sup>2</sup>/year
  - Post office: 170 kWh/m<sup>2</sup>/year
- How to control/manage this?



# A systematic approach to energy management



**Energy audit**  
is a critical  
step for energy  
management



# Basic Concepts

- What is Energy Audit (能源審核)?
  - Examination of an energy system or equipment to ensure that energy is being used *efficiently*
    - Process to check for areas of *inefficiency*
  - It is a top-down initiative. Its result depends on the resources being allocated by top management
  - Aims to identify **energy management opportunities (EMO)** & means for improvement
  - In many ways, an energy audit is similar to financial accounting and auditing



# Basic Concepts

- Overview of energy audit
  - Collection and analysis of relevant information that may affect building energy consumption
  - Review the information, analyse the conditions and performances of existing equipment, systems and installations, and the energy bills
  - Compare with performances at relevant energy efficient modes of operation
  - Identify areas of energy inefficiency and the means for improvement



# Basic Concepts

- Benefits of energy audit
  - Financial
    - Reduce energy and other running costs
    - Reduce maintenance costs
  - Operational
    - Improve building management
    - Increase productivity via improved working conditions
  - Environmental
    - Reduce CO<sub>2</sub> emission and conserve resources







# Basic Concepts

- Conducting the energy audit
  - Check the energy consuming equipment/systems of the central building services installations
  - Evaluate their operation characteristics and controlling parameters
  - Identify as many EMOs as possible and their categorisation





# Basic Concepts

- Auditing steps: (\* see also HK Energy Audit Code)
  - Step 1 – Collection of Building Information
  - Step 2 – Review of Energy Consuming Equipment
  - Step 3 – Identification of EMO
  - Step 4 – Cost Benefit Analysis of EMO
  - Step 5 – Recommendations
  - Step 6 – Compiling Energy Audit Report
- Energy audit and related forms
  - [www.beeo.emsd.gov.hk/en/mibec\\_forms.html](http://www.beeo.emsd.gov.hk/en/mibec_forms.html)



# Basic Concepts

- 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...

In fact, a lot of skills and experience are needed to ensure that recommendations are cost effective, technically feasible, and result in significant energy savings





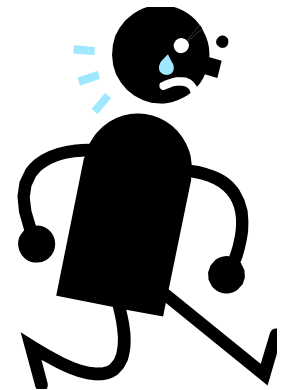
# Basic Concepts

- The term “*energy audit*” (能源審核)
  - It is perceived as carrying the negative connotations (an involuntary investigation of finances, where the intended goal is to uncover mistakes and assess monetary penalty)
- Better to avoid such negative connotations
  - To gain better acceptance by the building managers and operators
  - The term “*energy assessment*” (能源評估) is used

# Types of Energy Audits



- Two common types of energy audits:
  - General walk-through audit
    - Limited resources
    - Focus on major energy consuming equipment
    - Give an overview of potential saving options
    - Could identify areas for further investigation
  - Detailed audit (full audit)
    - More resources
    - Detailed planning
    - Practically investigating all equipment & systems



# Types of Energy Audits



- Investment grade audit (IGA)

- Expand on the detailed audit
- Analyses the financial aspects of energy savings and the return on investment (ROI) from potential changes or upgrades
- Aim to justify the energy investment
- Rely on a complete engineering study in order to detail technical and economical issues



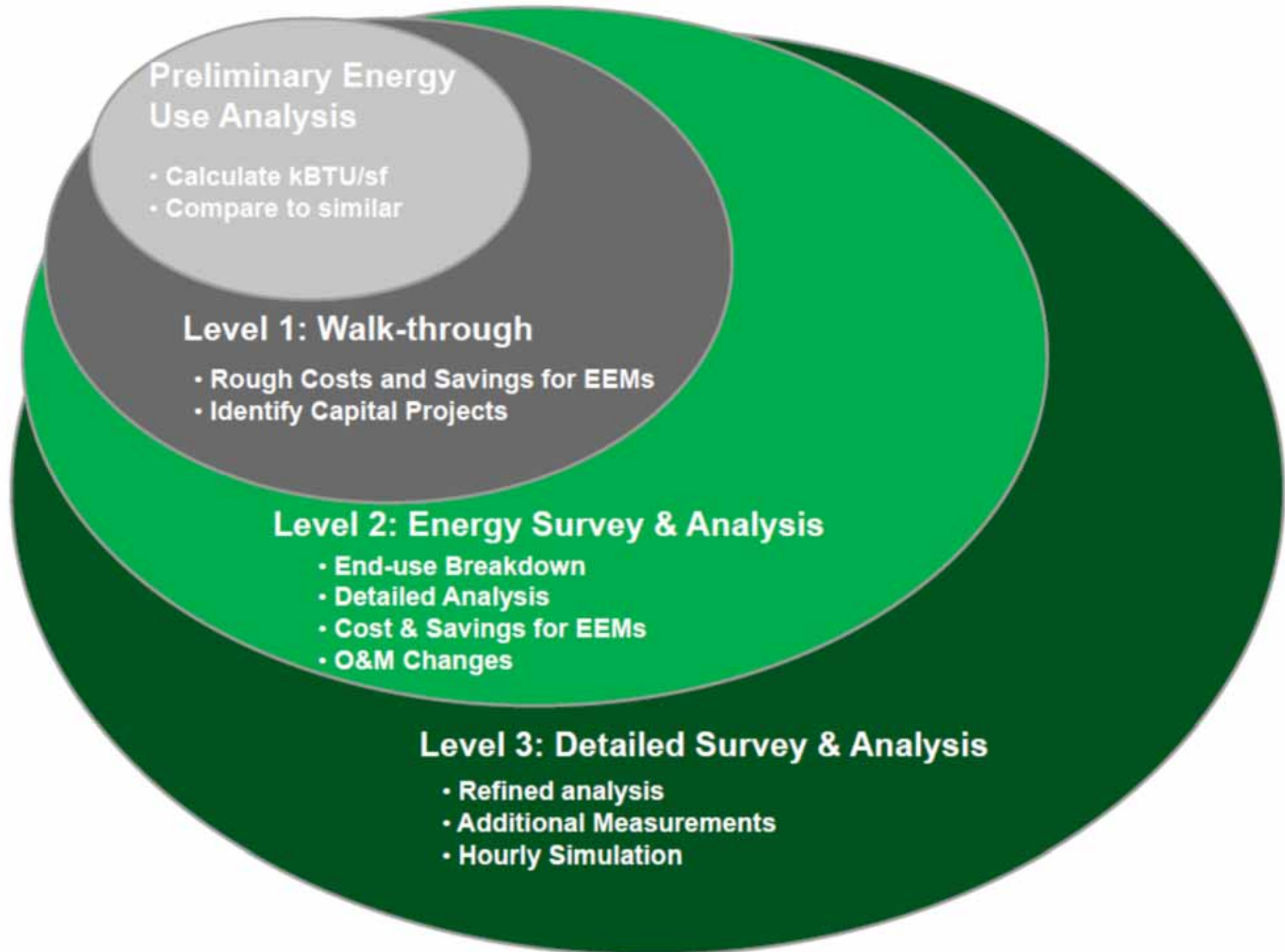
# Types of Energy Audits



- Levels of effort of energy audit (ASHRAE)\*
  - Preliminary Energy-Use Analysis (PEA)
  - Level 1 – Walk-Through Analysis
  - Level 2 – Energy Survey and Analysis
  - Level 3 – Detailed Analysis of Capital-Intensive Modifications
- Also, Targeted Audits (of a specific system or end use, such as the chiller plant)



# Relationship of energy audit levels 1, 2, and 3





## Energy audit level summary: Process

Process	Level		
	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		●	●
Analyse 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			●

# Energy audit level summary: Report

Report	Level		
	1	2	3
Estimate savings from utility rate change	●	●	●
Compare EUI (energy use index) 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 (measuremt. & verification) method		●	●
Financial analysis of recommended EMOs		●	●
Detailed description of recommended measures			●
Detailed EMO cost estimates			●



# Types of Energy Audits

- Preliminary Energy-Use Analysis (PEA)
  - Done prior to site visit
  - Required 1st step for Level 1 audit
  - Compile billing data
  - Calculate Energy Use Intensity (EUI)
    - (kWh/m<sup>2</sup> or MJ/m<sup>2</sup>)
  - Compare to similar buildings:
    - Using benchmark data
    - The building's own portfolio (don't forget to correct for weather, schedules, etc.)



# Types of Energy Audits

- Level 1 – Walk-Through Analysis
  - Process
    - Conduct Preliminary Energy Analysis (PEA)
    - Conduct walk-through survey
    - Identify low-cost/no-cost recommendations
    - Identify capital improvements
  - Report (brief)
    - Estimate savings from utility rate change
    - Compare EUI to that of similar sites
    - Summarise utility data
    - Estimate savings if EUI met target



# Types of Energy Audits

- Level 2 – Energy Survey and Analysis

- Process

- Detailed site visit
- Review M&E design, condition and O&M practices
- Measure key parameters
- Analyse capital measures (savings & costs including interaction)
- Meet with owner/operators to review recommendations



# Types of Energy Audits

- Level 2 – Energy Survey and Analysis (cont'd)
  - Report
    - 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 EMOs

# Example of EMO summary table

Measure Number	Measure Description	Annual Energy and Cost Savings					Payback with Incentive				
		Peak Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	CO <sub>2</sub> Savings (tons)	Measure Cost	Potential WG&E Incentive	Net Measure Cost	MIRR	Simple Payback (yr)
<b>Lighting Measures</b>											
EEM-1	Reduce Garage Lighting to Half Overnight	0.0	34,465	0	\$ 3,447	18.9	\$ 750	\$ 375	\$ 375	27%	0.1
EEM-2	Install Photocell To Control Lobby Lights	1.4	4,047	0	\$ 405	2.2	\$ 2,047	\$ 503	\$ 1,544	7%	3.8
EEM-3	Install Photocell to Control Outdoor Lights and Schedule	0.0	15,257	0	\$ 1,526	8.4	\$ 1,795	\$ 897	\$ 897	17%	0.6
EEM-4	Re-Commission Lighting Controls	0.0	109,102	0	\$ 10,910	59.9	\$ 9,720	\$ 4,860	\$ 4,860	19%	0.4
EEM-5	Install Bi-Level LED Fixtures in Garage	6.3	84,765	0	\$ 8,476	46.5	\$ 7,127	\$ 8,257	\$ 88,870	6%	10.5
<b>Kitchen Measures</b>											
EEM-6	Kitchen Hood and Fan Upgrade:	0.0	138,763	5,989	\$ 18,668	111.2	\$ 33,085	\$ 13,800	\$ 19,285	17%	1.0
EEM-7	Install Controls to Schedule Two Pan Chillers in Servery	0.0	9,907	0	\$ 991	5.4	\$ 1,400	\$ 700	\$ 700	16%	0.7
EEM-8	Kitchen AC-5 - Expand Outside Air Intake Area	2.2	5,192	0	\$ 519	2.9	\$ 1,464	\$ 689	\$ 775	15%	1.5
EEM-9	Install Controls to Schedule Temperature Setbacks for Kitchen AC-5	0.0	1,010	907	\$ 827	5.9	\$ 1,000	\$ 500	\$ 500	17%	0.6
<b>Main Air Handler Measures (Occupied Hours Only)</b>											
EEM-10	Repair Economizers and Convert to Dry Bulb Temperature Control	0.0	155,576	0	\$ 5,558	85.4	\$ 25,083	\$ 12,542	\$ 12,542	15%	0.8
EEM-11	Supply Air Temperature Optimization and Duct Static Pressure Reset	1.4	178,563	0	\$ 7,856	98.1	\$ 18,506	\$ 9,253	\$ 9,253	18%	0.5
EEM-12	Install VFDs on Exhaust Fans	(4.7)	31,858	0	\$ 3,186	17.5	\$ 33,853	\$ 2,396	\$ 31,456	6%	9.9
<b>SUB-TOTALS</b>		<b>6.5</b>	<b>768,505</b>	<b>6,896</b>	<b>\$ 2,368</b>	<b>462.3</b>	<b>\$ 225,830</b>	<b>\$ 54,772</b>	<b>\$ 171,058</b>	<b>12%</b>	<b>2.1</b>
<b>TOTALS (Recommended Measures)</b>		<b>6.5</b>	<b>768,505</b>	<b>6,896</b>	<b>\$ 82,368</b>	<b>462.3</b>	<b>\$ 225,830</b>	<b>\$ 54,772</b>	<b>\$ 171,058</b>	<b>12%</b>	<b>2.1</b>

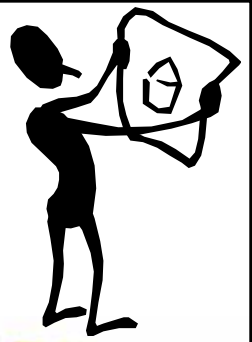


# Types of Energy Audits

- Level 3 – Detailed Analysis
  - Level 2 and then more...(additional scope & value)
  - Process
    - Additional testing/monitoring
    - Detailed system modelling
    - Schematic layouts for recommendations
  - Report
    - Detailed description of recommended measures
    - Detailed EMO cost estimates
    - LCCA (life cycle cost analysis)



# Planning of Energy Audits



- Energy audits can be carried out by
  - Building manager or internal staff (in-house)
  - External consultant or professionals
- Typical stages of energy audit:
  - 1. Pre-audit stage
  - 2. Energy audit stage
  - 3. Post-audit stage



# Procedure of energy audit

**Pre-audit stage**

Defining Scope of Energy Audit

Forming Energy Audit Team

Estimating Time Frame and Budget

Collecting Building Information

**Energy audit stage**

Conducting Site Inspection and Measurement

- Strategic measuring points
- Instrumentation

Analysing Data Collected

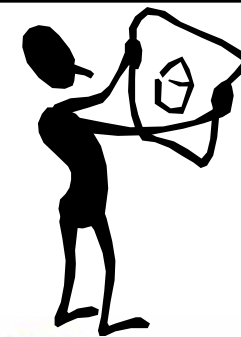
- Identification of energy management opportunities
- Costing
- Normalisation of data
- Maintain thermal and lighting comfort
- Already scheduled maintenance and refurbishment works

Preparing Energy Audit Report

**Post-audit stage**

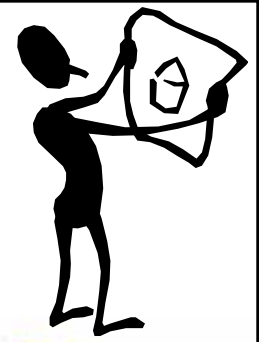
Implementation of Energy Management Opportunities

Monitoring and Review



# Planning of Energy Audits

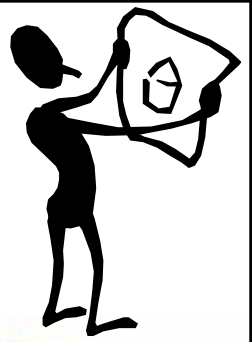
- Define available resources for energy audit:
  - Staff, Time and Budget
- Resources required for energy audits:
  - Staff with relevant knowledge/skills
  - Time to perform the tasks involved
  - Measuring equipment and metering
  - Finance for the audit and to implement measures
  - Technical and operational information



# Planning of Energy Audits

- Scope of energy audit include:
  - Areas to be audited
  - Level of sophistication
  - Savings anticipated
  - Needs for improvements on O&M
  - Needs for training
- Importance of involving senior management, facilities operator and staff
  - Will need assistance and cooperation from the end-users and building staff

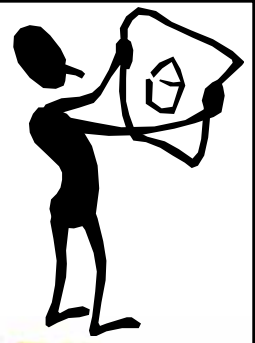
# Planning of Energy Audits



- Energy audit team
  - The number of auditors depend on the scope and objectives of the energy audit
  - Duties of the team members should be defined
  - Auditors are competent persons having adequate knowledge on building services installations
  - Involve the facilities operators to provide input
  - If in-house expertise is not adequate, energy audit consultants should be employed



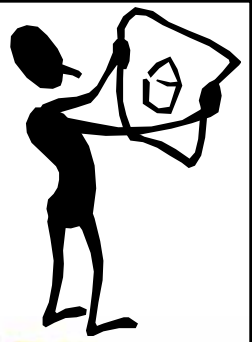
# Planning of Energy Audits



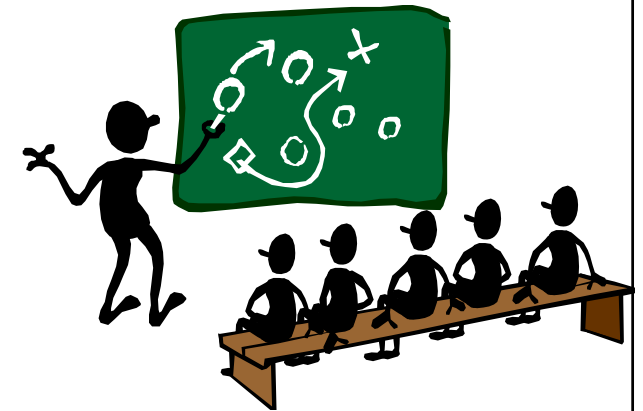
- Team building is key to audit & implementation success
  - Seek involvement with key players at site
  - Let folks do what they're good at
  - Leave site staff with the knowledge to follow through
- Don't believe everything you hear
  - Site inspections with staff can be misleading
  - Your questions may be threatening



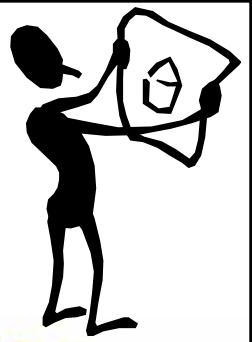
# Planning of Energy Audits



- Building a balanced team (if possible)
  - Committed management
  - Engaged financial staff who understand risks and rewards
  - Trained building engineers
  - Trusted contractors and vendors
  - Utility account representatives
  - Engaged and informed building occupants
  - Trained and experienced energy auditor



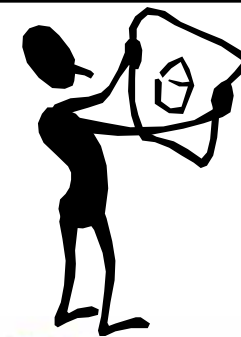
# Planning of Energy Audits



- Costs vs. Accuracy
  - Energy auditing seeks to strike a balance between time spent and the value returned
  - Important to allow flexibility to seek the best return on time
  - *Too little effort...* may result in less identified potential
  - *Too much effort...* gilded lilies and science projects



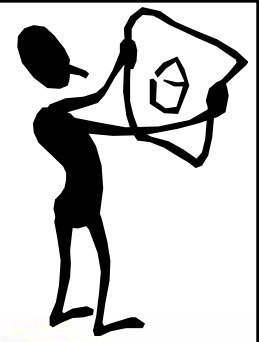




# Planning of Energy Audits

- Time frame and budget
  - Established based on available resources
  - Budget is mainly built up on cost of auditor hours
    - Auditor-hour depend on the degree of sophistication
    - A detailed audit can have auditor-hours that are about 5 to 10 times that required by a walk-through audit
  - Should check if adequate testing instruments are available and cost of additional instruments
  - Also, the cost of employing consultants (if any)
  - Disruption to building tenants





# Planning of Energy Audits

- Testing instruments
  - Electrical
    - e.g. multi-meter, wattmeter, power factor meter, light meter, power quality analyser
  - Temperature and humidity
    - e.g. sling psychrometer, infrared remote temp. sensing gun, digital thermometer
  - Pressure & velocity
    - e.g. manometer, anemometer, pressure gauge
  - Miscellaneous (exhaust gas analyser, tachometer)

# Instruments for energy audit and measurements



Anemometer



Luxmeter



Infrared thermometer



Sling psychrometer



Temp. logger



Pyranometer



Clamp-on ammeter



Multimeter



Temp + RH logger



Infrared camera

# Energy Audit Process



- Process of energy audit and analysis
  - Collect & analyse historical energy use
  - Study the building & its operational characteristics
  - Identify potential modifications that will reduce the energy use and/or cost
  - Perform an engineering & economic analysis of potential modifications
  - Prepare a rank-ordered list of appropriate modifications & a report to document the analysis process/results

# Energy audit process

Table 3.1 Key elements of the energy audit process (ASHRAE, 2011)

Building an Audit/Implementation Team	<ul style="list-style-type: none"> <li>▪ Assembling the right participants and establishing clear responsibilities</li> </ul>
Preliminary Energy Use Analysis	<ul style="list-style-type: none"> <li>▪ Analysis of two or more years of utility consumption cost</li> </ul>
Site Visit Procedures	<ul style="list-style-type: none"> <li>▪ Activities to prepare for the on-site audit</li> </ul>
Measurement	<ul style="list-style-type: none"> <li>▪ Site visit and audit of building to collect data to quantify operating parameters and performance</li> </ul>
Analysis	<ul style="list-style-type: none"> <li>▪ Description and analysis of the energy-using systems of the building</li> <li>▪ Can include a whole building energy model</li> </ul>
Energy Efficiency Measure Types	<ul style="list-style-type: none"> <li>▪ Classify the recommended energy efficient measures and bundle together synergistic measures</li> </ul>
Economic Evaluation	<ul style="list-style-type: none"> <li>▪ Evaluate the capital costs and life cycle cost of efficiency measures and bundle of efficiency measures</li> </ul>
Developing an Audit Report	<ul style="list-style-type: none"> <li>▪ Provide complete information needed by an owner/operator to decide whether to implement recommended measures</li> </ul>
Presentation	<ul style="list-style-type: none"> <li>▪ meet with the owner/operator to review the report, explain results, and plan the next step</li> </ul>
Implementing Measures	<ul style="list-style-type: none"> <li>▪ Implement the chosen efficiency measures</li> <li>▪ includes Measurement &amp; Verification and continuous commissioning</li> </ul>

# Energy Audit Process



- Collect building information
  - General characteristics, e.g. floor plan, number or occupants, operation hours, construction details
  - Technical details of energy consuming equipment/systems
  - Building services system schematic diagrams, layout drawings, etc.
  - Equipment/system operation records & log sheets
  - Operation & maintenance (O&M) manuals
  - Testing & commissioning (T&C) reports
  - Bills (electricity, town gas, LPG, diesel) for past 3 years
  - Records of energy saving measures already implemented

# Energy Audit Process



- The audit team should determine & discuss with building manager/operator to get familiar with the building and the equipment/systems
- If needed, may issue questionnaires to end-users to collect info. on thermal comfort, lighting, actual operational hours, etc.



# Energy Audit Process



- At this stage, the audit team should be able to tell the characteristics of the energy consuming equipment/items such as:
  - Types of chillers, their capacities & characteristics
  - Types of HVAC systems, their components & characteristics
  - Occupancies or usage for various systems
  - Control devices for various equipment/systems
  - Types of luminaires, their characteristics & control mechanisms
  - Power distribution system characteristics
  - Operational characteristics of lift & escalator system
  - Characteristics of the building



# Energy Audit Process



- Site inspection & measurement
  - Plan the site inspection for the areas & the equipment/systems to be investigated
  - Allocate the work among the auditors
  - Develop energy audit forms to record the findings
  - Plan ahead on the site measurements to supplement or verify the information collected
  - The measurements should focus on equipment/systems that inadequate information is available

# Energy Audit Process



- Site inspection & measurement (cont'd)
  - Inspection of building & plants to identify obvious areas of wastage and EMO. Typical areas include:
    - Running hours of AC system
    - Running hours of other systems/equipment
    - Length of AC pre-cool period
    - Control set point of above systems/equipment
    - Internal comfort conditions, e.g. temperature, humidity
    - Doors not properly closed
    - Curtains or blinds not provided in AC areas

# Energy Audit Process

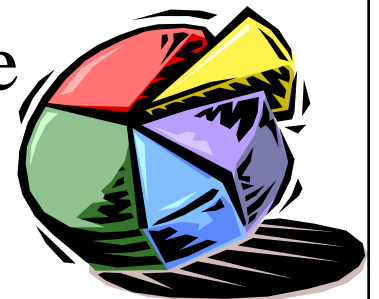


- Site inspection & measurement (cont'd)
  - Typical areas include: (cont'd)
    - Locations where AC & lighting are over provided
    - The use of energy inefficient lighting
    - Improper positioning of thermostats & switches
    - Abnormal water consumption
    - Adequacy of insulation of building fabrics
    - Amount of waste heat discharged from equipment that could be recovered
    - Areas of high energy consumption & the opportunities for improvement

# Energy Audit Process



- Analysing data collected
  - Identification of EMOs
  - Costing (calculate payback period, net present worth or rate of return, or assess life cycle cost)
  - Normalisation of data (e.g. for date or weather)
  - Maintaining thermal & lighting comfort
  - Scheduled maintenance & refurbishment works
  - Annual monthly energy consumption profile
  - Energy utilisation index, and breakdowns



# Energy Audit Report



- Typical report structure/contents:
  - Executive Summary
  - 1. Introduction
  - 2. Description of Equipment/Systems Audited
  - 3. Findings
  - 4. Analysis and Identification of EMOs
  - 5. Recommendations
  - References
  - Appendices



# Typical structure of an energy audit report

## Executive Summary

- Overview of the audit, EMOs identified
- Recommended actions, briefing on implementation plan



## Introduction and Building Information

- Objectives, energy audit scope, audit team
- Building characteristics (type, floor areas, operation)



## Description of the Equipment/Systems Audited

- System types, capacity ratings, zoning, operation hours etc.



## Energy Data and Survey Findings

- Historical energy consumption of the building
- System performance evaluation, O&M practices



## Energy Management Opportunities

- Identification & evaluation of potential EMOs
- List of recommended EMOs and implementation plan



## Conclusions and Recommendations





# Energy Audit Report

- Executive Summary
  - Provides a quick overview of the scope of audit, EMOs identified, recommended actions justified by savings and implementation plan
- 1. Introduction
  - The building being audited with characteristics of the building, schematics, layouts as appendix
  - Objectives
  - Scope of audit & audit team



# Energy Audit Report

- 2. Description of Equipment/Systems Audited
  - Zoning of systems from building height or usage
  - HVAC installation for different areas
  - Lighting installation
  - Electrical installation
  - Lift & escalator installation
  - Plumbing & drainage system
  - Hot water system
  - Other energy consuming equipment/systems



# Energy Audit Report



- 3. Findings
  - Focus on description of the results of the site inspection
  - Findings in a systematic format, e.g. in order of systems or order of floors or in order of usage
  - Description of areas with special requirements, e.g. 24-hour operation, low temperature, etc.



# Energy Audit Report

- 3. Findings (cont'd)
  - Calculation on cooling load, lighting load, electrical load & annual consumption with detailed calculation in appendix
  - Findings on O&M procedures and practices
  - Preliminary identification of EMOs

# Energy Audit Report



- 4. Analysis and Identification of EMOs
  - Comparison on actual performance of equipment/systems against original design & identify causes of any discrepancy
  - Possible EMOs and substantiations (detailed calculations in appendix)
  - Implementation costs for EMOs (detailed calculations in appendix)
  - Comparison of different solutions to the same EMOs



# Energy Audit Report

- 4. Analysis and Identification of EMOs (cont'd)
  - Classification of the EMOs into categories
  - Listing of all EMOs in a systematic format such as in order of system, e.g. HVAC, lighting, etc.
  - Investment and payback of each EMO
  - Difficulties that may encounter in implementation
  - Programme for implementation of EMOs
  - Areas for further study, if any

# Energy Audit Report

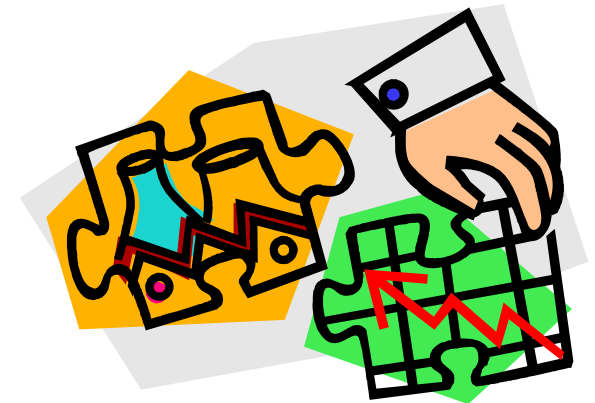


- 5. Recommendations
  - Recommendations should be made in a systematic order
  - Grouping items of similar nature/location/usage together
  - Grouping according to their categories (i.e. Cat. 1, Cat. 2 and Cat. 3)
  - The initial investment and payback should be highlighted here again

# Energy Audit Report



- What to ask for in an audit report
  - Actionable recommendations
  - Realistic treatment of rates
  - Transparent analysis
  - Guidance to more resources
  - Reasonable savings estimates
  - Reasonable cost estimates
  - Analysis of interactive effects
  - Measurements of key input variables
  - Monitoring of baseline performance
  - Hourly modelling



# Energy Audit Report



- Top 10 to check in an energy audit
  - **1.** Proposed measures are feasible and appropriate for the building
  - **2.** Proposed measures meet /exceed applicable building codes
  - **3.** Data are internally consistent
  - **4.** Savings estimate methods follow established principles and methods
  - **5.** Energy savings estimates are reasonable compared to quick estimates and historical energy use

# Energy Audit Report



- Top 10 to check in an energy audit (cont'd)
  - **6.** Proposed cost estimates are reasonable relative to field experience
  - **7.** Cost savings adequately treat utility rates
  - **8.** Interactions between EMOs are identified and addressed
  - **9.** Recommendations and report meet the project scope, goals, and client's needs
  - **10.** Financial discussion includes current and viable mechanisms available per the tax structure, location, and motivations of the client



# Energy Management Opportunities



- 3 categories of EMOs:
  - *Category I (no cost):*
    - Housekeeping measures which are improvements with practically no cost investment and no disruption to building operation
  - *Category II (low cost):*
    - Changes in operation measures with relatively low cost investment
  - *Category III (high cost):*
    - Relatively higher capital cost investment to attain efficient use of energy

# Energy Management Opportunities



- Category I (Cat. I) EMOs (no cost)
  - Correct air/water flow rate
  - Switch off fittings in vacant areas
  - Delamping
  - Closing of doors, windows
  - Check fresh air dampers
  - Switch off lifts & escalators in off peak periods
  - Adopt natural or mechanical ventilation as far as possible

# Energy Management Opportunities



- Category I (Cat. I) EMOs (cont'd)
  - Housekeeping measures, e.g.
    - Notices, promotional activities, turn on equipment & systems based on operational hours
  - Adopt good operation & maintenance procedure
  - Check water leakage and air leakage
  - Cleaning of luminaries/heat exchanger/filter
  - Top up refrigerant, compressor oil, etc.
  - Lower lighting level for areas that is too bright
  - Proper setting of thermostat

# Energy Management Opportunities



- Category II (Cat. II) EMOs (with little cost)
  - Blinds & curtains
  - Tree planting near curtain wall
  - Air curtain for automatic door
  - Self luminous exit sign
  - Additional switches and controllers
  - Sealing of building leakages
  - Replace incandescent lamps with CFLs
  - Replace electro-magnetic ballasts w/ electronic ones

# Energy Management Opportunities



- Category II (Cat. II) EMOs (cont'd)
  - Energy efficient office equipment
  - Replacing damaged insulation
  - Occupancy sensor, CO<sub>2</sub> sensor & daylight sensor
  - Time switch
  - Re-programming of control systems
  - Setback control
  - Harmonic filter
  - Power factor correction device

# Energy Management Opportunities



- Category III (Cat. III) EMOs (high cost)
  - Installing T5, T8 with electronic ballasts
  - Building management system (BMS) and software enhancement
  - New chillers w/ high coeff. of performance (COP)
  - Water-cooled system with cooling tower
  - High efficiency motors
  - Variable speed drive (VSD)
  - Water saving taps & low volume water closet

# Energy Management Opportunities



- Category III (Cat. III) EMOs (cont'd)
  - Recover waste heat/cool air e.g. thermal wheel,
  - Heat pump
  - Automatic condenser cleaning
  - Modernization of old lifts
  - Green Initiatives that enhance corporate image, e.g. renewable energy, replacement of ozone depleting refrigerant

(\*See also [http://ee.emsd.gov.hk/english/general/gen\\_energy/gen\\_en\\_energy.html](http://ee.emsd.gov.hk/english/general/gen_energy/gen_en_energy.html) for some typical findings in an audit, the corresponding EMOs and energy savings percentage)



# Implementation Issues

- An audit is worth nothing if managers do not use the information productively
  - Should incorporate the findings into an energy-savings plan to immediately begin reducing costs and eliminating energy waste
  - Can use the audit financial analyses to convince the owner of the potential financial and energy-saving benefits. The owner then can budget for the cost of implementing the approved measures





# Implementation Issues

- Four tasks to complete an investment grade audit (IGA):
  - **Task 1.** Preliminary assessment of needs and opportunities
  - **Task 2.** Preliminary analysis of measures
  - **Task 3.** Detailed analysis and investment grade audit report
  - **Task 4.** Develop energy savings performance contract proposal



# Implementation Issues

- **Task 1.** Preliminary assessment of needs and opportunities
  - Clearly define your expectations and requirements for the ESCO
  - Collect preliminary building data (Walk Through Audit)
  - ESCO interviews facilities staff and occupants
  - Results (a preliminary list of potential savings measures)



# Implementation Issues

- Keys to a successful first step
  - Clearly communicate your technical and financial goals
  - Meet early and often to discuss potential improvements
  - Share information on future planned capital projects
  - Make staff available for interviews
  - Include decision makers in the discussions





# Implementation Issues

- **Task 2. Preliminary analysis of measures**
  - Establish base year energy consumption
    - Review 3 years of utility bill data
  - Determine end use energy loads
    - Determine the energy intensity by major end uses of utilities (e.g. HVAC, lighting, plug load)
    - Analyse operations (runtimes, temperatures, occupancy)
  - Compare to benchmark energy data to establish potential savings levels
  - Explore potential energy grants and rebates

# Implementation Issues



- Task 2 Report:
  - Comprehensive list of potential energy and water saving measures
  - Preliminary cost and savings estimates
    - Project economics by specific savings measure
      - Preliminary cost estimate
      - Preliminary energy savings estimate
      - Operational cost savings estimate
      - Future capital cost avoidance estimate
      - Financial cash flow charts
      - Escalation factors





# Implementation Issues

- **Task 3.** Detailed analysis and investment grade audit report
  - Firms up cost and savings assumptions
  - Perform detailed energy saving calculations
    - Energy saving software modelling
      - Detailed energy model
      - Perform life cycle analysis
    - Typical energy tools: e-Quest, Carrier Hourly Analysis Program (HAP), Trane TRACE 700
  - Follow Measurement and Verification guidelines

# Implementation Issues



- Task 3 Project Costing:
  - Prepare detailed scopes of work
    - Include design and specifications
  - Solicit trade contractor bids
    - Solicit bids from qualified local contractors
    - Bids for each trade involved in the project
  - Add ESCO mark-ups to final contractor bids





# Implementation Issues

- **Task 4.** Develop energy savings performance contract proposal
  - Proposal to include:
    - Design
    - Equipment and Installation
    - Monitoring of savings
    - Insurance and bonding
    - Schedule
    - Procure project financing







# Implementation Issues

- Typical time line
  - Preliminary findings: 30-90 days
  - Detailed audit report: 60-90 days
  - Energy performance contract: 15-30 days
- Total time line of 105-210 days

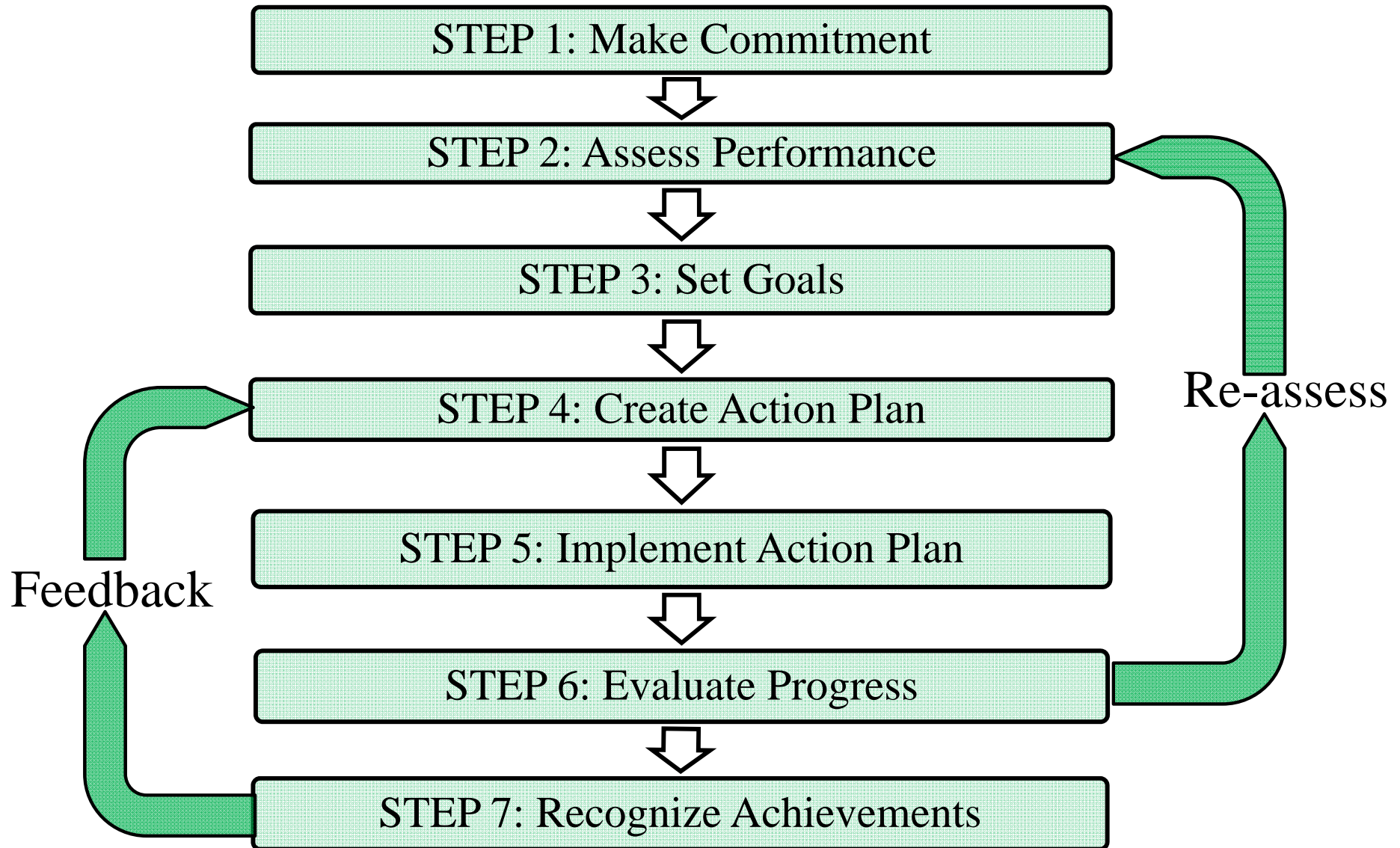




# Implementation Issues

- Management support
  - The auditor/audit team may have the authority to implement some EMOs, particularly Cat. I EMOs
  - The energy audit report should be endorsed by the building owner/manager for Cat. II and Cat. III EMOs, so as to have more cooperation from end-users in the implementation of these EMOs
- Commitment to energy efficiency
  - Organisational, technological, behavioural change

# Important steps for energy management



# Commitment to energy efficiency

Table 5.1 Commitment to energy efficiency for religious buildings [adapted from Climate Change Centre (2006)]

Organisational Commitment	<ul style="list-style-type: none"><li>• The more people who commit to action within a place of worship, the stronger the project. Having a project champion(s) is essential.</li><li>• Concerted action within an organisation will lead to more resources, ideas, and creative ways to move forward on energy efficiency.</li><li>• Time may be needed to get consensus, but it will be worth it.</li></ul>
Technological Commitment	<ul style="list-style-type: none"><li>• When doing retrofits, there is a good chance that new technology will have to be purchased, such as energy efficient lighting, weatherstripping, or a new chiller.</li><li>• Commitment to technological change (along with the financial planning for such changes) is essential.</li></ul>
Commitment to Behavioural Change	<ul style="list-style-type: none"><li>• If people have poor energy management habits (such as leaving lights on), it takes away from the benefits of retrofiting.</li><li>• Educating and inspiring the congregation to change behaviour is therefore an important step.</li></ul>





# Implementation Issues

- How to implement the EMOs
  - Check if adequate staff resources would be available and if not employ an audit consultant to do the detailed design and specification
  - Identify the roles and responsibilities of the O&M personnel, the building management, end-users and relevant parties concerned
  - Discuss with all parties involved and inform them the audit objectives and the audit scope



# Implementation Issues

- How to implement the EMOs (cont'd)
  - Organise meetings & an ad-hoc committee for the monitoring & coordination of EMOs
  - Consider ideas and comments from parties involved on the proposed EMOs
  - A lot of work may have to be carried out outside office hours, in order to minimise disruptions to routine building operation
  - A lot of lobbying may be worthwhile, in order to obtain end-users' support and cooperation



# Implementation Issues

- Communication with end-users involved, O&M personnel and the building owner is very important to the success of EMOs
  - The audit team should take effort and time to convince these parties and have a harmonious relationship with them
  - The management concept of “partnership” among all parties concerned will smoothen the implementation process



# Implementation Issues

- Monitoring of EMO implementation
  - To ensure that the EMOs are implemented properly, the audit team has to monitor the works and participation of parties concerned
  - The audit team needs to exercise control and adjust procedures from time to time, e.g. further negotiation with end-users on permitted working hours, settling site work conflicts with O&M personnel, processing payments to contractors, etc.





# Implementation Issues

- Funding options
  - Self funding – this will harvest the biggest benefits but the organisation must have initial funding
  - Energy services company – can be employed to carry out the implementation of EMOs
  - Energy performance contracting
    - Using the saved energy cost to finance the energy efficiency improvement works
    - Needs for fair contract & protocol for verification of energy savings



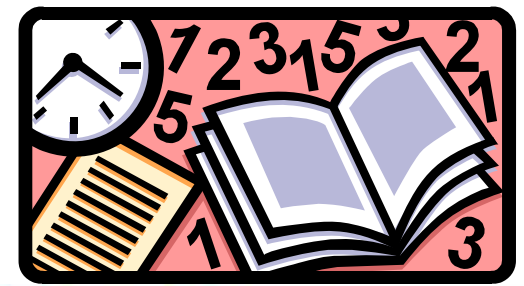
# Implementation Issues

- Continual energy savings
  - Continuing improvement on O&M is important
    - Raise technical know-how and awareness on importance of good operation and preventive maintenance of O&M personnel
    - Proper training is required
  - Raise the awareness of end-users through more publicity, talks or campaigns on energy efficiency and conservation
  - A long-term energy management programme



# Further Reading

- EMSD, 2012. *Code of Practice for Building Energy Audit*, Electrical and Mechanical Services Department, Hong Kong.
  - [www.emsd.gov.hk/emsd/e\\_download/pee/EAC\\_2012.pdf](http://www.emsd.gov.hk/emsd/e_download/pee/EAC_2012.pdf)
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