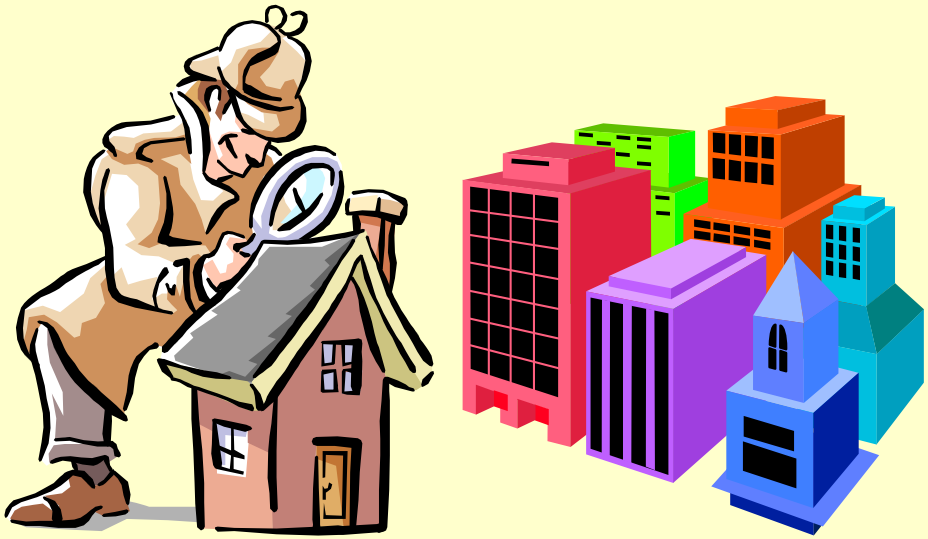
MEBS6016 Energy Performance of Buildings

http://me.hku.hk/bse/MEBS6016/



Energy Auditing of Buildings

Dr. Sam C. M. Hui

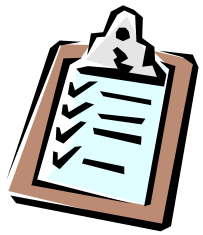
Department of Mechanical Engineering

The University of Hong Kong

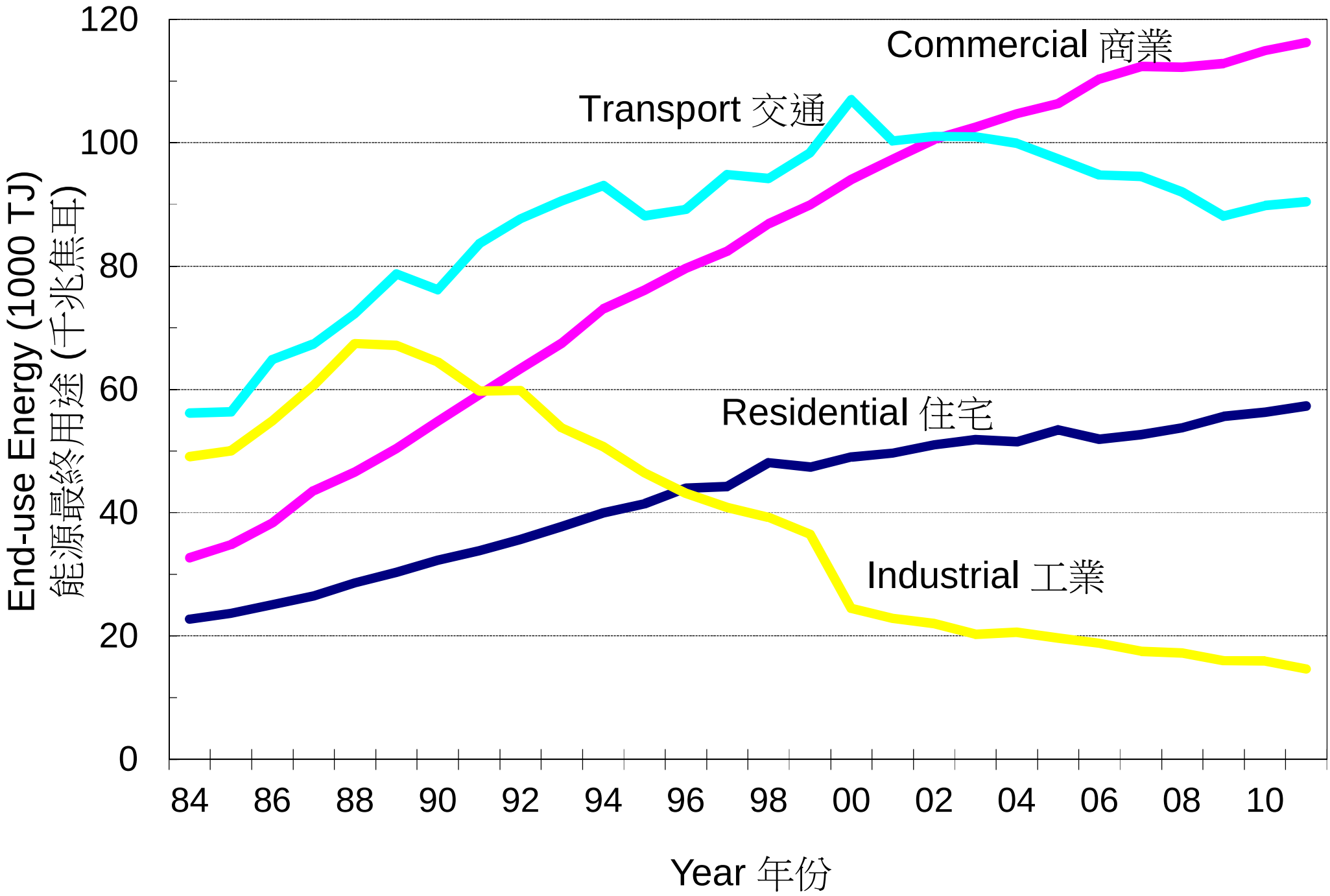
E-mail: cmhui@hku.hk

Jan 2015

Contents



- Basic Concepts
- Types of Energy Audits
- Planning of Energy Audits
- Energy Audit Process
- Energy Audit Report
- Energy Management Opportunities
- Implementation Issues

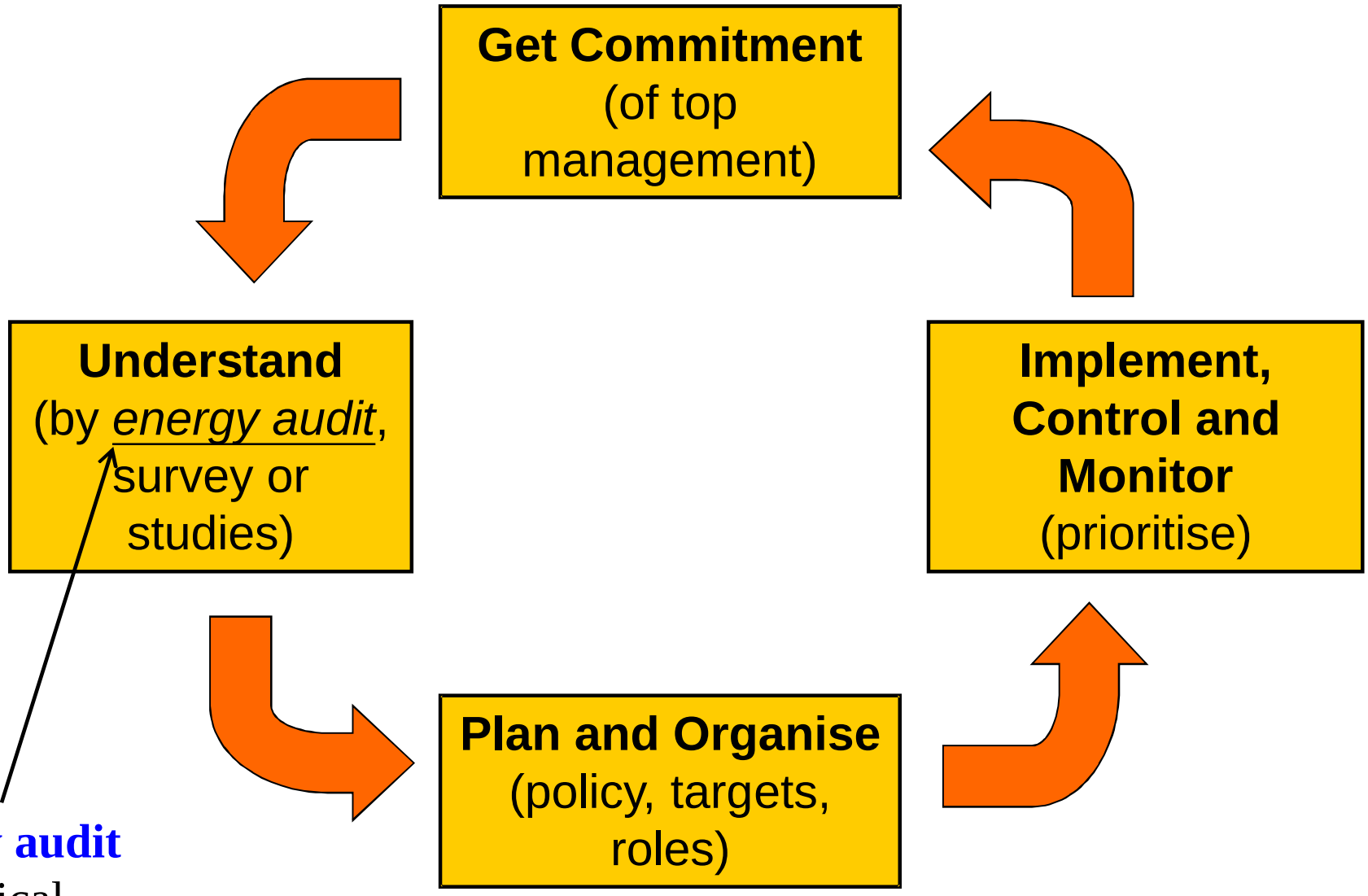


(Data source: EMSD) Energy end-use in Hong Kong by sectors, 1984-2011

Basic Concepts

- Energy end-use in HK (trend in 1984-2011)
  - Commercial sector: increases at 5% per year
  - Residential sector: increases at 3.5% per year
- Average consumption: (examples)
  - Office: 265 kWh/m^2/year
  - Hospital: 200 kWh/m^2/year
  - Post office: 170 kWh/m^2/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

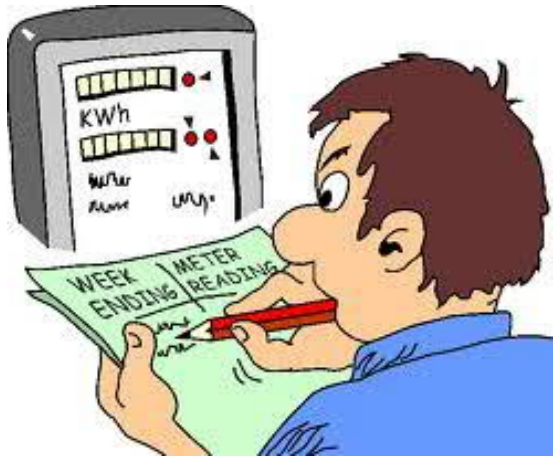
- Overview of energy audit
  - Collection and analysis of relevant information that may affect building energy consumption
  - Review the information, analyse the conditions and performances of existing equipment, systems and installations, and the energy bills
  - Compare with performances at relevant 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_2 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

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

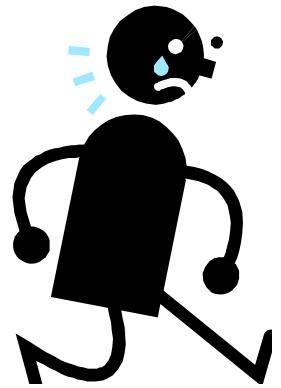
(Source: www.kw-engineering.com)

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

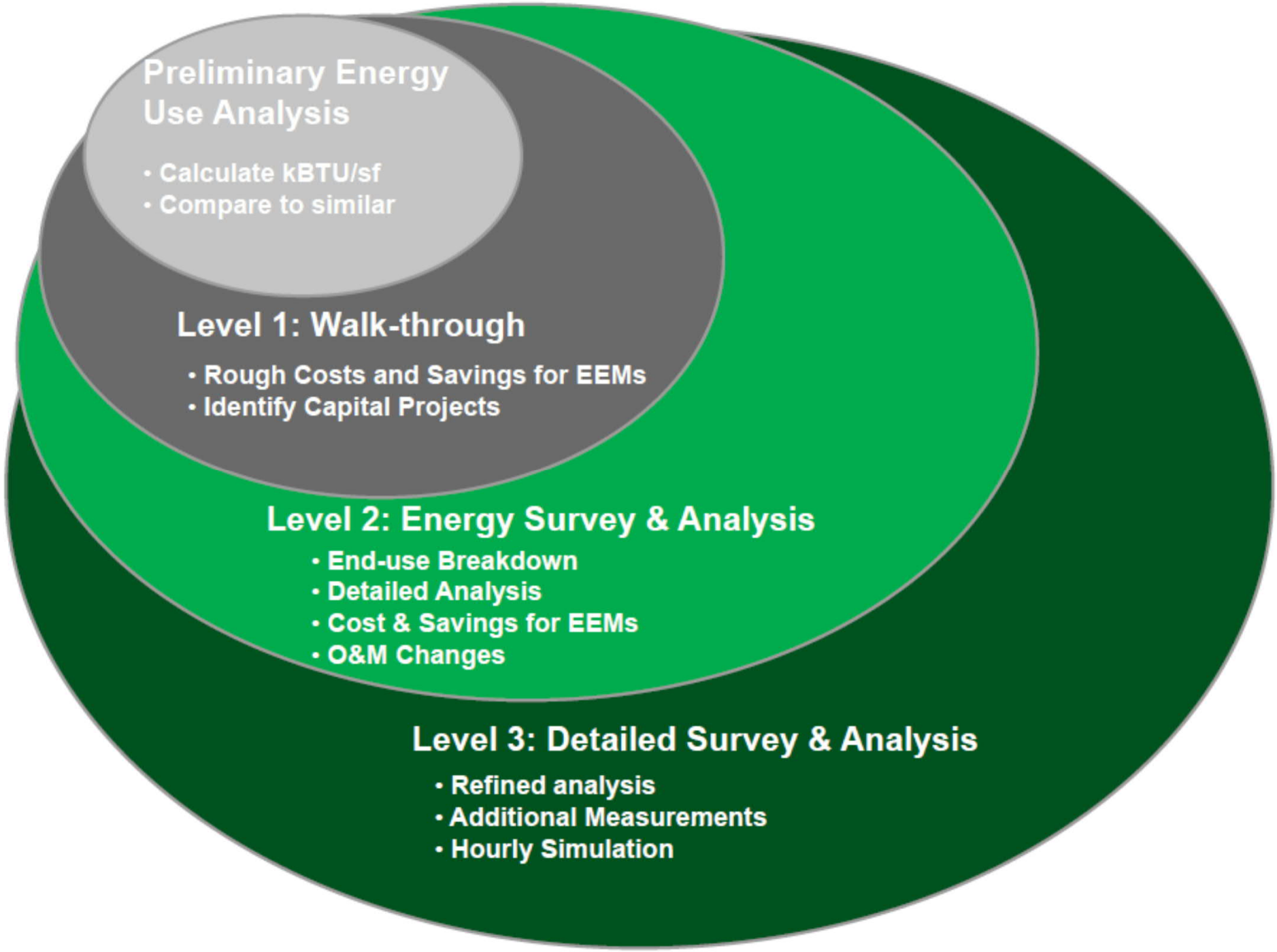
- Investment grade audit (IGA)
  - Expand on the detailed audit
  - Analyses the financial aspects of energy savings and the return on investment (ROI) from potential changes or upgrades
  - Aim to justify the energy investment
  - Rely on a complete engineering study in order to detail technical and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

(* Source: ASHRAE 2011. *Procedures for Commercial Building Energy Audits*, Second Edition)

Relationship of energy audit levels 1, 2, and 3



(Source: ASHRAE 2011. *Procedures for Commercial Building Energy Audits*, Second Edition)

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			●

(Source: ASHRAE 2011. *Procedures for Commercial Building Energy Audits*, Second Edition)

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			●

(Source: ASHRAE 2011. *Procedures for Commercial Building Energy Audits*, Second Edition)

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^2 or MJ/m^2)
  - 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

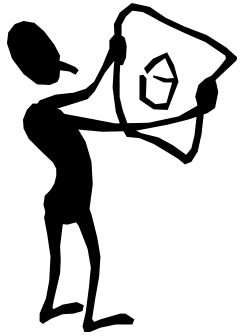
Measure Number	Measure Description	Annual Energy and Cost Savings					Payback with Incentive				
		Peak Savings (kW)	Electricity Savings (kWh)	Gas Savings (therms)	Total Cost Savings	CO_2 Savings (tons)	Measure Cost	Potential WG&E Incentive	Net Measure Cost	MIRR	Simple Payback (yr)
	Lighting Measures										
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
	Kitchen Measures										
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
	Main Air Handler Measures (Occupied Hours Only)										
EEM-10	Repair Economizers and Convert to Dry Bulb Temperature Control	0.0	155,576	0	$ 5,558	85.4	$ 25,089	$ 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
	SUB-TOTALS	**6.5**	**768,505**	**6,896**	**$ 2,368**	**462.3**	**$ 225,830**	**$ 54,772**	**$ 171,058**	**12%**	**2.1**
TOTALS (Recommended Measures)		**6.5**	**768,505**	**6,896**	**$ 82,368**	**462.3**	**$ 225,830**	**$ 54,772**	**$ 171,058**	**12%**	**2.1**

(Source: www.kw-engineering.com)

Types of Energy Audits

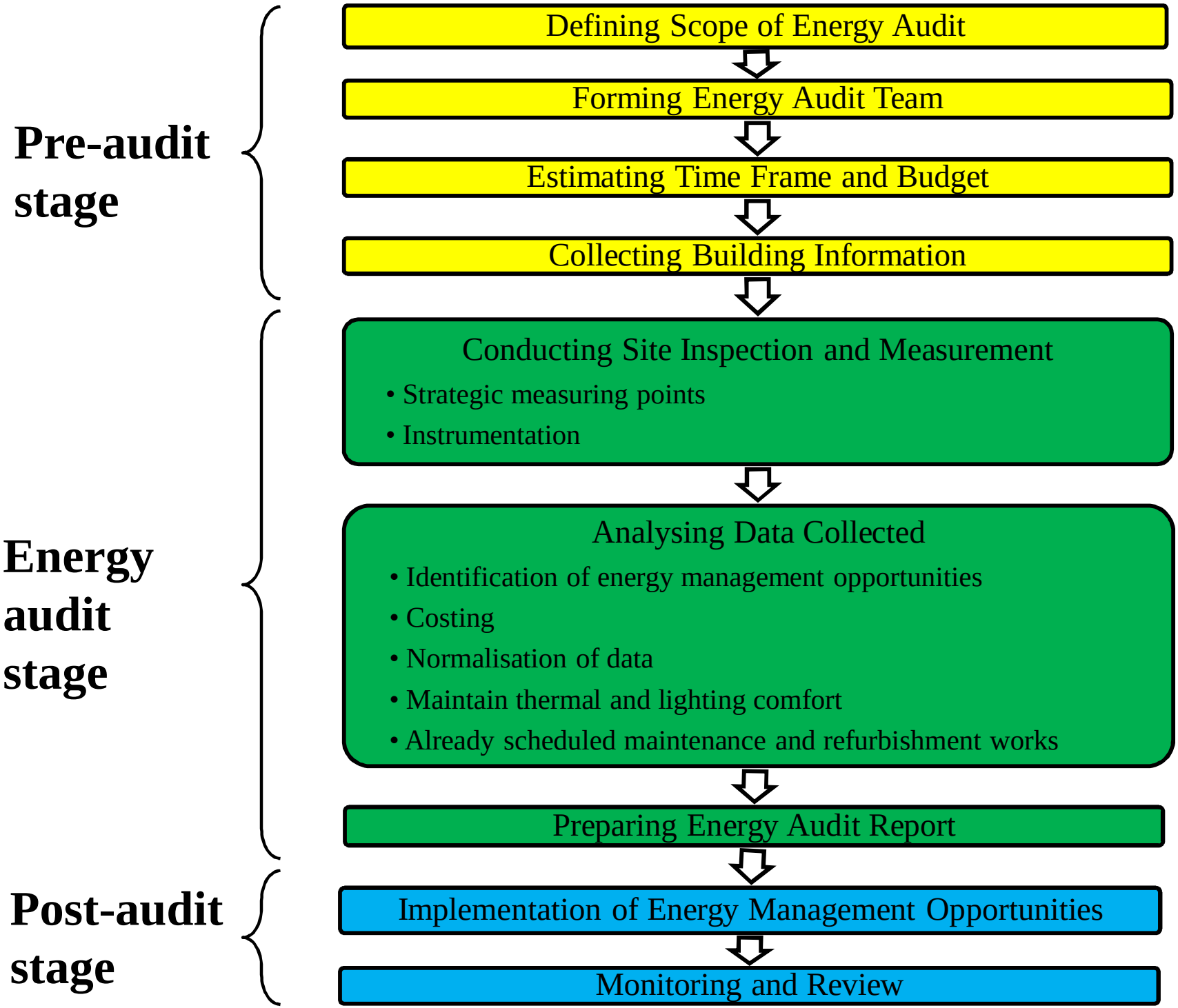
- Level 3 – Detailed Analysis
  - Level 2 and then more…(additional scope & value)
  - Process
    - Additional testing/monitoring
    - Detailed system modelling
    - Schematic layouts for recommendations
  - Report
    - Detailed description of recommended measures
    - Detailed EMO cost estimates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

Planning of Energy Audits

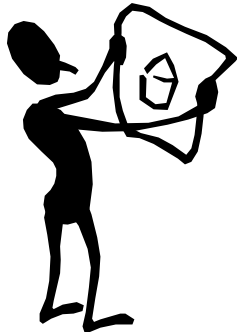


- Energy audits can be carried out by
  - Building manager or internal staff (in-house)
  - External consultant or professionals
- Typical stages of energy audit:
  - 1. Pre-audit stage
  - 2. Energy audit stage
  - 3. Post-audit stage

Procedure of energy audit

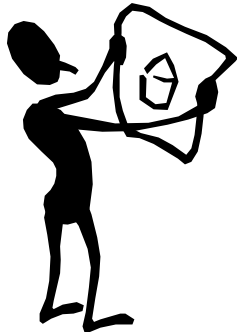


Planning of Energy Audits



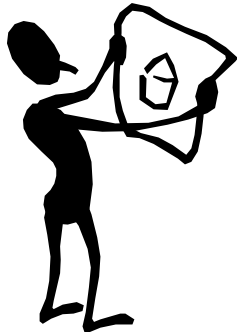
- Define available resources for energy audit:
  - Staff, Time and Budget
- Resources required for energy audits:
  - Staff with relevant knowledge/skills
  - Time to perform the tasks involved
  - Measuring equipment and metering
  - Finance for the audit and to implement measures
  - Technical and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

Planning of Energy Audits



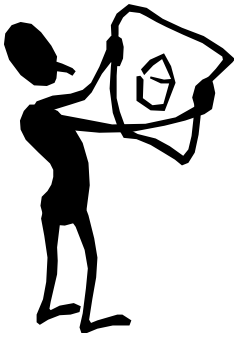
- Scope of energy audit include:
  - Areas to be audited
  - Level of sophistication
  - Savings anticipated
  - Needs for improvements on O&M
  - Needs for training
- Importance of involving senior management, facilities operator and staff
  - Will need assistance and cooperation from the end-users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

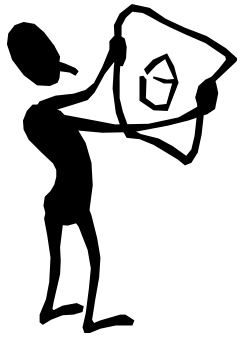
Planning of Energy Audits



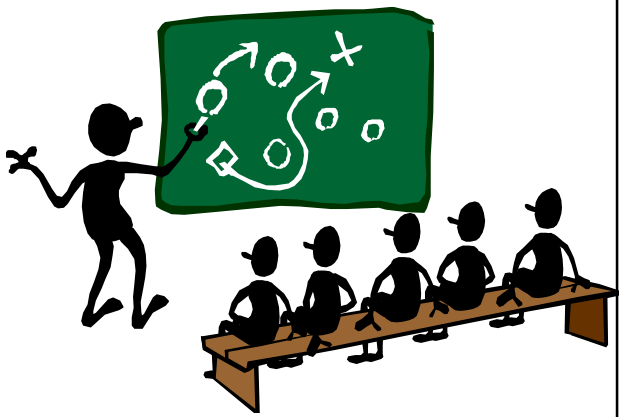
- Team building is key to audit & implementation success
  - Seek involvement with key players at site
  - Let folks do what they're good at
  - Leave site staff with the knowledge to follow through

- Don't believe everything you hear
  - Site inspections with staff can be misleading
  - Your questions may be threatening

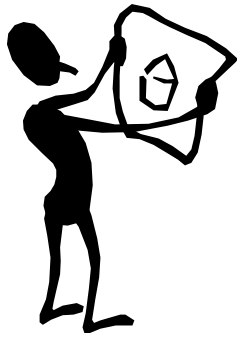
Planning of Energy Audits



- 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

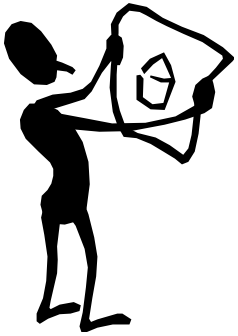


Planning of Energy Audits



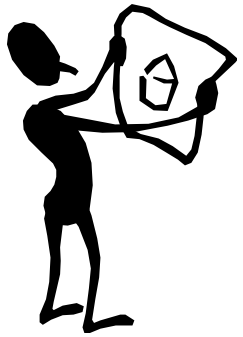
- Costs vs. Accuracy
  - Energy auditing seeks to strike a balance between time spent and the value returned
  - Important to allow flexibility to seek the best return on time
  - *Too little effort*… may result in less identified potential
  - *Too much effort*… gilded lilies and science projects

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 (exhuast gas analyser, tachometer)

Instruments for energy audit and measurements

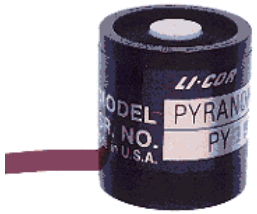
Anenometer

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	▪ Assembling the right participants and establishing clear responsibilities
Preliminary Energy Use Analysis	▪ Analysis of two or more years of utility consumption cost
Site Visit Procedures	▪ Activities to prepare for the on-site audit
Measurement	▪ Site visit and audit of building to collect data to quantify operating parameters and performance
Analysis	▪ Description and analsysis of the energy-using systems of the building ▪ Can include a whole building energy model
Energy Efficiency Measure Types	▪ Classify the recommended energy efficient measures and bundle together synergistic measures
Economic Evaluation	▪ Evaluate the capital costs and life cycle cost of efficiency measures and bundle of efficiency measures
Developing an Audit Report	▪ Provide complete information needed by an owner/operator to decide whether to implement recommended measures
Presentation	▪ meet with the owner/operator to review the report, explain results, and plan the next step
Implementing Measures	▪ Implement the chosen efficiency measures ▪ includes Measurement & Verification and continuous commissioning

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

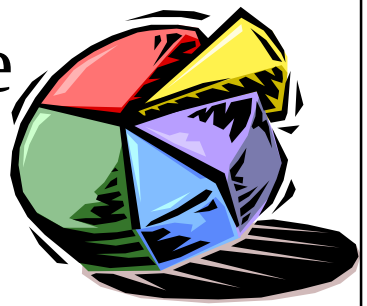
- Site inspection & measurement (cont'd)
  - Inspection of building & plants to identify obvious areas of wastage and EMO. Typical areas include:
    - Running hours of AC system
    - Running hours of other systems/equipment
    - Length of AC pre-cool period
    - Control set point of above systems/equipment
    - 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
  - Pluming & 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

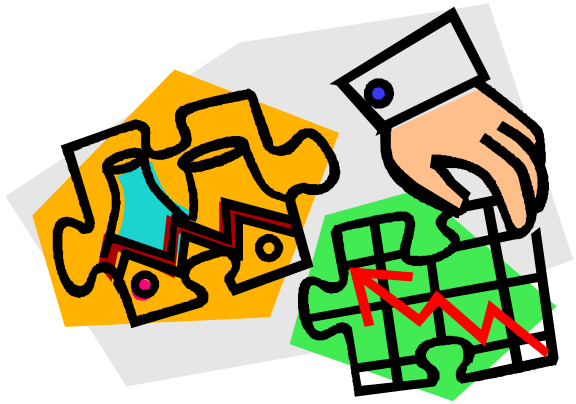
- 4. Analysis and Identification of EMOs (cont'd)
  - Classification of the EMOs into categories
  - Listing of all EMOs in a systematic format such as in order of system, e.g. HVAC, lighting, etc.
  - Investment and payback of each EMO
  - Difficulties that may encounter in implementation
  - Programme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



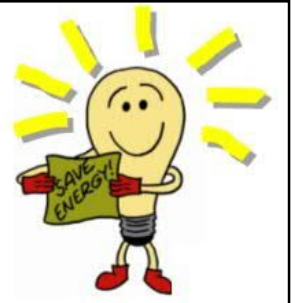
Energy Audit Report

- 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

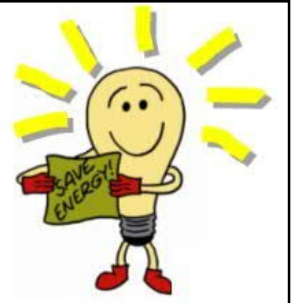
- Top 10 to check in an energy audit (cont'd)
  - **6.** Proposed cost estimates are reasonable relative to field experience
  - **7.** Cost savings adequately treat utility rates
  - **8.** Interactions between EMOs are identified and addressed
  - **9.** Recommendations and report meet the project 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



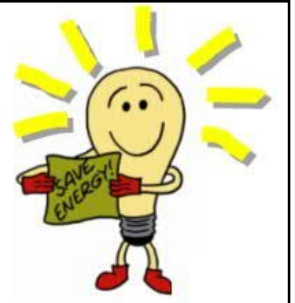
- 3 categories of EMOs:
  - ***Category I (no cost)***:
    - Housekeeping measures which are improvements with practically no cost investment and no disruption to building operation
  - ***Category II (low cost)***:
    - Changes in operation measures with relatively low cost investment
  - ***Category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

Energy Management Opportunities



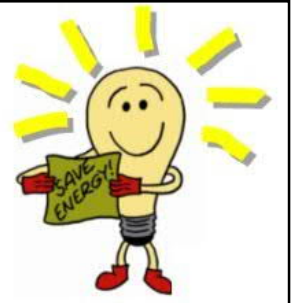
- Category I (Cat. I) EMOs (no cost)
  - Correct air/water flow rate
  - Switch off fittings in vacant areas
  - Delamping
  - Closing of doors, windows
  - Check fresh air dampers
  - Switch off lifts & escalators in off peak periods
  - Adopt natural or mechanical ventilation as far as possible

Energy Management Opportunities



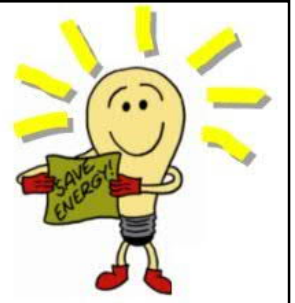
- Category I (Cat. I) EMOs (cont'd)
  - Housekeeping measures, e.g.
    - Notices, promotional activities, turn on equipment & systems based on operational hours
  - Adopt good operation & maintenance procedure
  - Check water leakage and air leakage
  - Cleaning of luminaries/heat exchanger/filter
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

Energy Management Opportunities



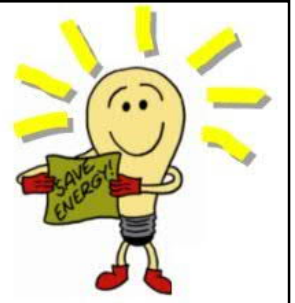
- Category II (Cat. II) EMOs (with little cost)
  - Blinds & curtains
  - Tree planting near curtain wall
  - Air curtain for automatic door
  - Self luminous exit sign
  - Additional switches and controllers
  - Sealing of building leakages
  - Replace incandescent lamps with CFLs
  - Replace electro-magnetic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

Energy Management Opportunities



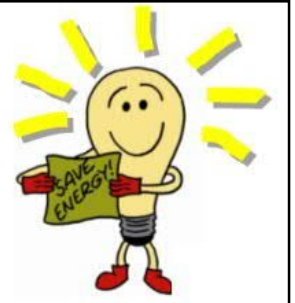
- Category II (Cat. II) EMOs (cont'd)
  - Energy efficient office equipment
  - Replacing damaged insulation
  - Occupancy sensor, CO_2 sensor & daylight sensor
  - Time switch
  - Re-programming of control systems
  - Setback control
  - Harmonic filter
  - Power factor correction device

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 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

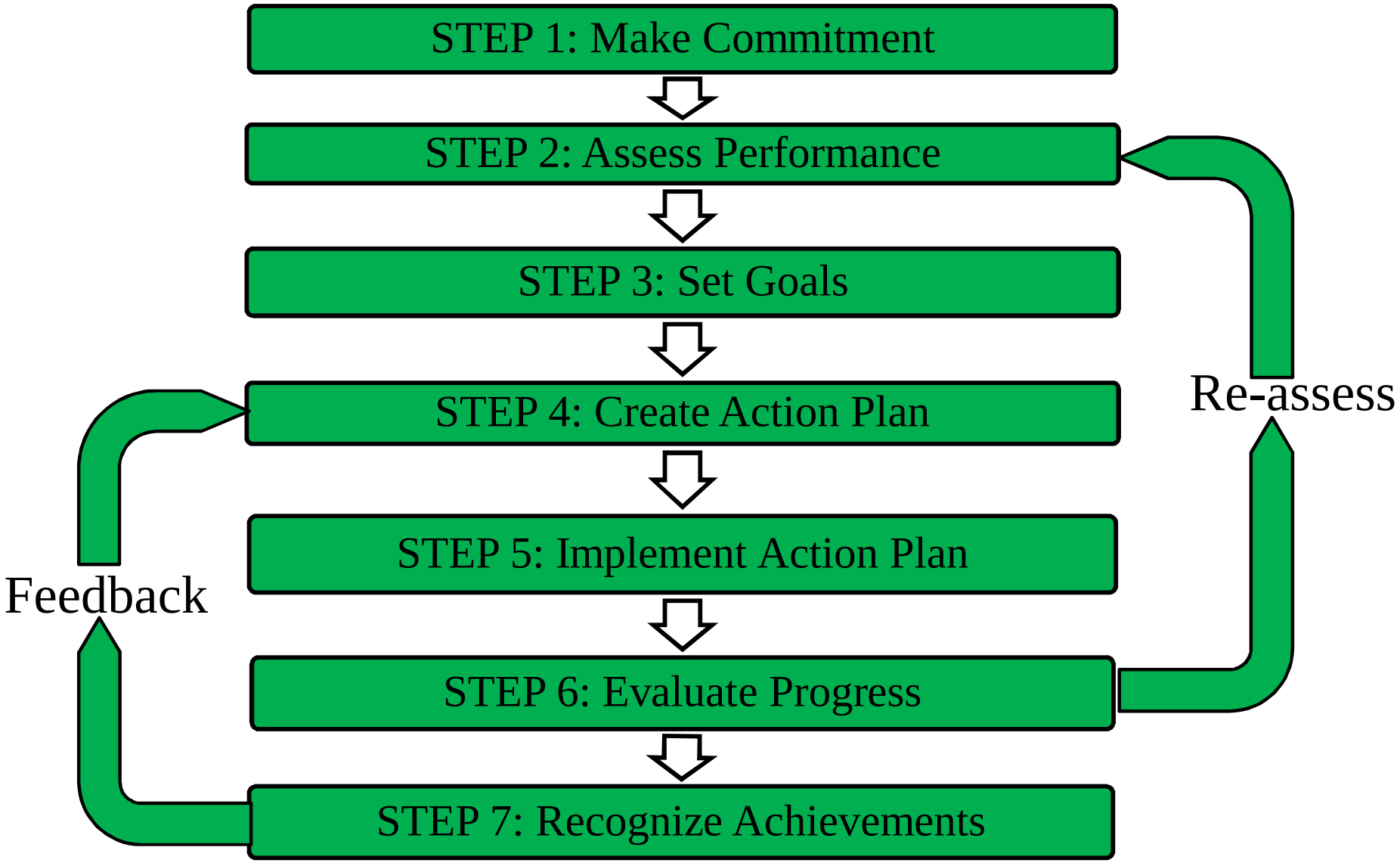
Implementation Issues

- 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	• The more people who commit to action within a place of worship, the stronger the project. Having a project champion(s) is essential. • Concerted action within an organi sation will lead to more resources, ideas, and creative ways to move forward on energy efficiency. • Time may be needed to get consensus, but it will be worth it.
Technological Commitment	• 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. • Commitment to technological change (along with the financial planning for such changes) is essential.
Commitment to Behavioural Change	• If people have poor energy manag ement habits (such as leaving lights on), it takes away from the benefits of retrofitting. • Educating and inspiring the congregation to change behaviour is therefore an important step.

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.

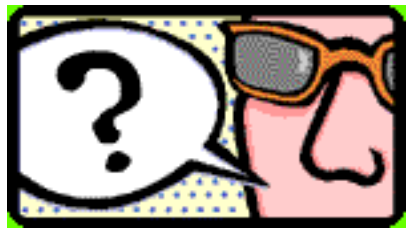
Implementation Issues

- Funding options
  - Self funding – this will harvest the biggest benefits but the organisation must have initial finding
  - 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

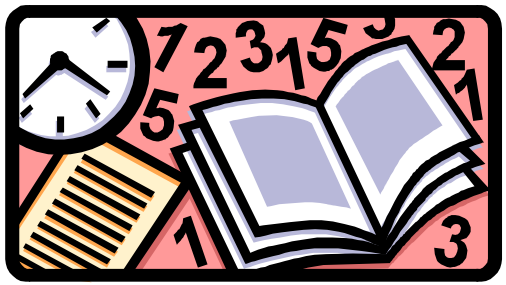
- Continual energy savings
  - Continuing improvement on O&M is important
    - Raise technical know-how and awareness on importance of good operation and preventive maintenance of O&M personnel
    - Proper training is required
  - Raise the awareness of end-users through more publicity, talks or campaigns 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
- EMSD, 2007. *Guidelines on Energy Audit*, 2007 Edition, Electrical and Mechanical Services Department, Hong Kong.
  - www.emsd.gov.hk/emsd/e_download/pee/Guidelines_on_Energy_Audit_2007.pdf

References



- ASHRAE, 2011. *Procedures for Commercial Building Energy Audits*, 2nd ed., American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Atlanta, GA. [696 P963 A]
- Hansen, S. J. and Brown, J. W., 2004. *Investment Grade Energy Audit: Making Smart Energy Choices*, Fairmont Press, Lilburn, GA. [658.26 H249 i][ebook EBSCOhost]
- Krarti, M., 2011. *Energy Audit of Building Systems: An Engineering Approach*, 2nd ed., CRC Press, Boca Raton, Florida. [696 K898 e56]