Gammon Technical Talk

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Improving energy efficiency of existing buildings in Hong Kong

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Earth Hour 地球一小時

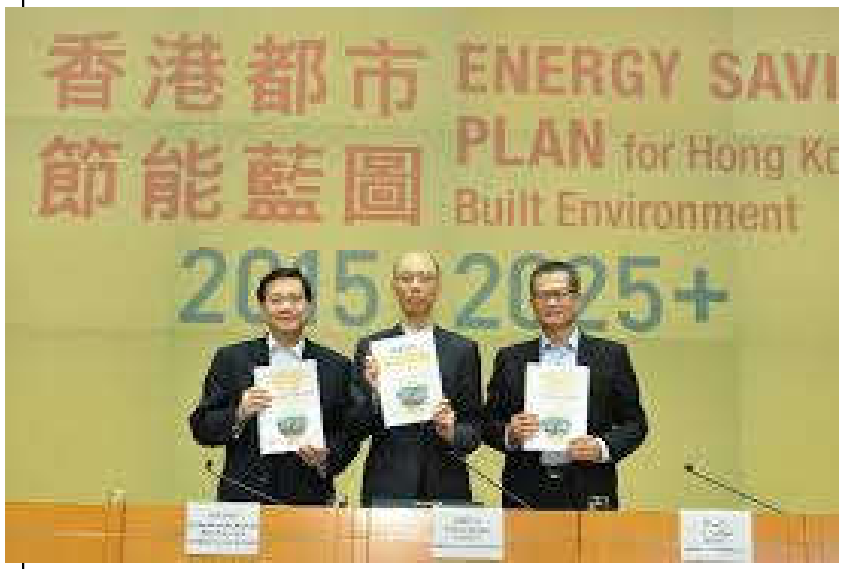
(Image source: https://earthhour.wwf.org.hk)

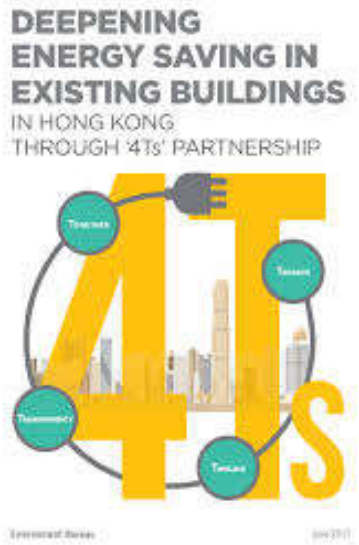
Introduction

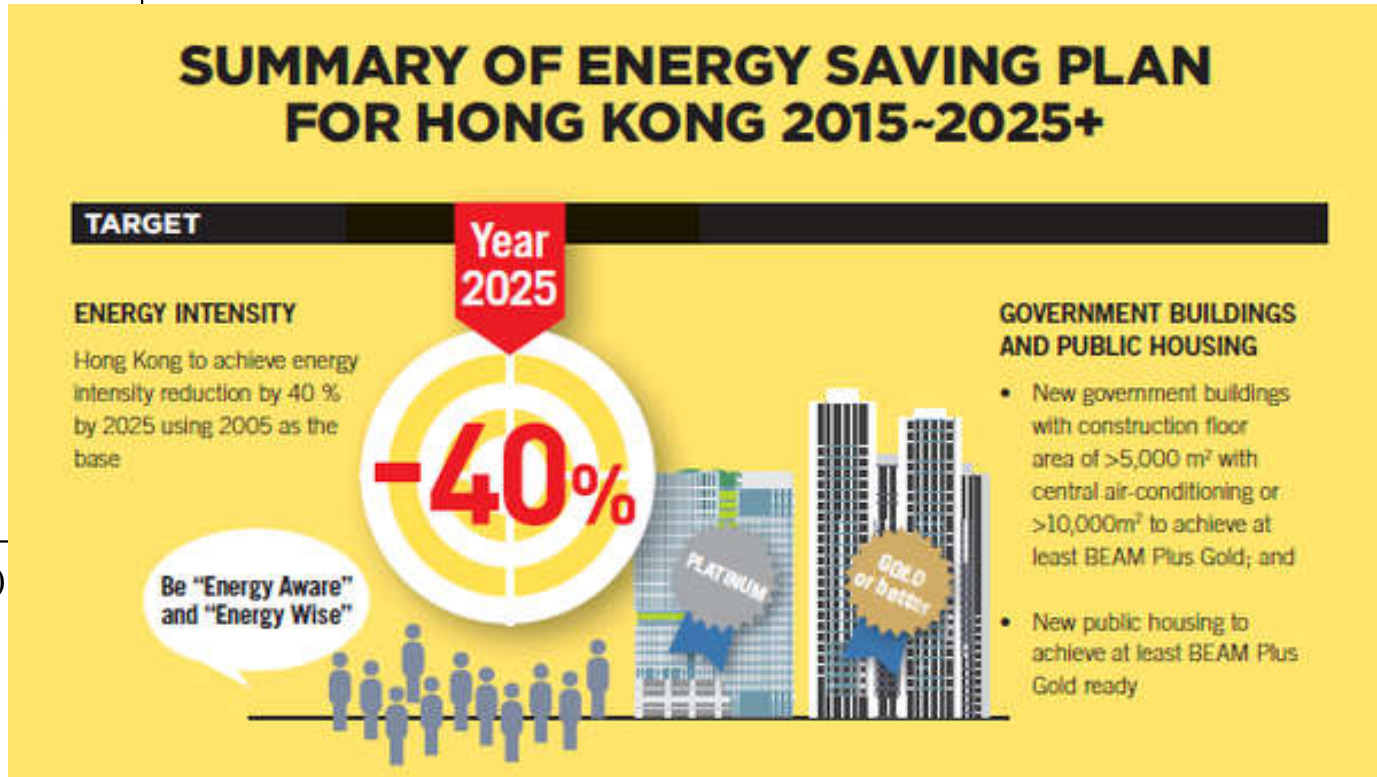
- Buildings in Hong Kong
  - Account for 90% of the electricity used and over 60% of the carbon emissions
- Improving the energy efficiency of existing buildings is crucial for long-term sustainability
  - Also provide economic and environmental benefits to the building owners and users

- Energy Saving Plan for Hong Kong
  - Reduce energy intensity by 40% by 2025

(http://www.enb.gov.hk/en/energysavingplan.html)







(Source: http://www.info.gov.hk/gia/general/201505/14/P201505140408.htm)

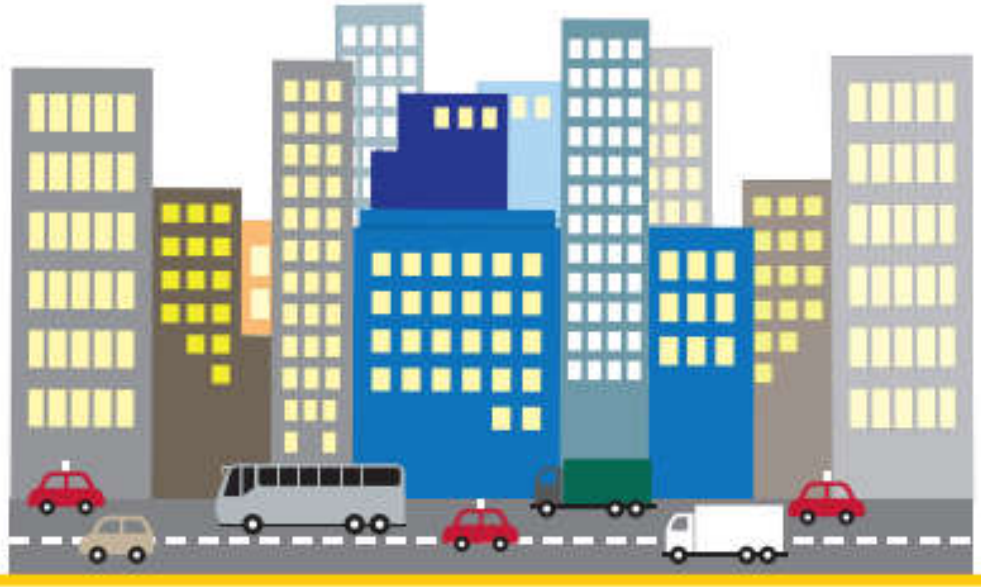
Enhanced tax incentive to promote renewable energy and building energy efficiency

- Starting from the 2018-19 financial year, capital expenditure on related installations can be fully deducted in the first year of purchase, instead of five years as currently stipulated
- The building must be registered under the EMSD's voluntary Energy Efficiency Registration Scheme for Buildings
- They must also reach specified standards under a green building certification system

(Source: http://www.info.gov.hk/gia/general/201803/01/P2018030100661.htm)

Relative energy saving priorities for different types of buildings in Hong Kong

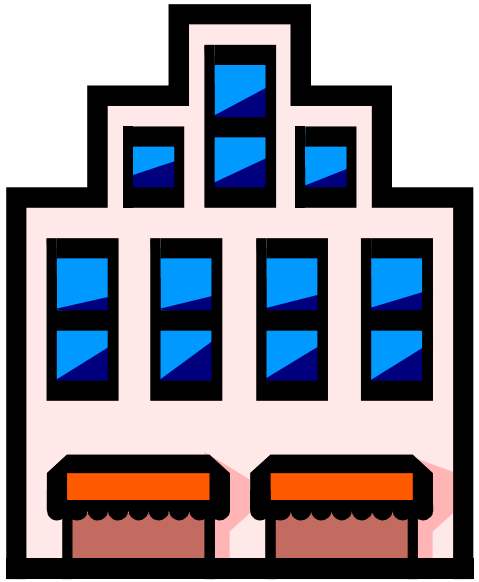
Commercial & Institutional Buildings		Residential Buildings
Building design and structure	1	Appliances occupants choose to use
Occupants' behaviour	2	Occupants' behaviour
Appliances occupants choose to use	3	Building design and structure



(Source: Environment Bureau, 2017. *Deepening Energy Saving in Existing Buildings in Hong Kong Through '4Ts' Partnership*.)

Energy efficiency

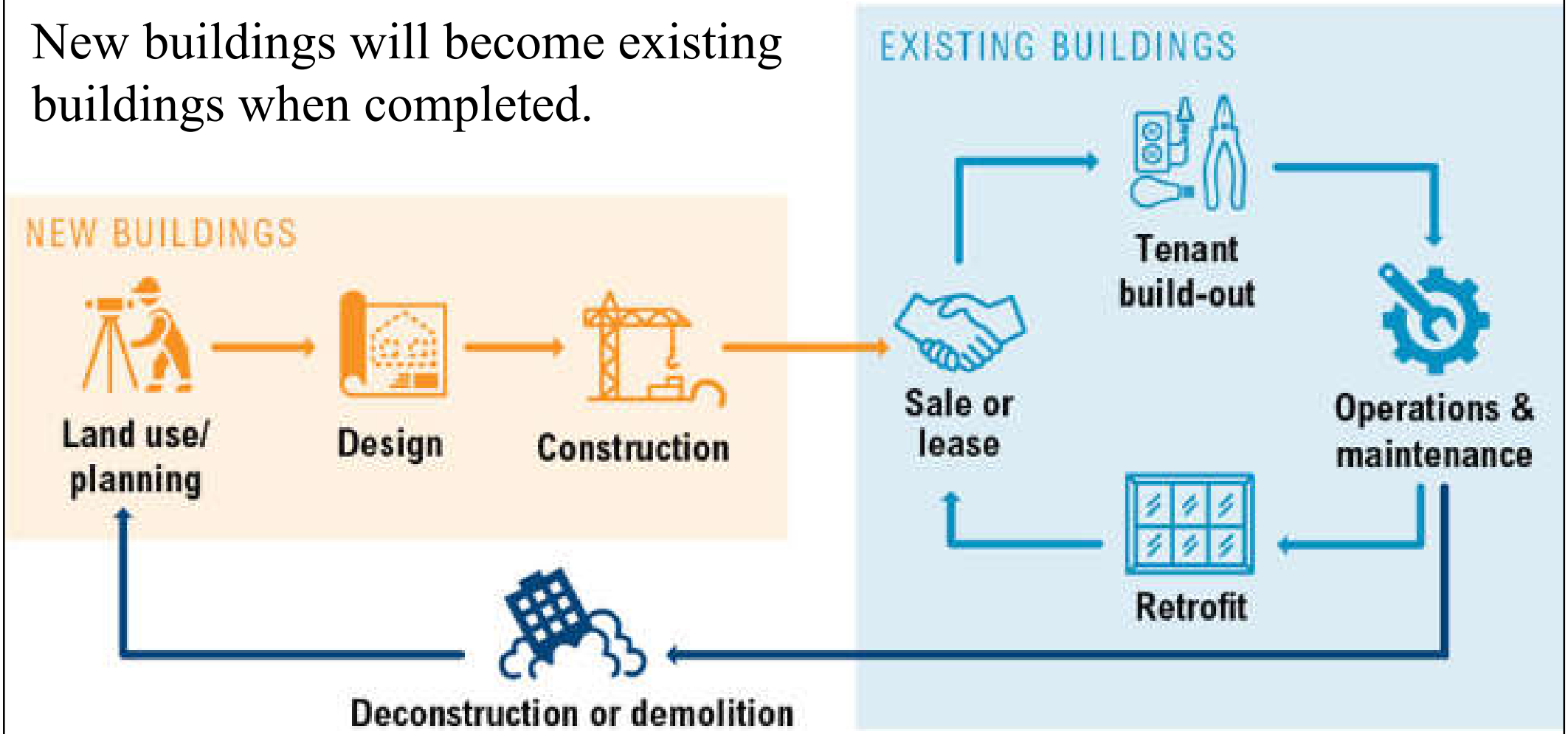
- For new buildings
  - Designing the building
    - Design strategy
    - Control strategies
    - Commissioning
- For existing buildings
  - Operating and upgrading the building
    - Building management
    - Refurbishment/renovation/retrofitting
    - Maintenance and monitoring



Lifecycle of a building and importance of existing buildings

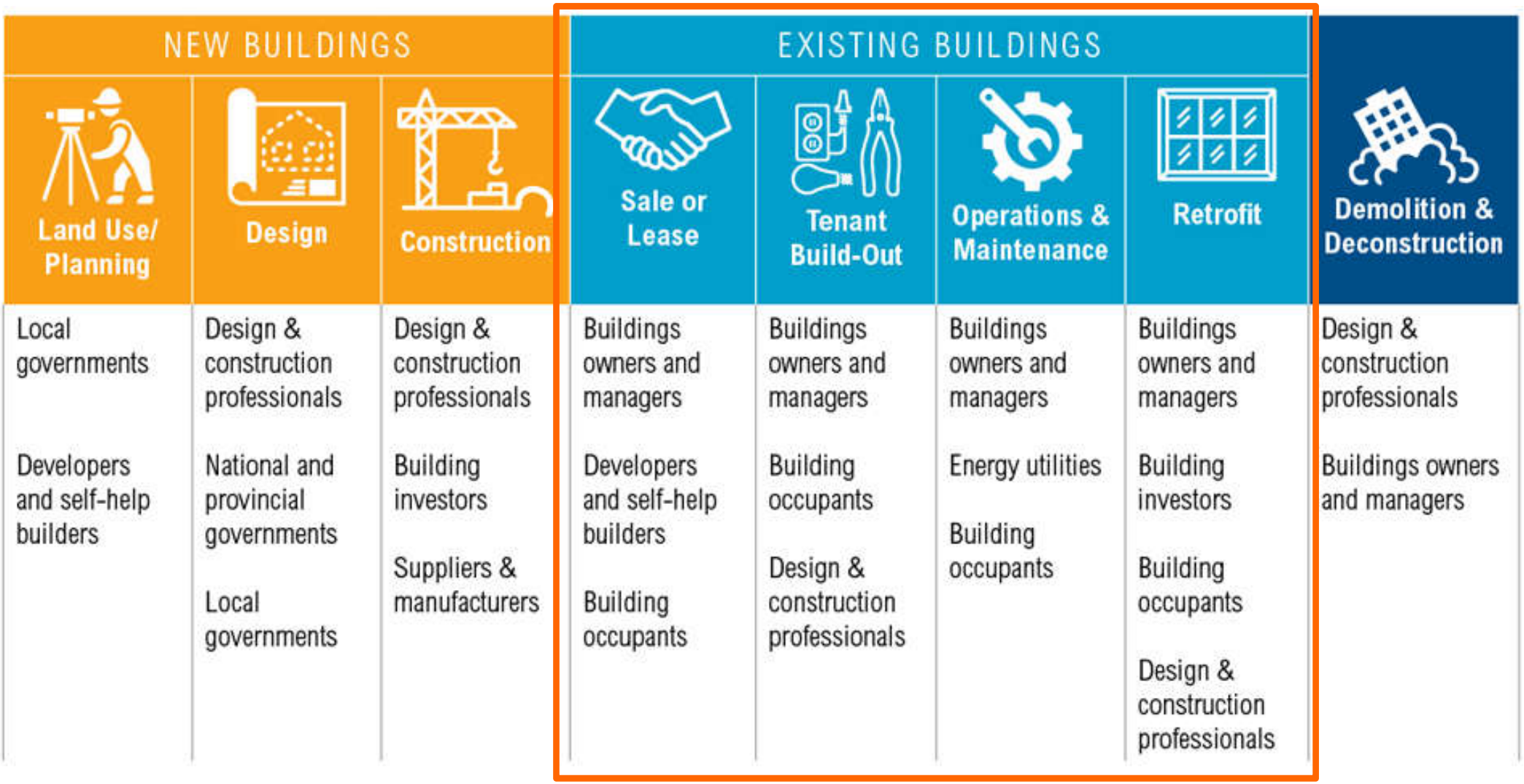
Most significant impacts during the building in use.

New buildings will become existing buildings when completed.



(Source: World Resources Institute, http://publications.wri.org/buildingefficiency/)

Stakeholder roles and engagement to enhance building efficiency



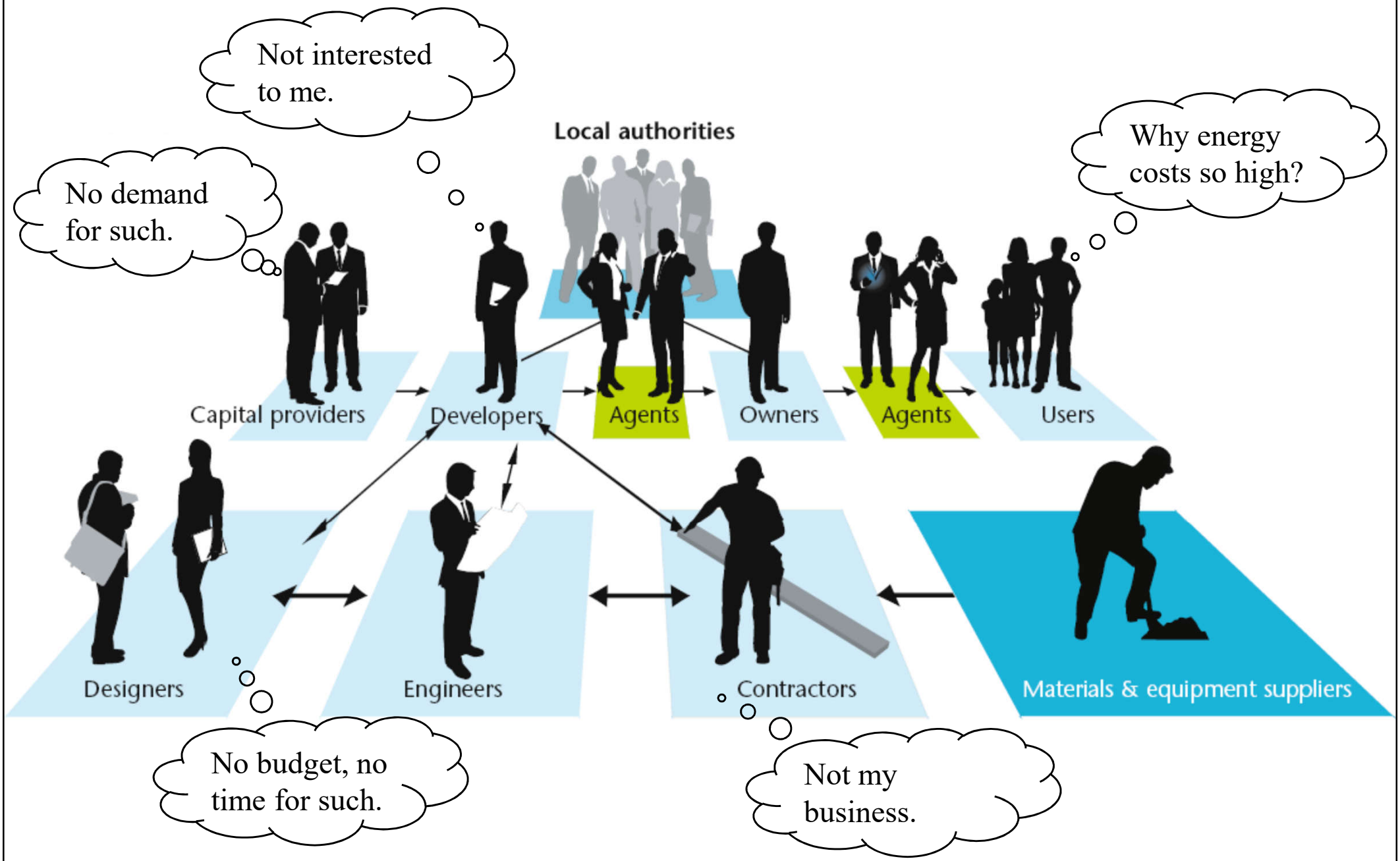
- Buildings owners and managers
- Building occupants
- Design & construction professionals
- Energy utilities

(Source: World Resources Institute, http://publications.wri.org/buildingefficiency/)

Energy efficiency

- Barriers to energy efficiency:
  - Market: split incentives, price distortion, low energy tariffs
  - Financial: limited internal capital & operational budgets, high upfront costs, dispersed benefits
  - Technical: lack of affordable technologies or know-how suitable to local conditions
  - Awareness: lack of information & understanding
  - Institutional: energy utilities are compensated for selling energy, not efficiency

The complex value chain in the building sector

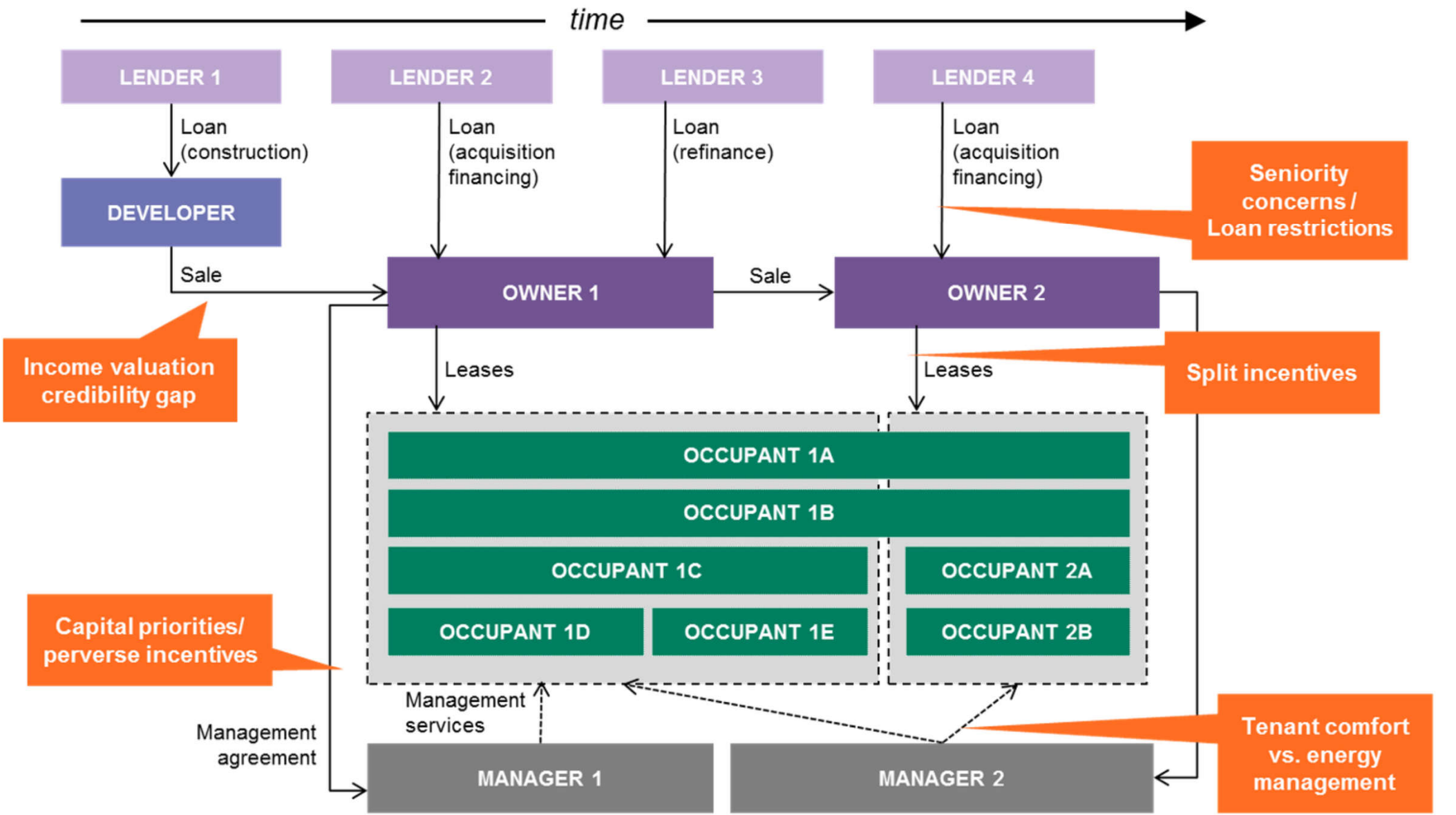


(Source: World Business Council for Sustainable Development, www.wcbsd.org)

Energy efficiency

- An interesting article:
  - Why Energy Efficiency and Buildings Don't Mix
    - http://www.energytrendsinsider.com/2012/09/20/why-energy-efficiency-and-buildings-dont-mix/
  - 5 friction points:
    - Income valuation & credibility gap (developer-owner)
    - Seniority concerns/loan restrictions (owner-lender)
    - Split incentives (owner-occupant)
    - Capital priorities/perverse incentives (owner-manager)
    - Tenant comfort vs. energy management (occupant-manager)

Real estate industry interfaces and energy efficiency 'friction points'



Source: Bloomberg New Energy Finance

(Source: http://www.energytrendsinsider.com/2012/09/20/why-energy-efficiency-and-buildings-dont-mix/)

Energy efficiency

- Strategies to improve energy efficiency of existing buildings:
  - Measure and assess energy performance
  - Set up goals and targets
  - Understand energy use and end-use/system energy
  - Select energy efficiency measures
  - Refine financial analysis
  - Establish priorities

Examples of energy saving measures in an educational institute

Automatic on-off for lighting and fan coil units in classrooms

Fan coil unit group control and usage control

Replacement of existing chillers with better energy performance options

CO2 sensor and Variable Speed Drive for Primary Air-Handling Units

Automatic sensing device

T5 light fitting

(Source: http://sustainability.hkbu.edu.hk/index.php/wwrd/listing/cid/2/p/1.html)

Examples of energy saving measures in an educational institute (cont'd)

Occupancy sensors for toilet

Campus lighting review and adjustment

LED exit signs

LED outdoor lighting

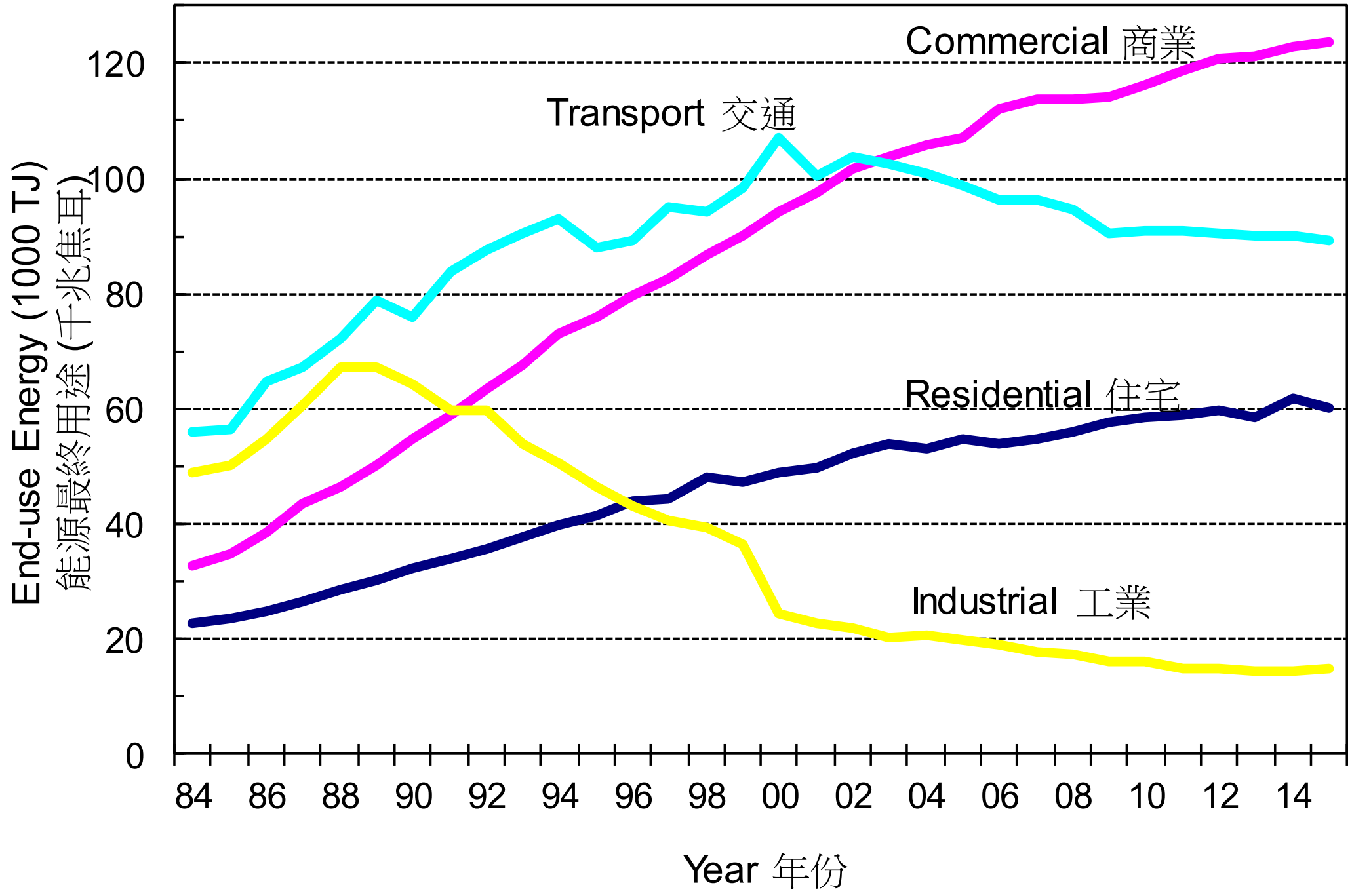
Water-cooled air-conditioning systems

Lamp replacements

(Source: http://sustainability.hkbu.edu.hk/index.php/wwrd/listing/cid/2/p/1.html)

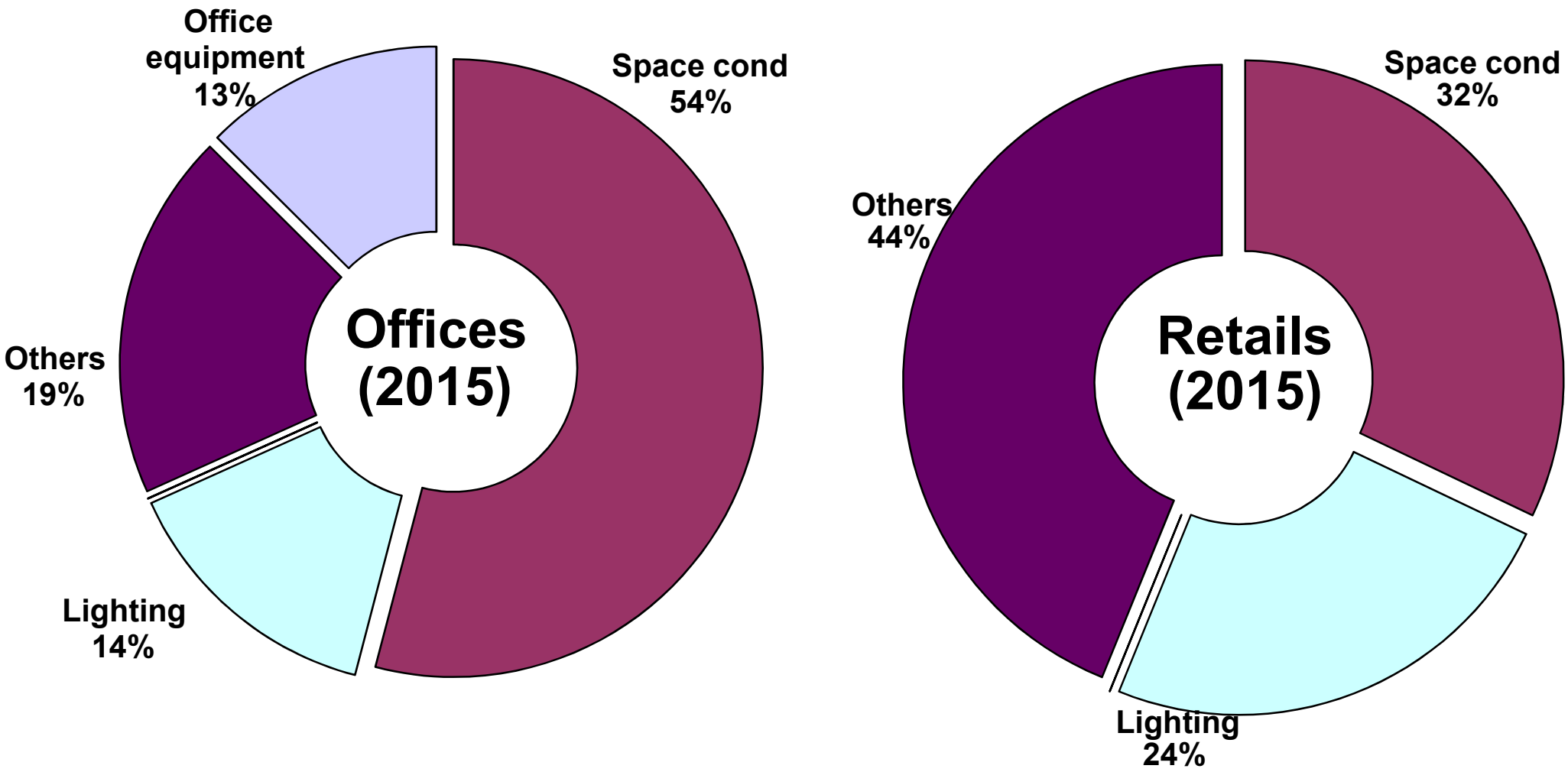
Hong Kong situation

- Energy end-use in HK (trend in 1984-2015)
  - 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?



(Data source: EMSD) Energy end-use in Hong Kong by sectors, 1984-2015

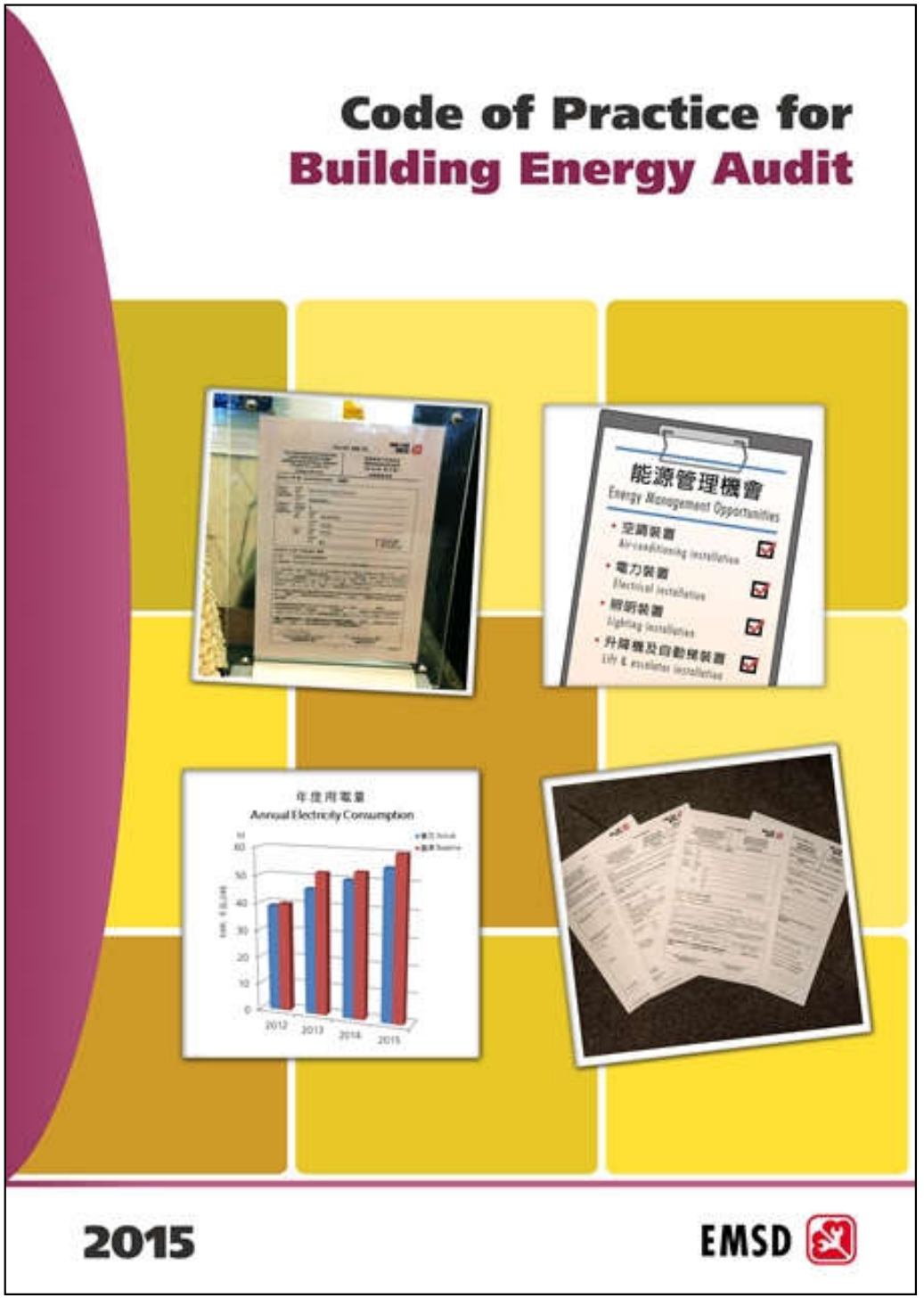
What are the major energy usages?



Energy consumption patterns in offices and retails
(Data source: Energy Efficiency Office, HK)

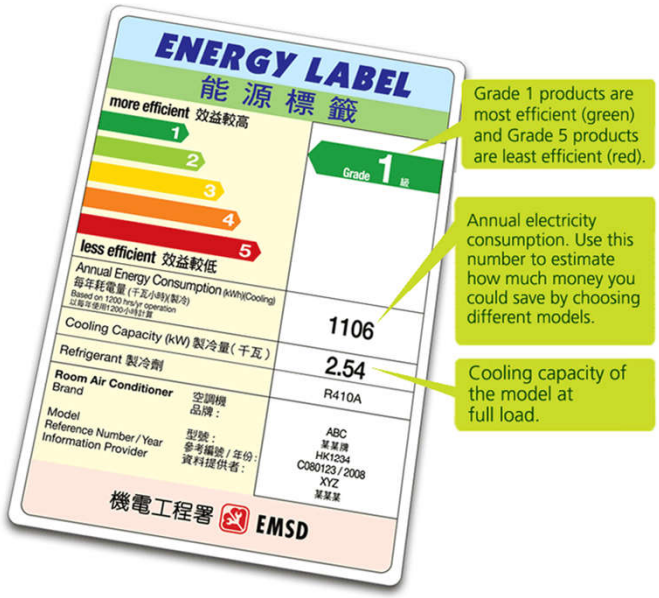
(Source: EMSD)

(See http://www.beeo.emsd.gov.hk for details)



(Source: www.emsd.gov.hk)

Energy efficiency labels in HK



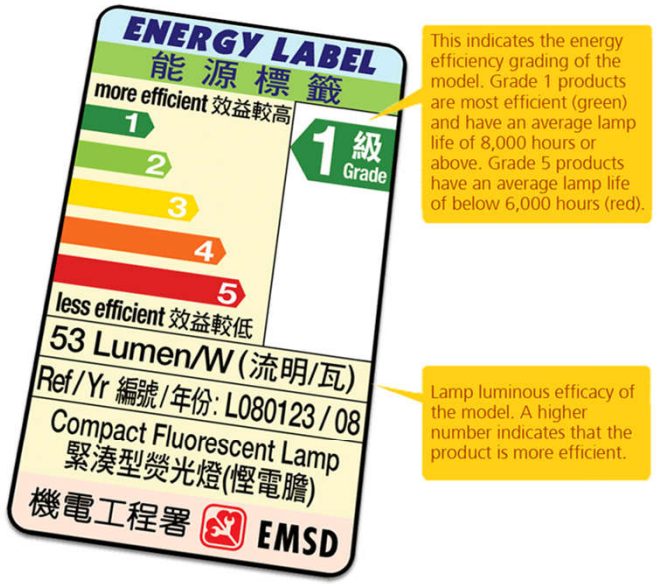


Figure 4.8 Examples of mandatory energy efficiency labels in Hong Kong

Figure 4.9 Examples of voluntary energy efficiency labels in Hong Kong

(Source: www.energylabel.emsd.gov.hk)

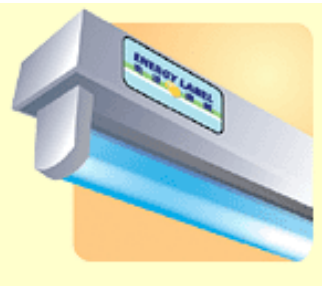
BEAM Plus Existing Buildings (EB)

(Source: Hong Kong Green Building Council https://www.hkgbc.org.hk/)

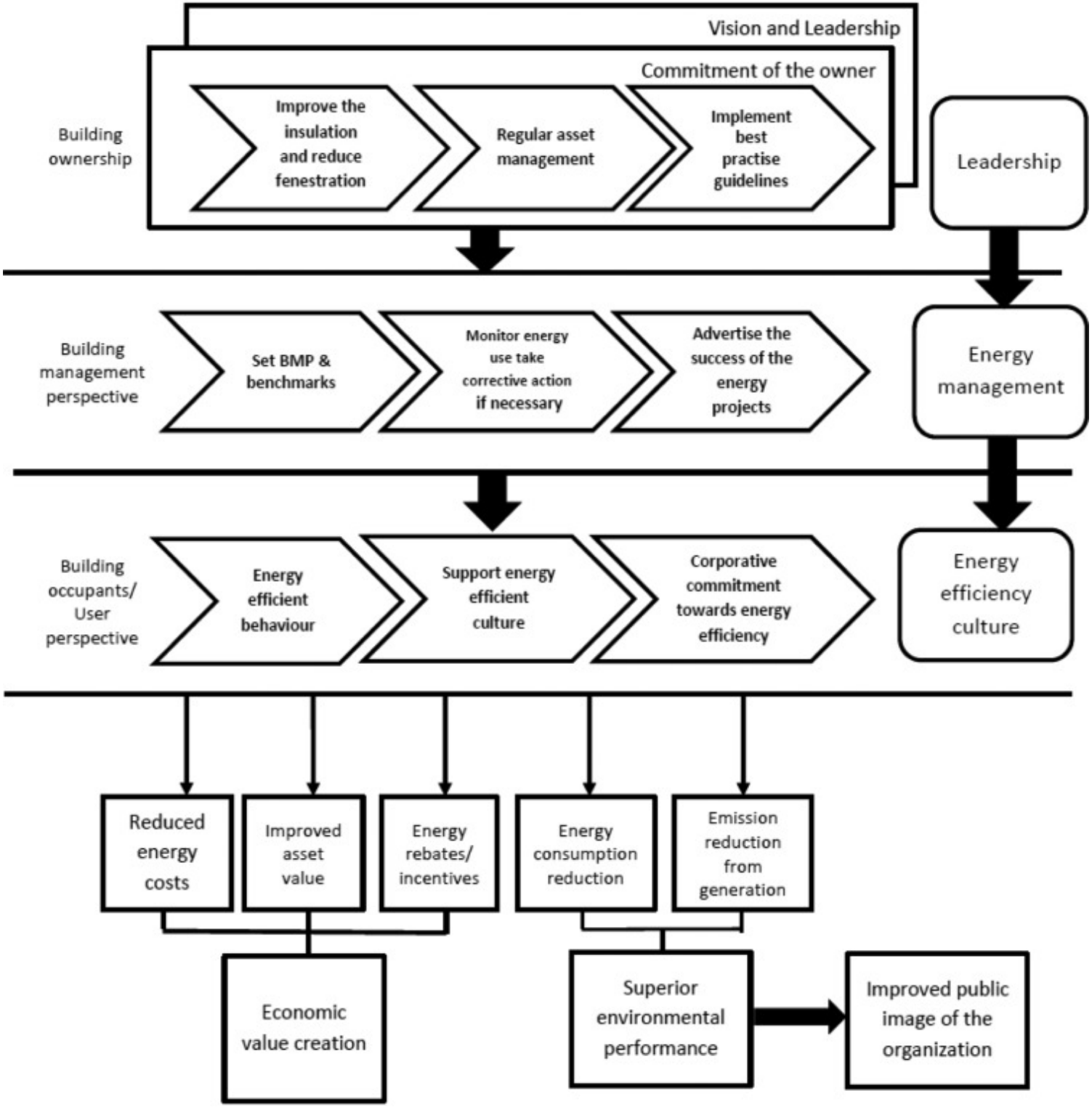
Major considerations

- Leadership & building ownership
  - Vision of senior management
  - Commitment of the owner

- Energy management
  - Building operation, maintenance & retrofits



- Energy efficiency culture
  - Energy efficient behaviours
  - Building occupants & users



(Source: *Renewable and Sustainable Energy Reviews*, Volume 53, January 2016, Pages 1032-1045)

Major considerations

- Key persons in building energy efficiency
  - Building Developer or Owner (Client)
  - Architect
  - Building Services Engineer
  - Building/Facility Manager
  - End-Users

Good design practices

Integrated & total energy approach

Efficient systems

Good house-keeping

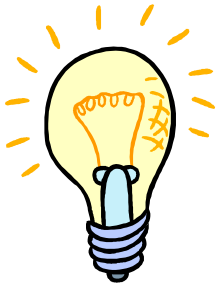
User education & awareness

Efficient operation

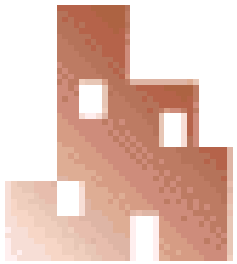
Major considerations

- Occupant involvement
  - Motivation and training
    - Managing PEOPLE
  - Occupant satisfaction
    - Comfort, health and safety of the occupants
    - Securing understanding and involvement of occupants

Major considerations



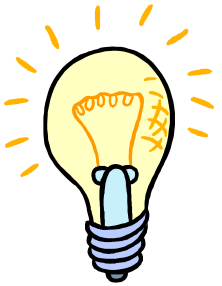
- Planning maintenance
  - Maintenance policy
  - Types of maintenance
    - Reactive or breakdown maintenance
    - Planned preventative maintenance
- Maintenance contracts
  - Performance specification
  - Use of maintenance contractors



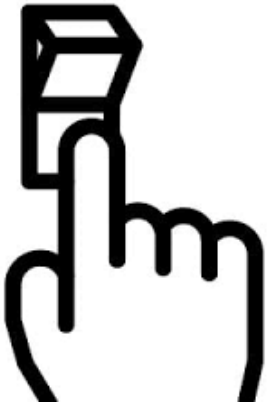
Major considerations

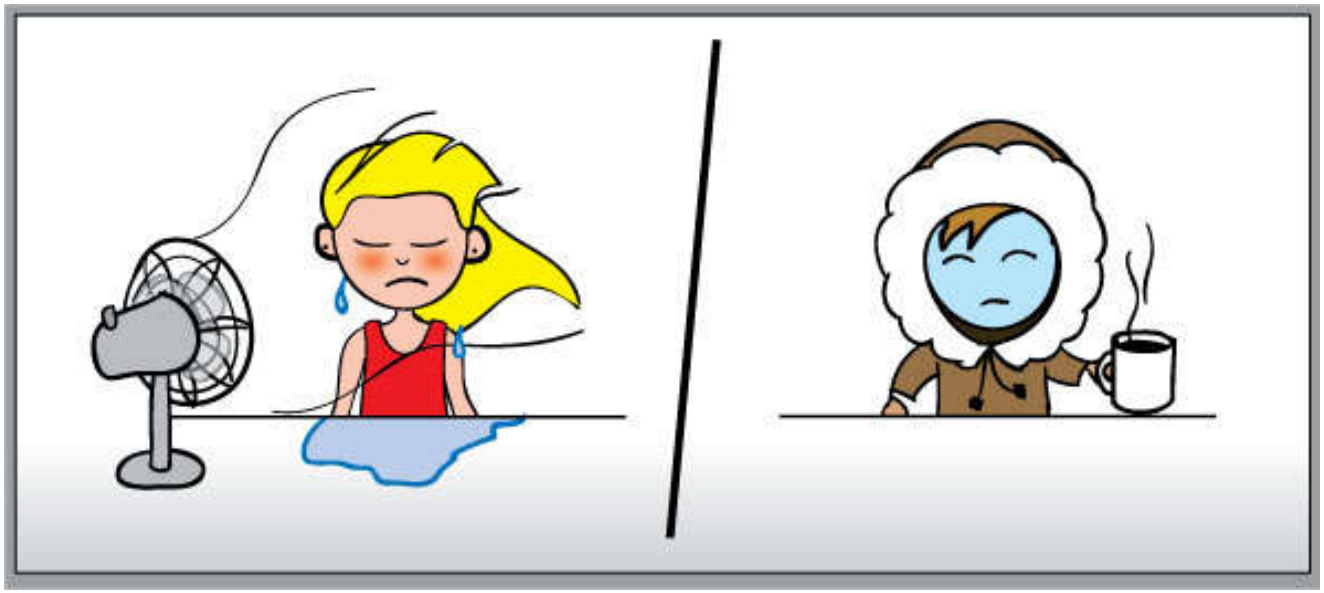
- Monitoring maintenance
  - Maintenance records
    - Installation records: e.g. O&M manuals, plant details
    - Service records: include log sheets, job records, etc.
  - Checking maintenance standards
    - Such as breakdown frequency
    - Annual spend on building services maintenance
  - Post-occupancy evaluation (POE)
    - Obtaining feedback on a building's performance in use

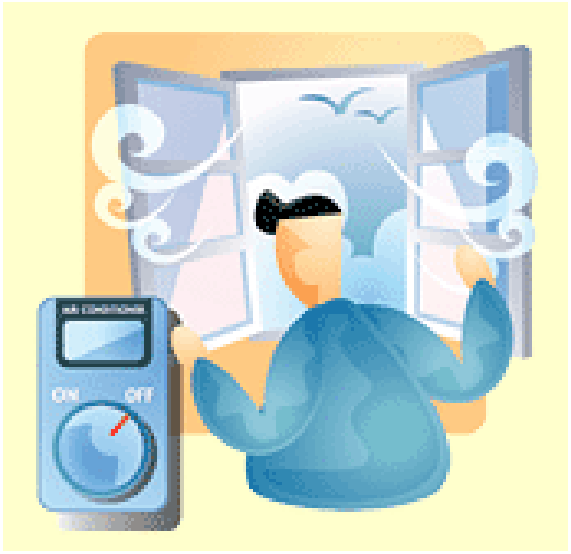
Major considerations

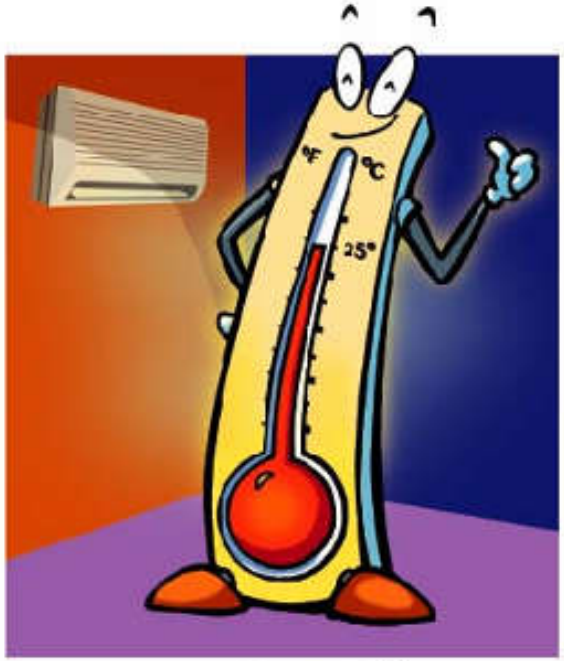


- Good housekeeping
  - Such as switch off lights when not needed
- Maintaining for energy efficiency
  - Building fabric
  - Controls
  - Heating ventilation & air conditioning systems
  - Refrigeration systems
  - Lighting systems
  - Motors and drives









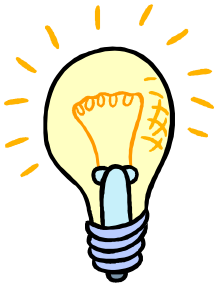
Just nice at 25°C

Electricity Efficiency Centre

Cleaner filter filters better.

Electricity Efficiency Centre

Major considerations



- Refurbishing existing buildings
  - Complete refurbishment
    - Total replacement of plant & major changes to fabric
  - Major refurbishment
    - Replacement of major plant & some changes to fabric
  - Minor refurbishment
    - Refitting the interior & making minor alterations to space layout and plant
  - Passive refurbishment
    - Passive methods: daylighting & natural ventilation

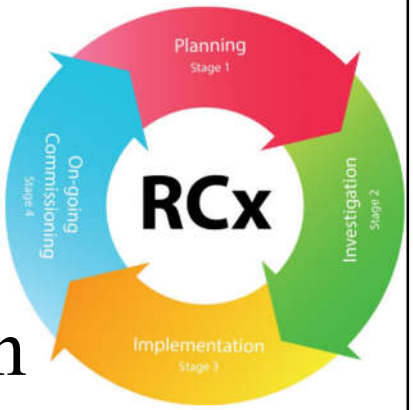
Major considerations

- Retrofitting energy saving measures
  - Identify high energy users
  - Establish the potential for energy saving through measurement, audits etc.
  - Identify practicable measures to achieve savings
  - Establish the financial case for introducing these measures, as well as other benefits
  - Implement the savings in a planned way
  - Monitor the savings to confirm

Major considerations

- Retro-commissioning (RCx)

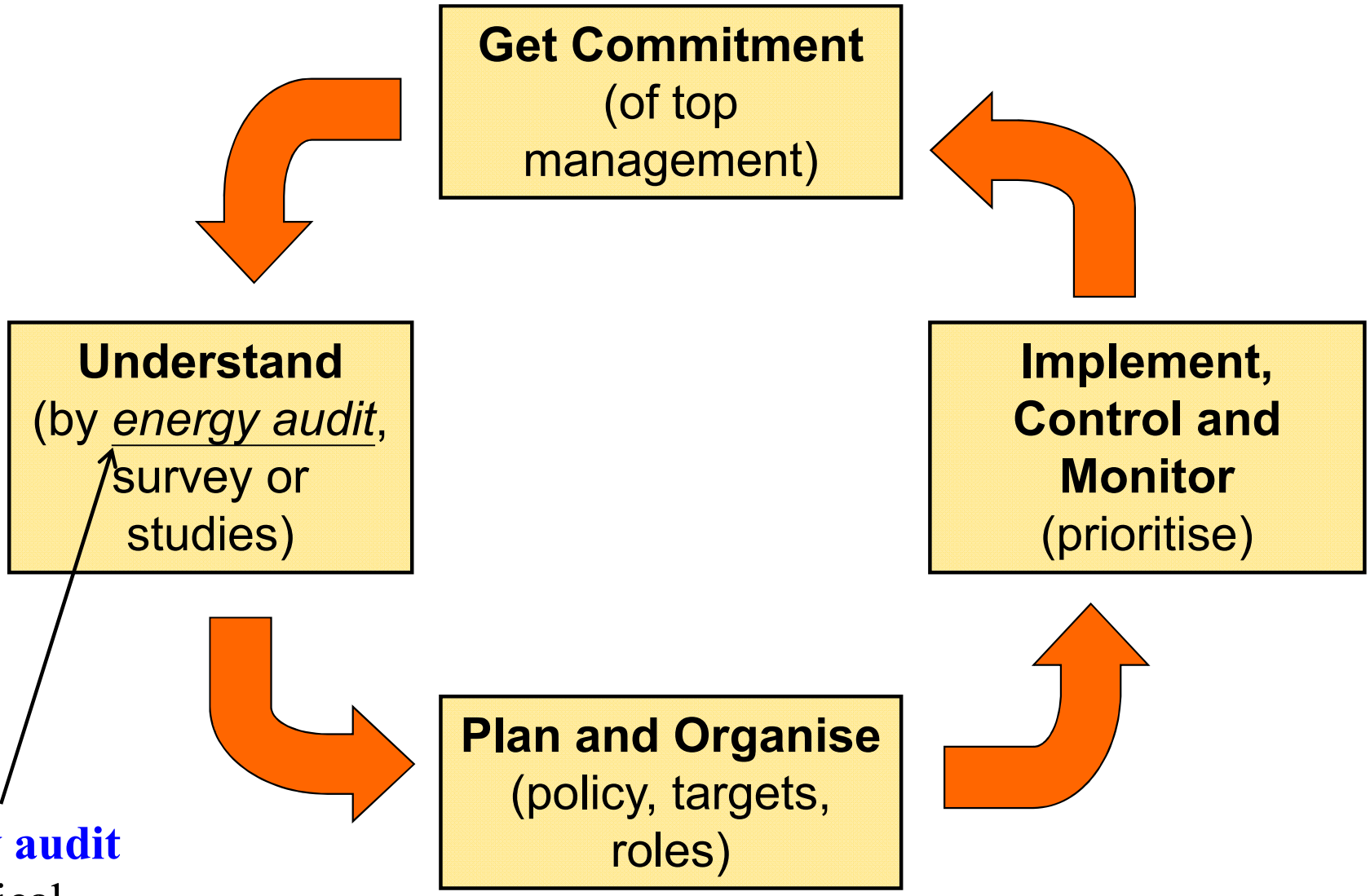
重新校驗



  - A way for system optimization
  - Systematic process to periodically check an existing building's performance
  - Resume the system efficiency back to design standard
  - Help identify operational improvements that can save energy
    - Review of building operation & original intended design; improvement & optimization

(Source: http://www.energysaving.gov.hk/en/retro_commissioning_rcx/)

A systematic approach to energy management



Energy audit is a critical step for energy management

Energy management skills

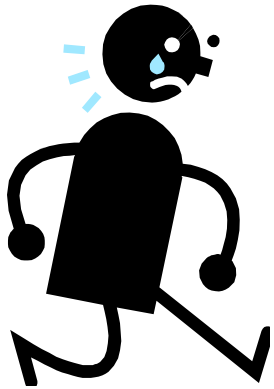
- What is Energy Audit (能源審核)?
  - Examination of an energy system or equipment to ensure that energy is being used *efficiently*
    - Process to check for areas of *inefficiency*
  - It is a top-down initiative. Its result depends on the resources being allocated by top management
  - Aims to identify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

Energy management skills

- 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

Energy management skills

- 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



Energy management skills

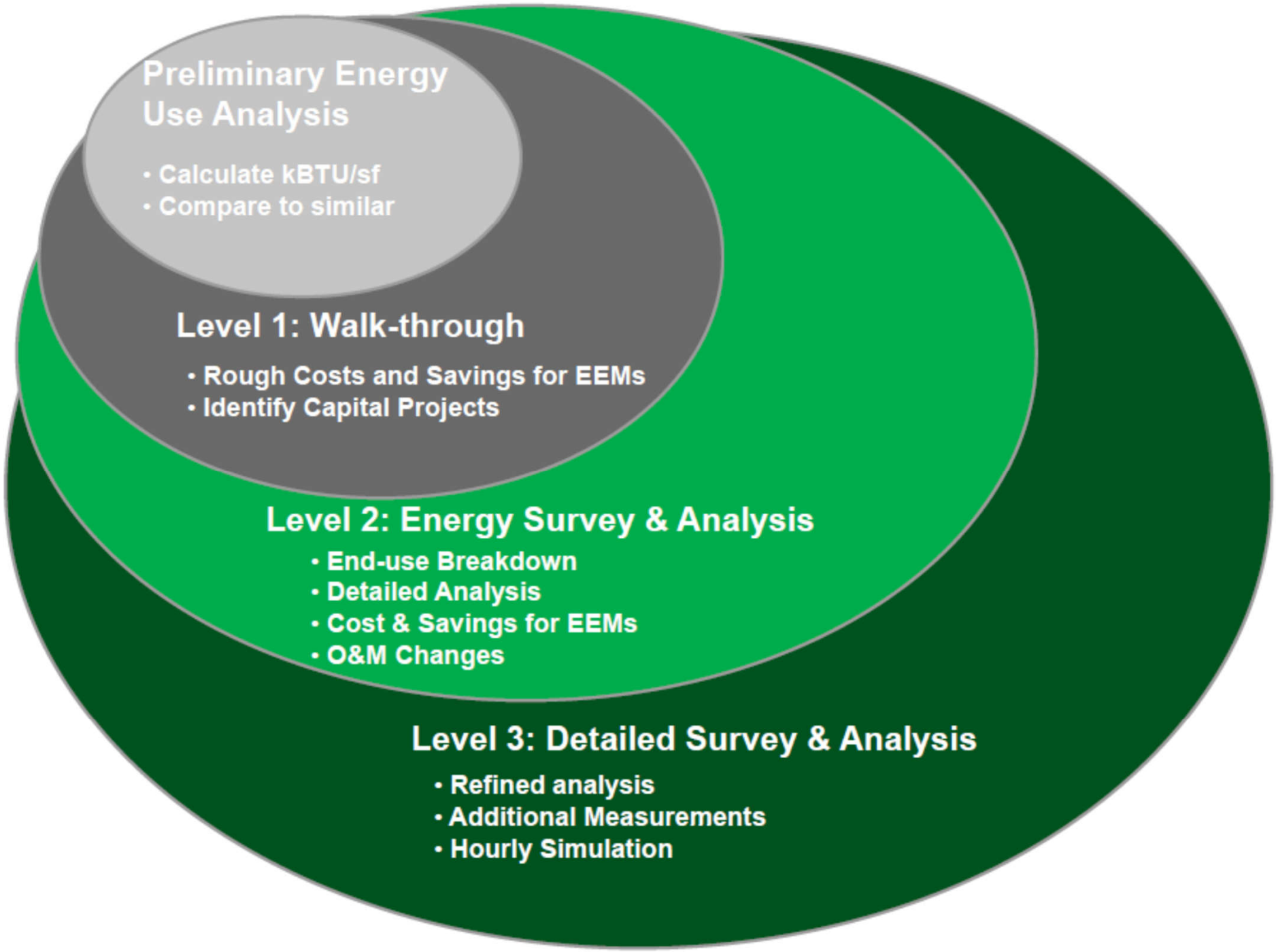
- Investment grade audit (IGA)
  - Expand on the detailed audit
  - Analyses the financial aspects of energy savings and the return on investment (ROI) from potential changes or upgrades
  - Aim to justify the energy investment
  - Rely on a complete engineering study in order to detail technical and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

Energy management skills

- 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			●

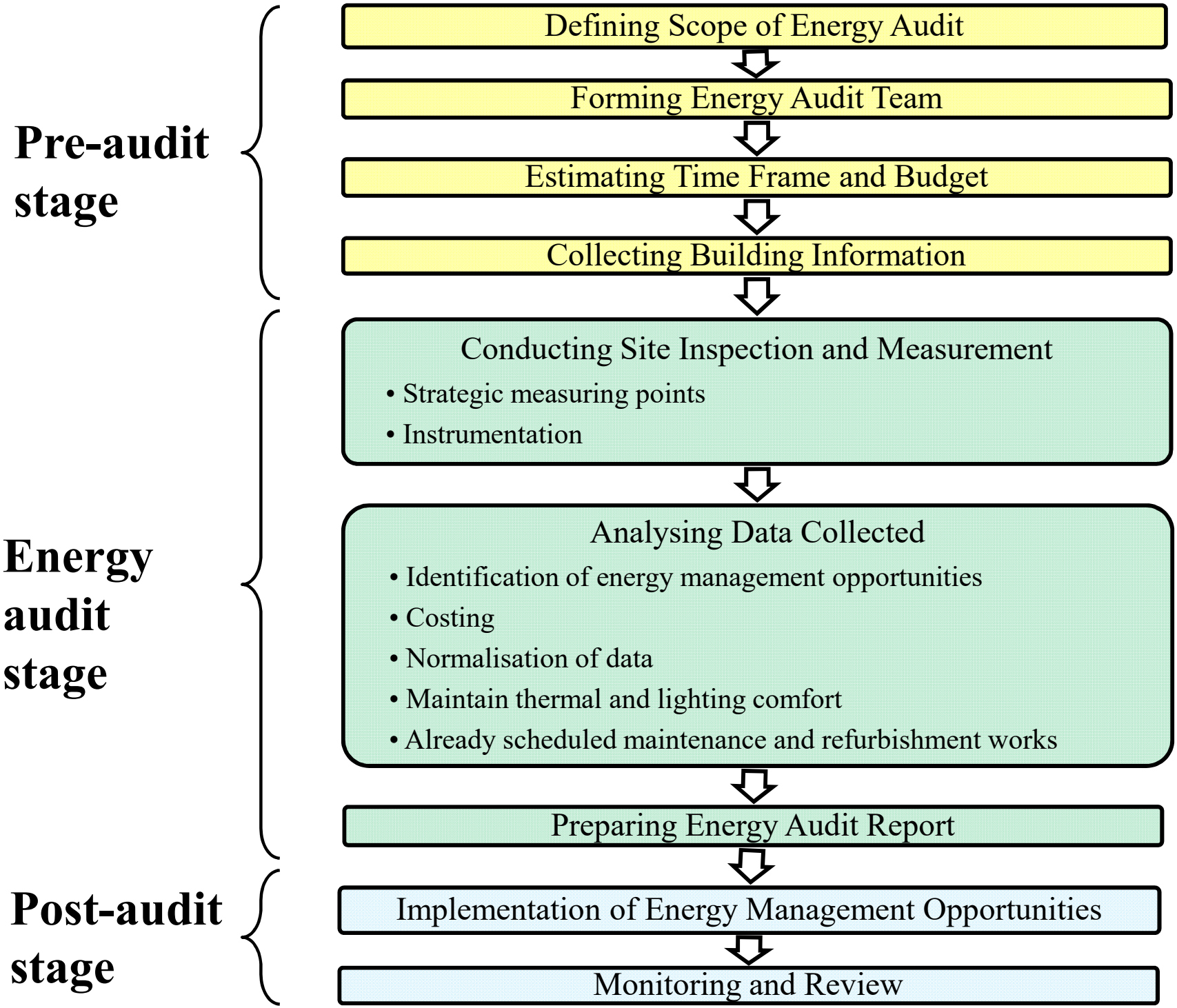
(Source: ASHRAE 2011. *Procedures for Commercial Building Energy Audits*, Second Edition)

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)

Procedure of energy audit



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

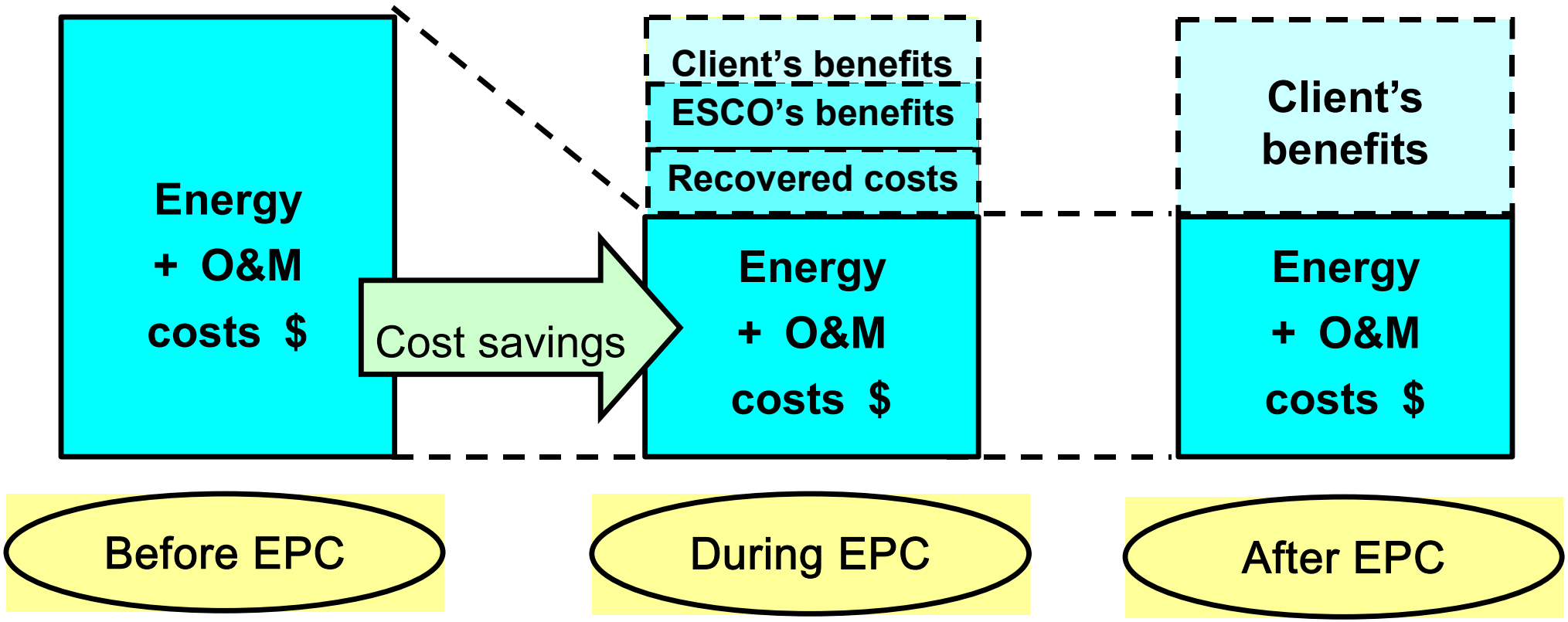
- Identification & evaluation of potential EMOs
- List of recommended EMOs and implementation plan

Conclusions and Recommendations

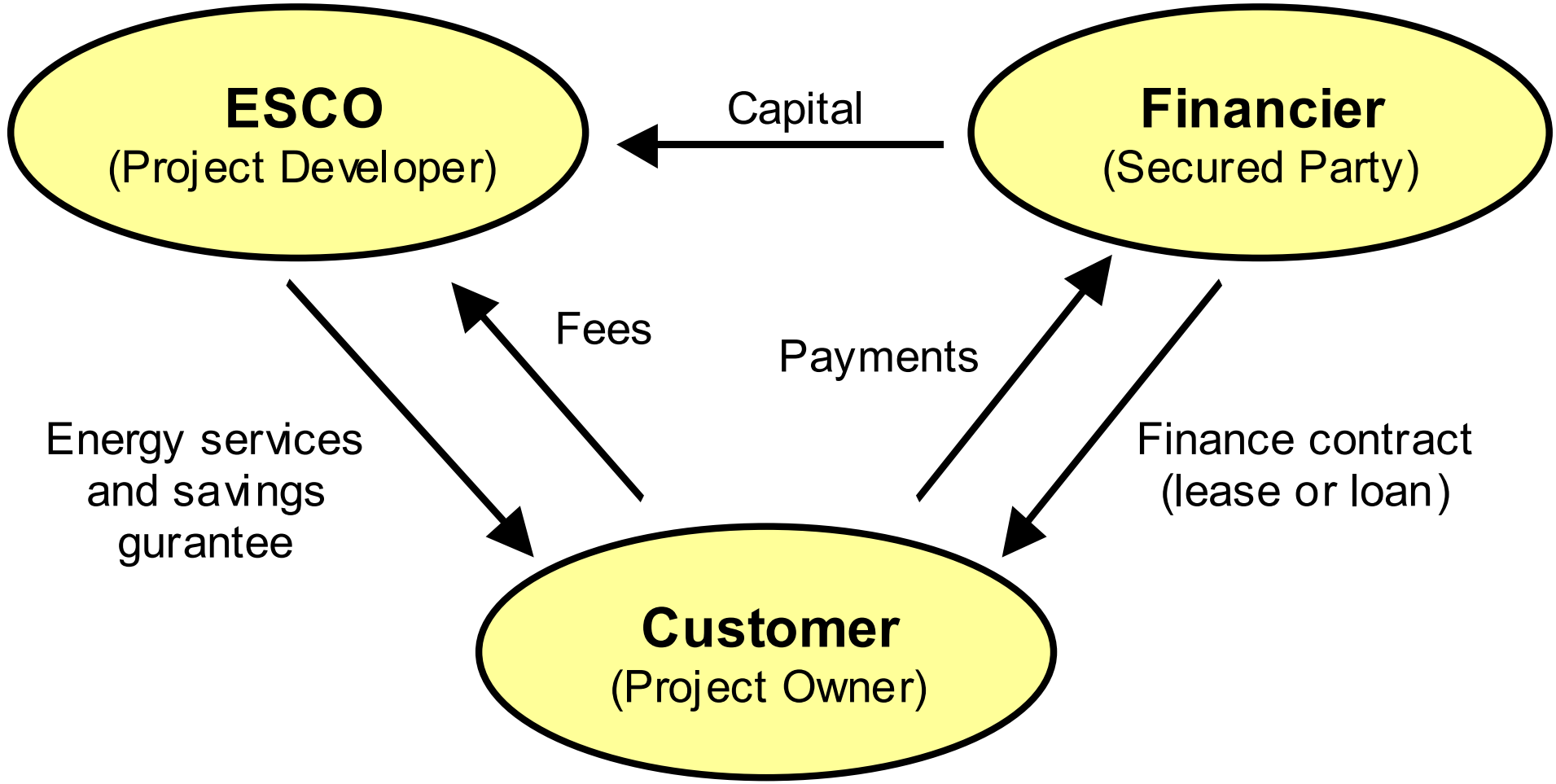
Energy management skills

- Energy performance contracting (EPC)
  - = energy savings performance contracting
  - A financing technique to raise money for energy efficiency investments based on future savings
- Energy services companies (ESCO)*
  - Offer EPC services, without upfront capital on building owners
  - Becoming an important trend in many countries like USA and Japan

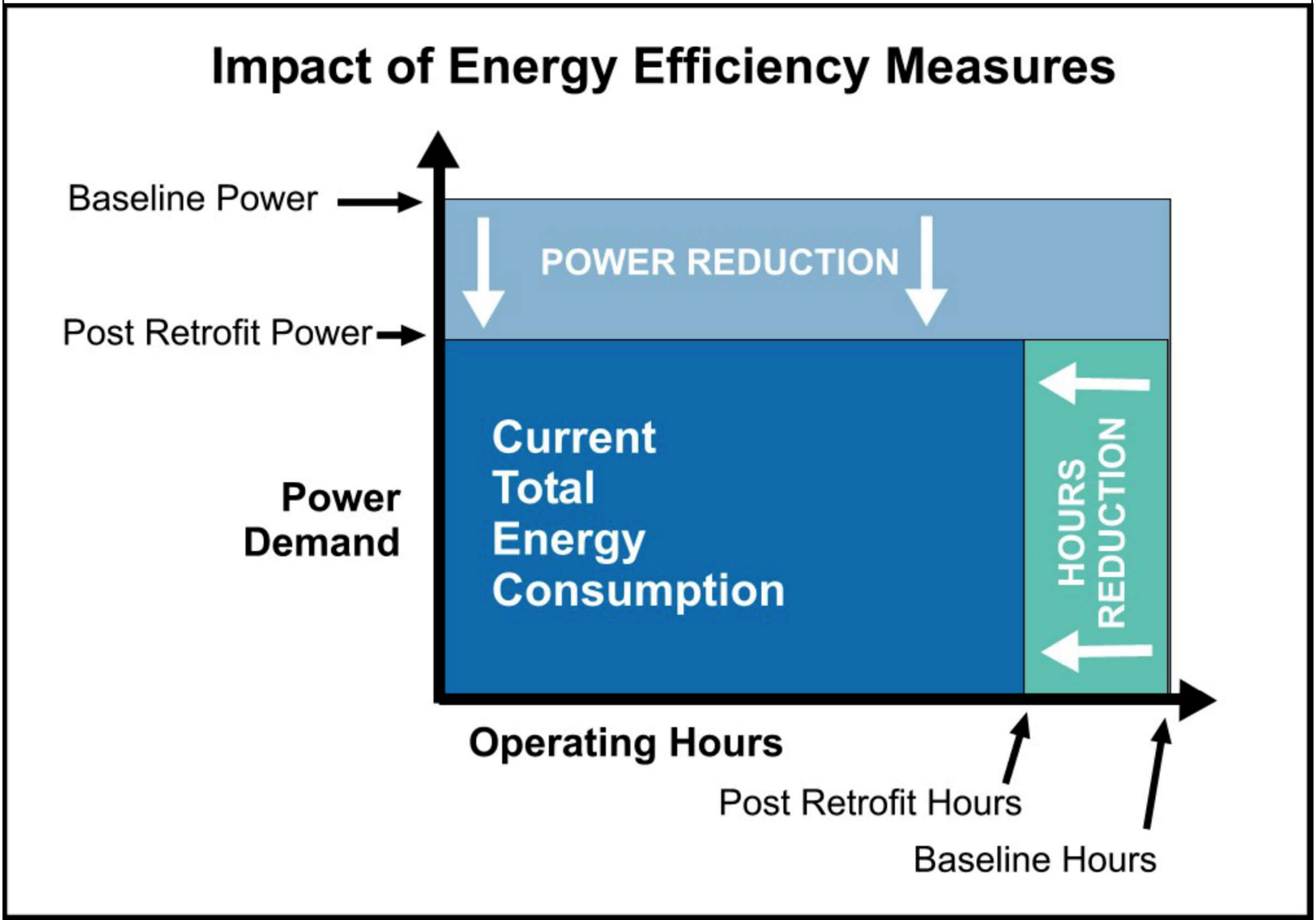
(* See also http://en.wikipedia.org/wiki/Energy_service_company)



Basic concept of energy performance contracting (EPC)



Financial structure used by ESCO



(Source: http://energyperformancecontracting.org)

Energy saving technologies

- Energy information system 能源信息系統
  - Better data and reporting
  - Inexpensive sub-metering
  - Wireless devices + remote assessment

- Energy data analytics
  - “Big Data (energy)”
  - Monitoring and assessment
  - Software and cloud services

An example of energy dashboard for buildings
建築能源儀表板的例子

能源狀況一目了然

(Source: https://hbsmicrosites.honeywell.com)

Example of analysing the electricity billings

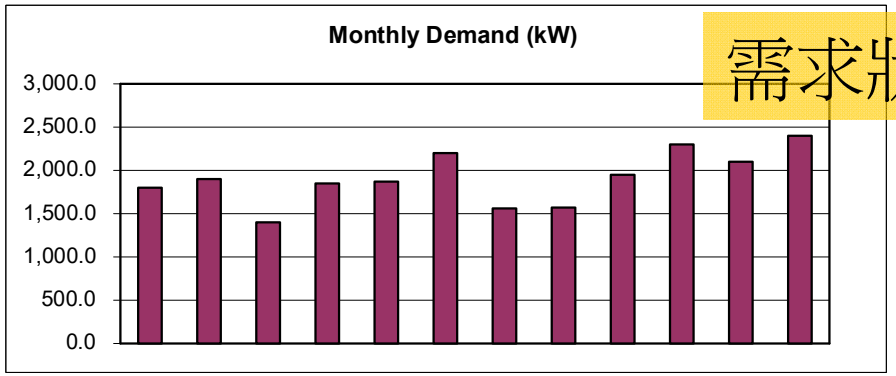
Electricity Consumption Data

Location: ABC Facility

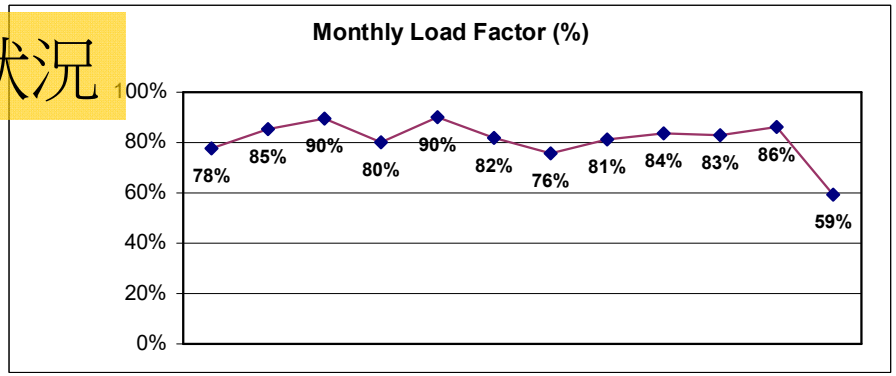
用電量數據

[C:\Project Files\Audit Manual\Spreadsheets\[Electricity Cost.xls]Electicity Consumption Data]

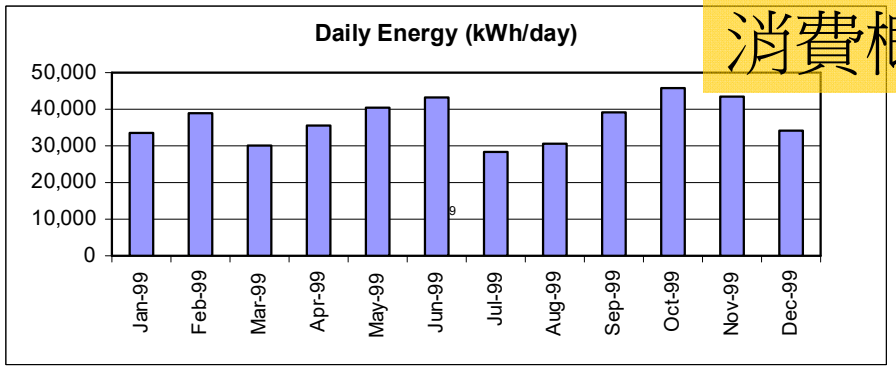
Billing Date	Metered kVA	Metered kW	Power Factor	Billed kW	Energy kWh	Days	Daily kWh	Load Factor	Demand Cost	Energy Cost	Adjust (+/-)	Sub Total	Total Cost
01/01/99		1,800.0		1,800.0	1,006,703	30	33,557	78%	$21,250	$50,365	($11,147)	$71,615	$64,701
02/01/99		1,900.0		1,900.0	1,206,383	31	38,916	85%	$22,750	$56,441	($13,204)	$79,191	$70,607
03/01/99		1,400.0		1,400.0	842,286	28	30,082	90%	$15,250	$42,144	($9,263)	$57,394	$51,501
04/01/99		1,850.0		1,850.0	1,102,176	31	35,554	80%	$22,000	$53,315	($12,132)	$75,315	$67,606
05/01/99		1,870.0		1,870.0	1,213,021	30	40,434	90%	$22,300	$56,641	($13,252)	$78,941	$70,287
06/01/99		2,200.0		2,200.0	1,339,599	31	43,213	82%	$27,250	$60,438	($14,716)	$87,688	$78,080
07/01/99		1,560.0		1,560.0	850,195	30	28,340	76%	$17,650	$42,540	($9,438)	$60,190	$54,304
08/01/99		1,570.0		1,570.0	948,747	31	30,605	81%	$17,800	$47,467	($10,429)	$65,267	$58,677
09/01/99		1,950.0		1,950.0	1,213,798	31	39,155	84%	$23,500	$56,664	($13,308)	$80,164	$71,536
10/01/99		2,300.0		2,300.0	1,373,054	30	45,768	83%	$28,750	$61,442	($15,111)	$90,192	$80,337
11/01/99		2,100.0		2,100.0	1,347,059	31	43,454	86%	$25,750	$60,662	($14,731)	$86,412	$76,699
12/01/99		2,400.0		2,400.0	1,024,475	30	34,149	59%	$30,250	$50,984	($11,685)	$81,234	$74,418
Totals/Max		**2,400.0**		**2,400.0**	**13,467,496**	**364**			**$274,500**	**$639,104**	**($148,415)**	**$913,604**	**$818,752**

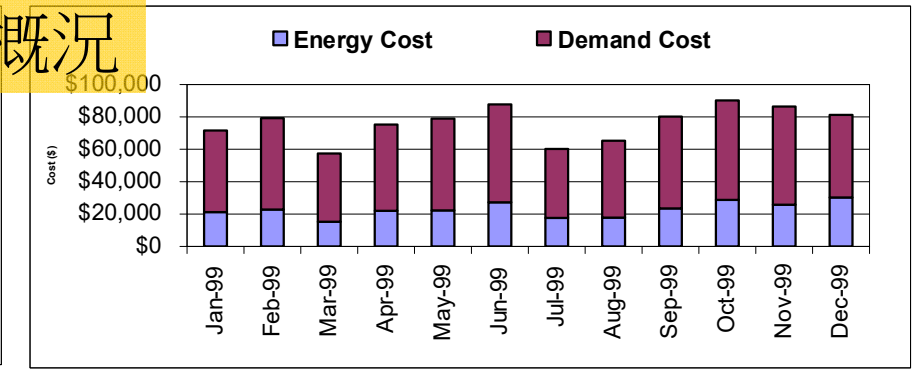


需求狀況



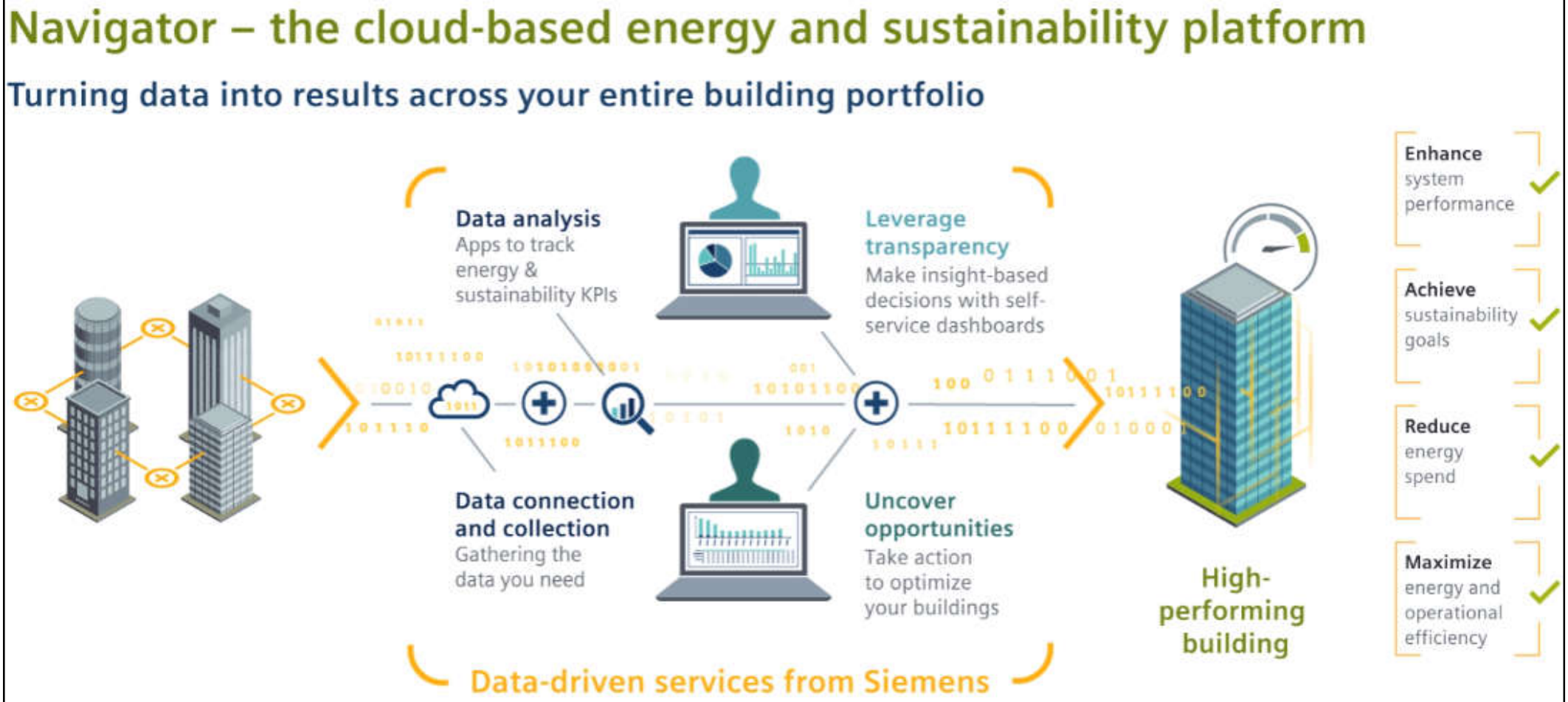
消費概況





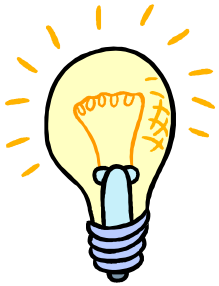
(Source: Department of Minerals and Energy, South Africa)

Cloud-based energy and sustainability analytics for buildings

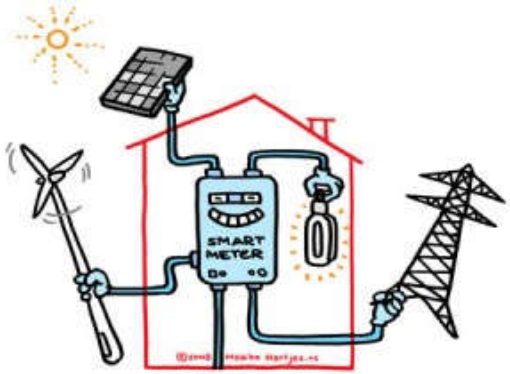


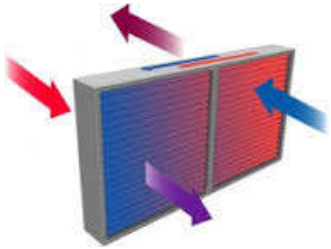
(Source: https://www.siemens.com/global/en/home/company/topic-areas/intelligent-infrastructure/buildings/performance.html)

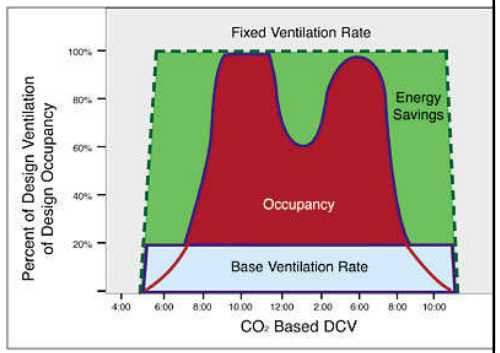
Energy saving technologies



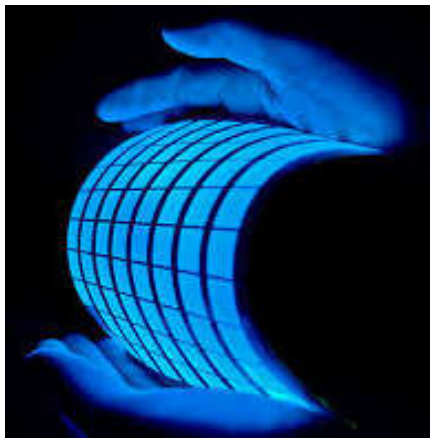
- Intelligent devices 智能設備
  - Intelligent lighting fittings
  - High efficient systems
  - Smart meters
- Smart operation 智能操作
  - Demand control/response
  - Energy recovery
  - Variable speed/frequency







照明技術的發展 Evolution of lighting technology



Edison lamp
愛迪生燈

Incandescent lamp
白熾燈

Compact fluorescent lamp
緊湊型熒光燈

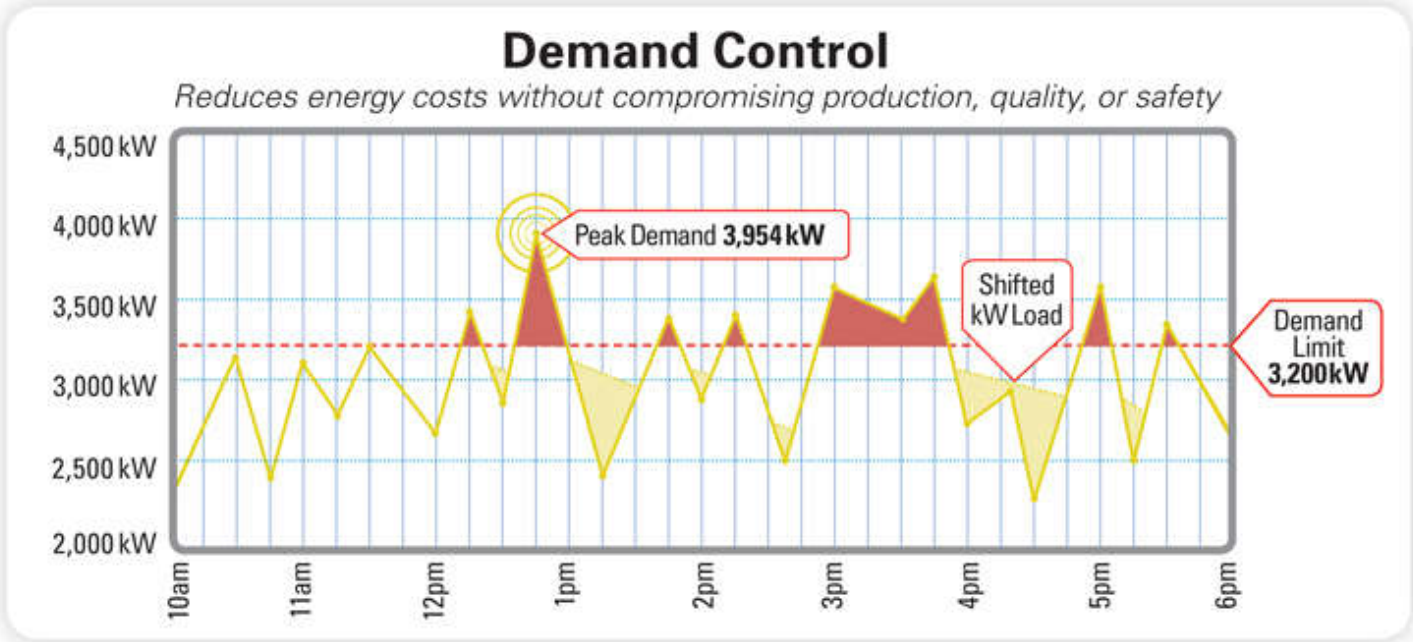
LED lamp
發光二極管燈

OLED lighting
有機發光二極體照明

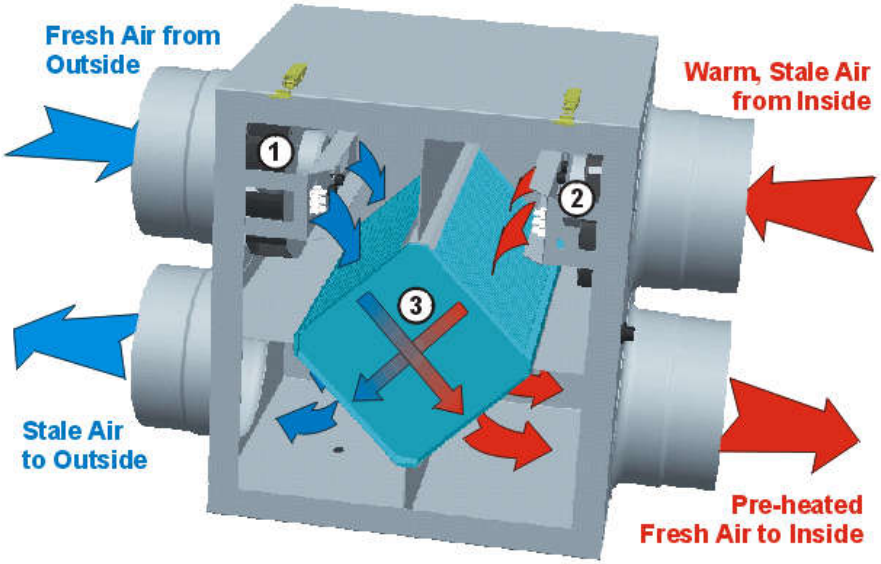
Intelligent luminaires have the potential to integrate various sensors
智能燈具可能整合各種傳感器

[Image Source: http://www.ledsmagazine.com]

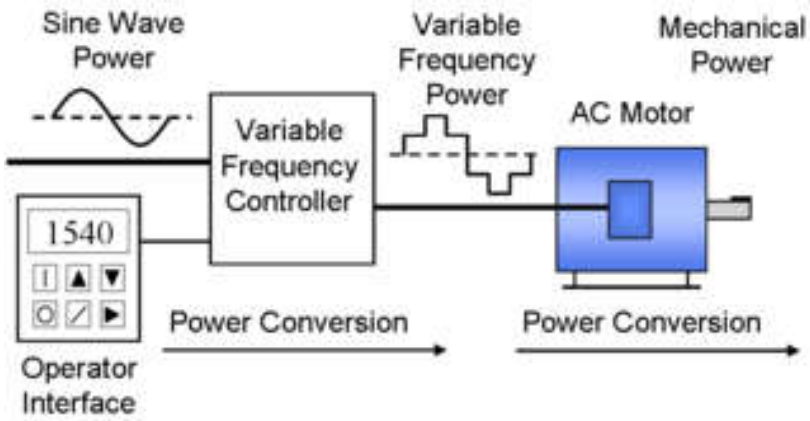
Demand control ventilation 需求控制通風



Energy recovery system
能量回收系統



Variable speed/frequency
變速/變頻



THANK YOU 謝謝 !!