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Building Energy Efficiency in Hong Kong: How High We Can Go?

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- Building energy use
- Energy efficiency codes
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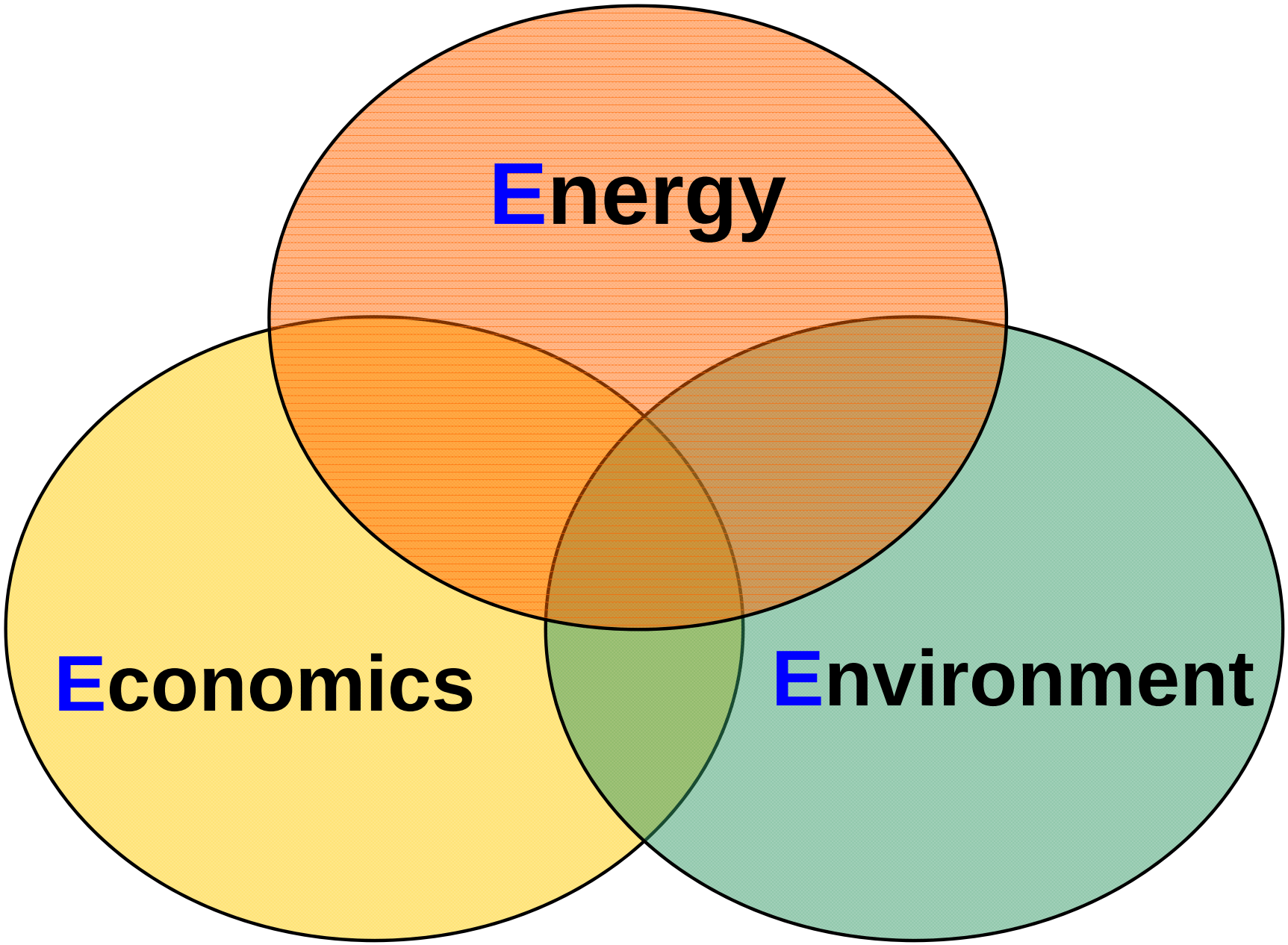
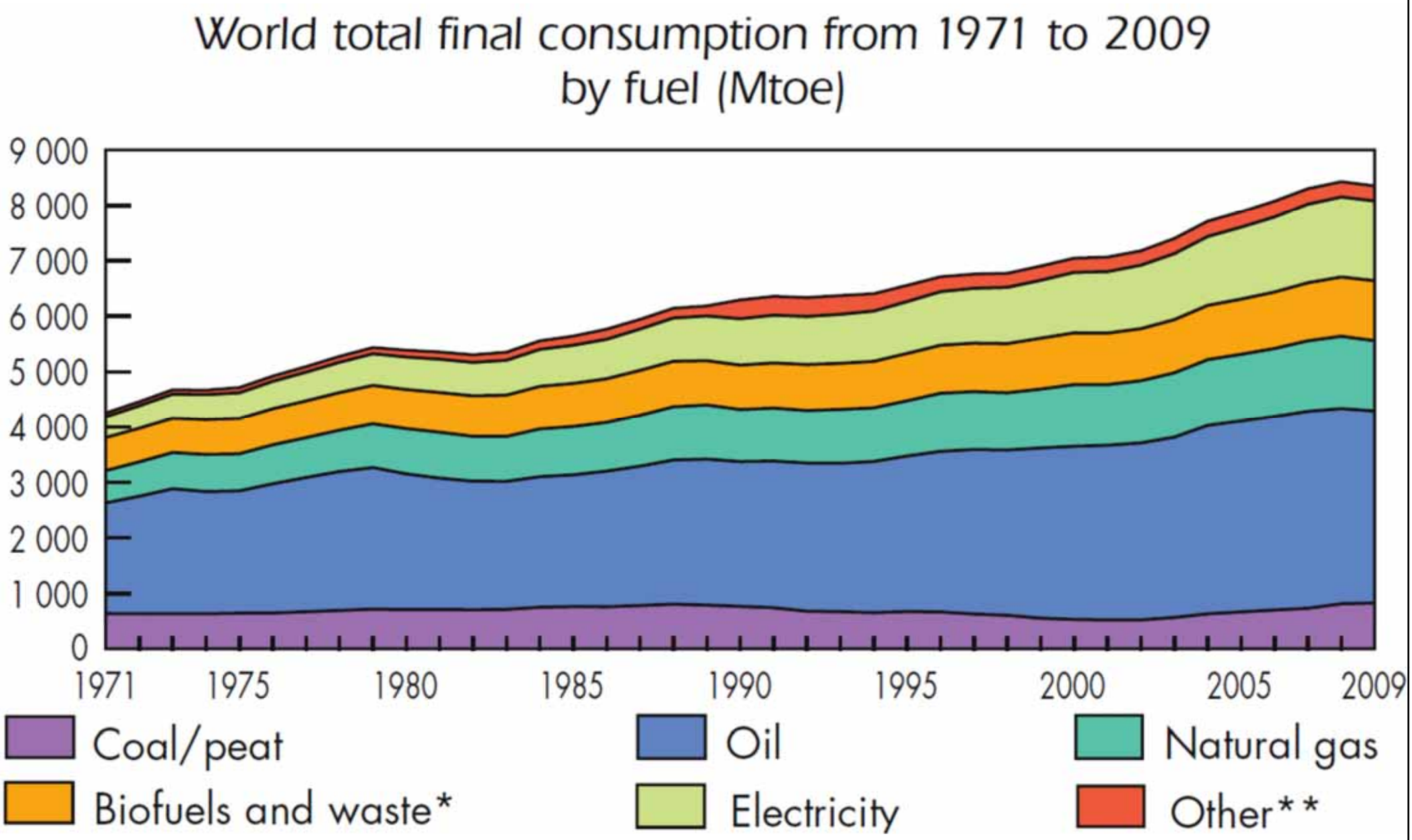
Introduction

- **Energy** is important to every society
  - Economic, environmental & social impacts
  - It is also a key issue for ***sustainable development***
- Use energy …
  - Consume finite fossil fuels (oil, coal, natural gas)
  - Cause air pollution & environmental damage
  - Contribute to global warming
  - Cost money

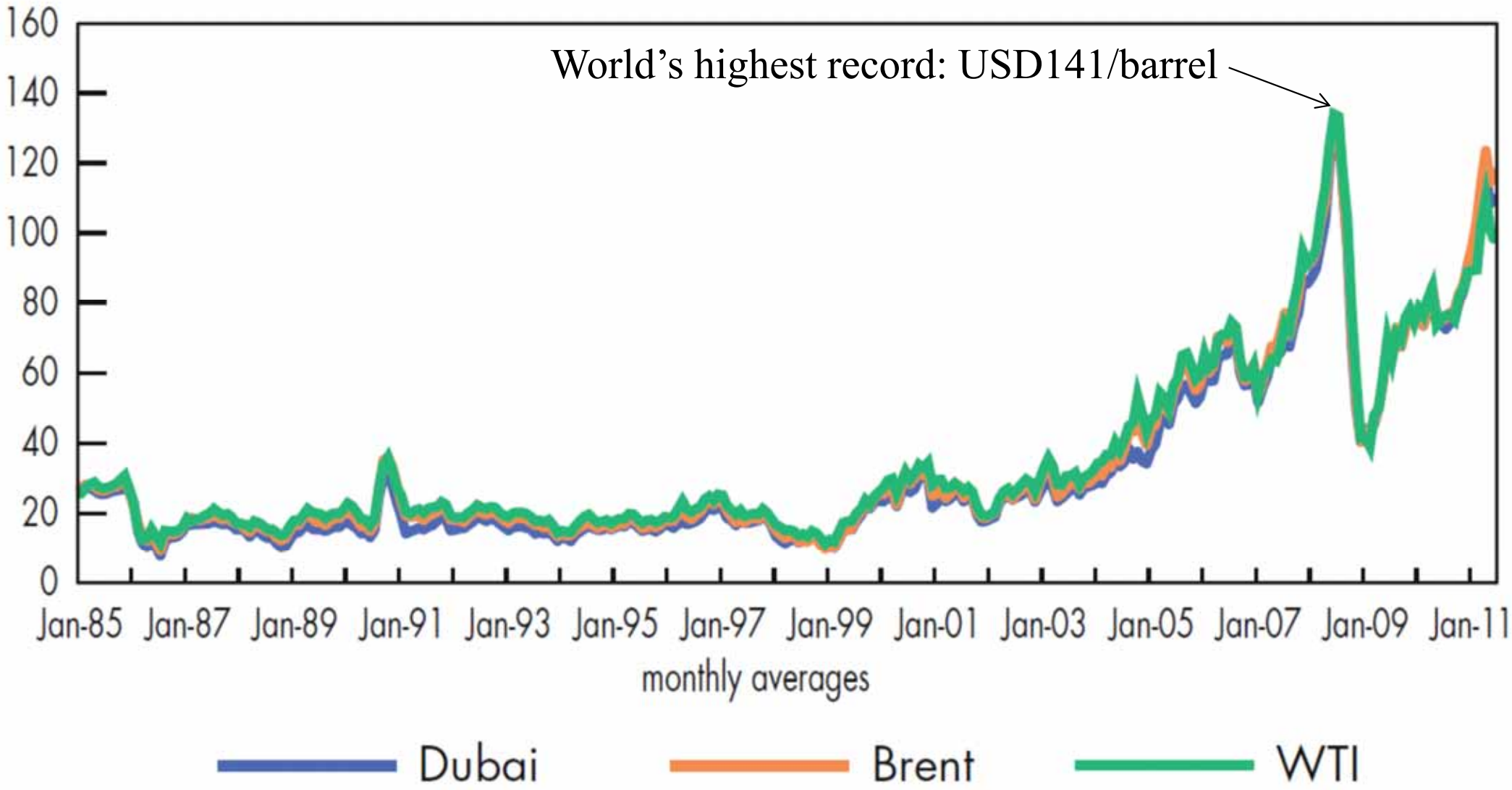
3 ‘E’ Relationships





(* Source: IEA, 2011. *Key World Energy Statistics 2011*, International Energy Agency, Paris. Available at www.iea.org)

Key crude oil spot prices in USD/barrel



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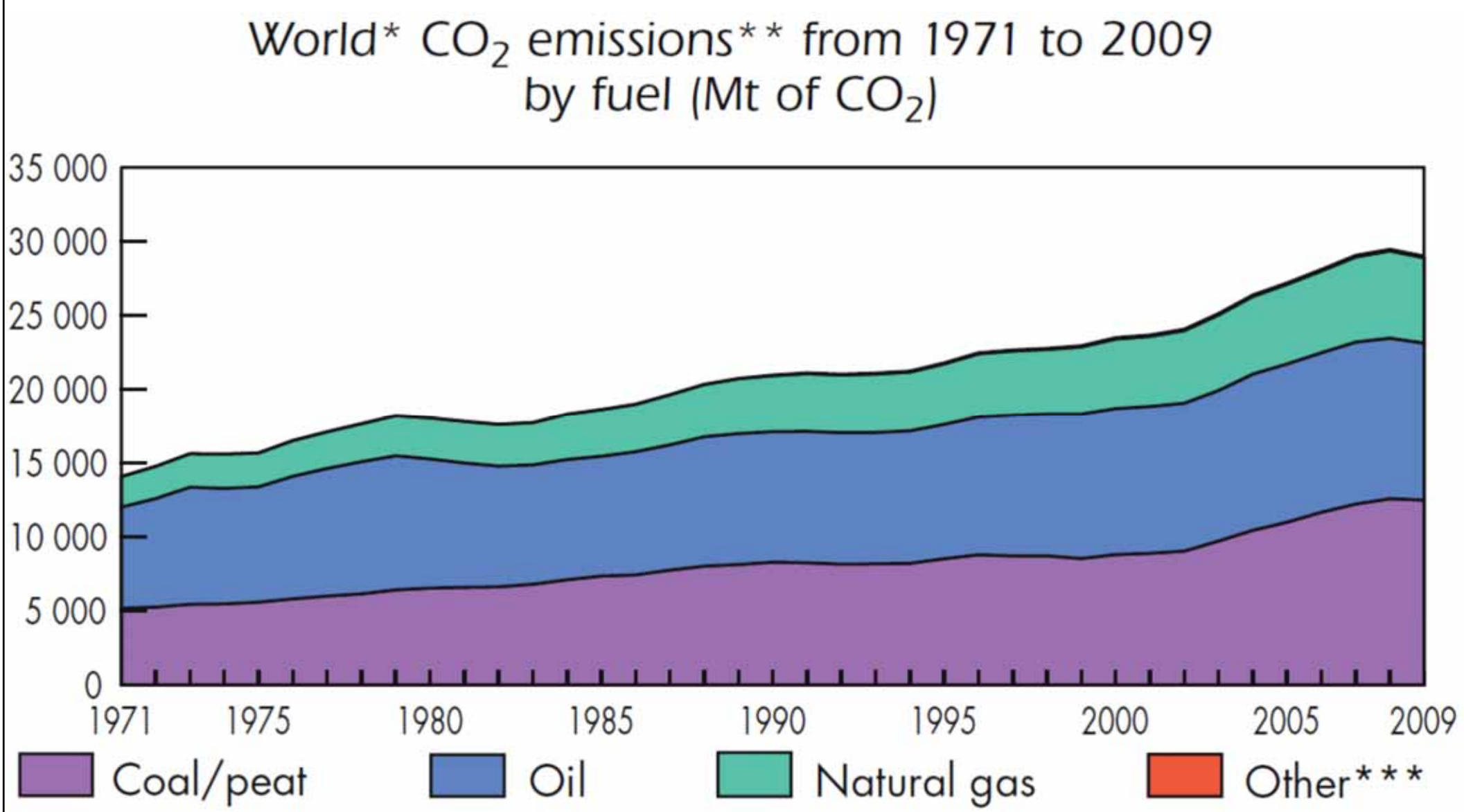


***Other includes industrial waste and non-renewable municipal waste

(* Source: IEA, 2011. *Key World Energy Statistics 2011*, International Energy Agency, Paris. Available at www.iea.org)

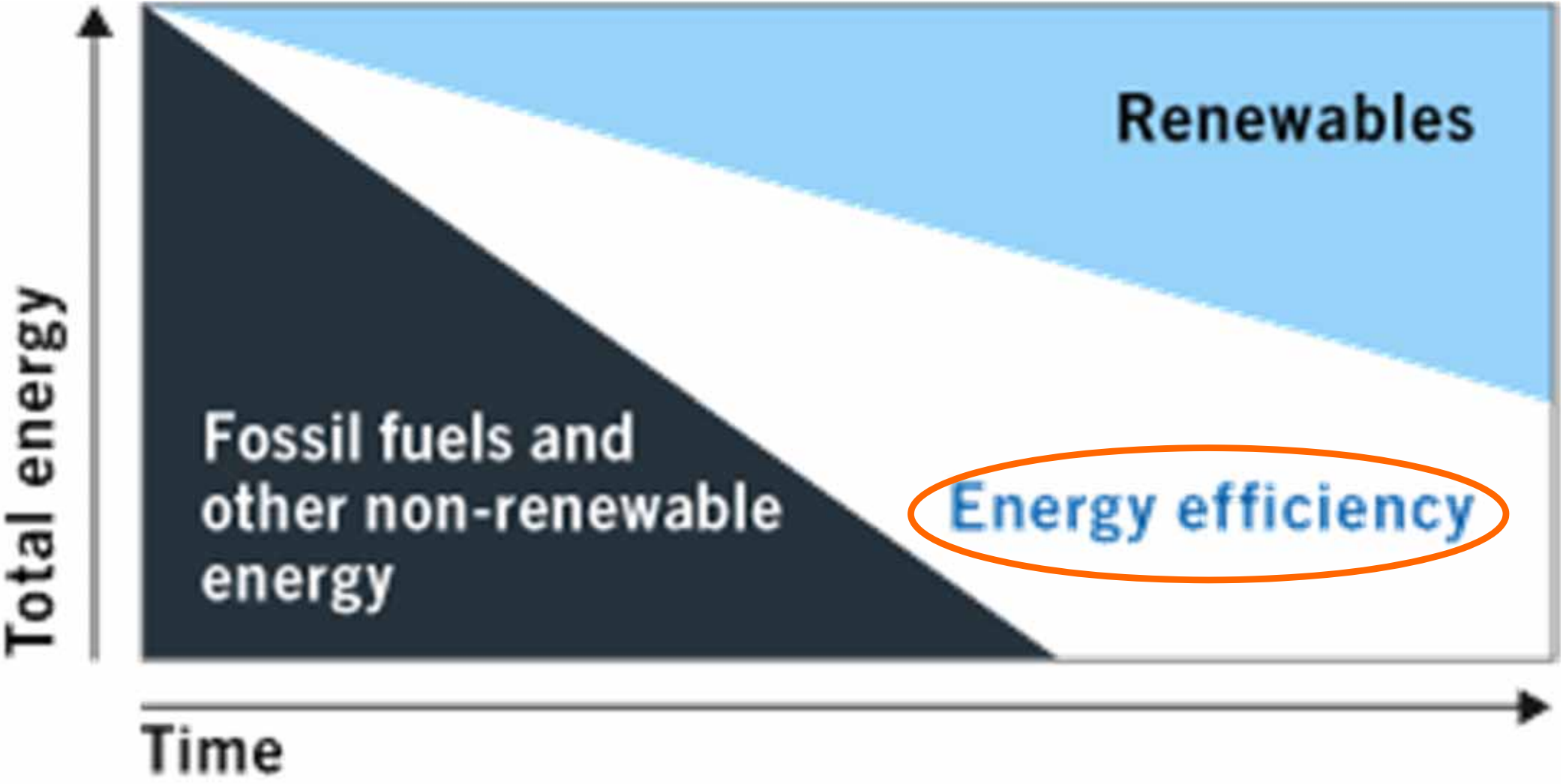
Introduction

- A growing demand for energy
  - Increase of population and living standard
  - Fast urbanization and building developments
- High energy costs and environmental concerns drive efficiency
  - Increasing energy prices and volatility
  - Climate change and greenhouse gas emissions
  - Global momentum for better energy efficiency

Introduction

- The "negawatts" contributed by **energy efficiency** is as valuable in economic terms as the "produced watts" of energy they replaced
- With today's energy prices, a negawatt of energy savings costs about half of what it costs to produce the same amount of energy
- The cheapest, most competitive, cleanest and most secure form of energy remains saved energy

Energy efficiency provides us with the time needed to replace fossil fuels and other non-sustainable energy sources with renewables in an ecological, economic and socially responsible manner



(Source: www.eceee.org)

Energy indicators for 2009

Economy	**Population** (million)	**GDP/pop** (yr2000 USD)	**TPES/pop** (toe/ capita)	**TPES/GDP** (toe/yr2000 USD)	**CO_2/pop** (t CO_2/ capita)	**CO_2/GDP** (kg CO_2/ yr2000 USD)
World	6761	5.87	1.80	0.31	4.29	0.73
China	1331	2.21	1.70	0.77	5.13	2.33
India	1155	0.76	0.58	0.77	1.37	1.81
USA	307	36.94	7.03	0.19	16.9	0.46
Japan	127	38.26	3.71	0.10	8.58	0.22
Germany	82	24.41	3.89	0.16	9.16	0.38
Hong Kong	7	33.05	2.13	0.06	6.51	0.2
Singapore	5	28.75	3.70	0.13	8.99	0.31

(* Extracted from: IEA, 2011. *Key World Energy Statistics 2011*, International Energy Agency, Paris. Available at www.iea.org)

Introduction

- Why energy indicators for Hong Kong are low?
  - High population density (compact city)
  - Service-oriented (few industries & manufacturing)
  - No oil refinery (e.g. in Singapore)
  - Extensive use of public transportation
- Is Hong Kong doing well in energy efficiency?
  - Not really. Many examples of energy inefficiency can be found. Need to examine the actual situation and identify areas for improvement.

Hong Kong

Building energy use

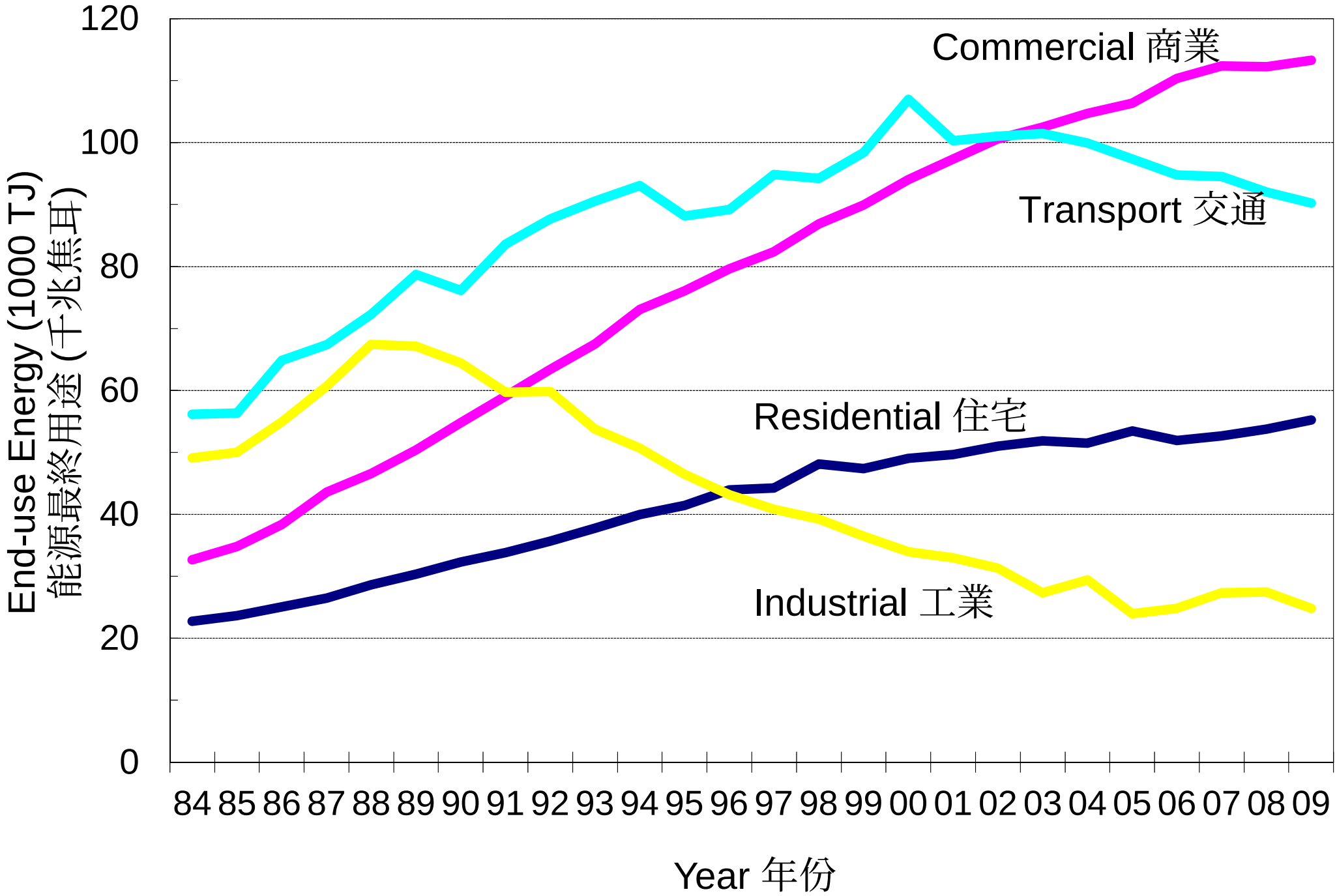
- Buildings constitute 60% of energy needs
  - Residential + commercial + industrial
  - The potential for energy saving is large
- In past decades, fast growing energy demand in commercial and residential sectors
  - Growth of service industries in HK (e.g. financial, trade, professional services)
  - Increase of population and living standard

Table 1 - Final energy requirements (FER) in Hong Kong (year 2010)

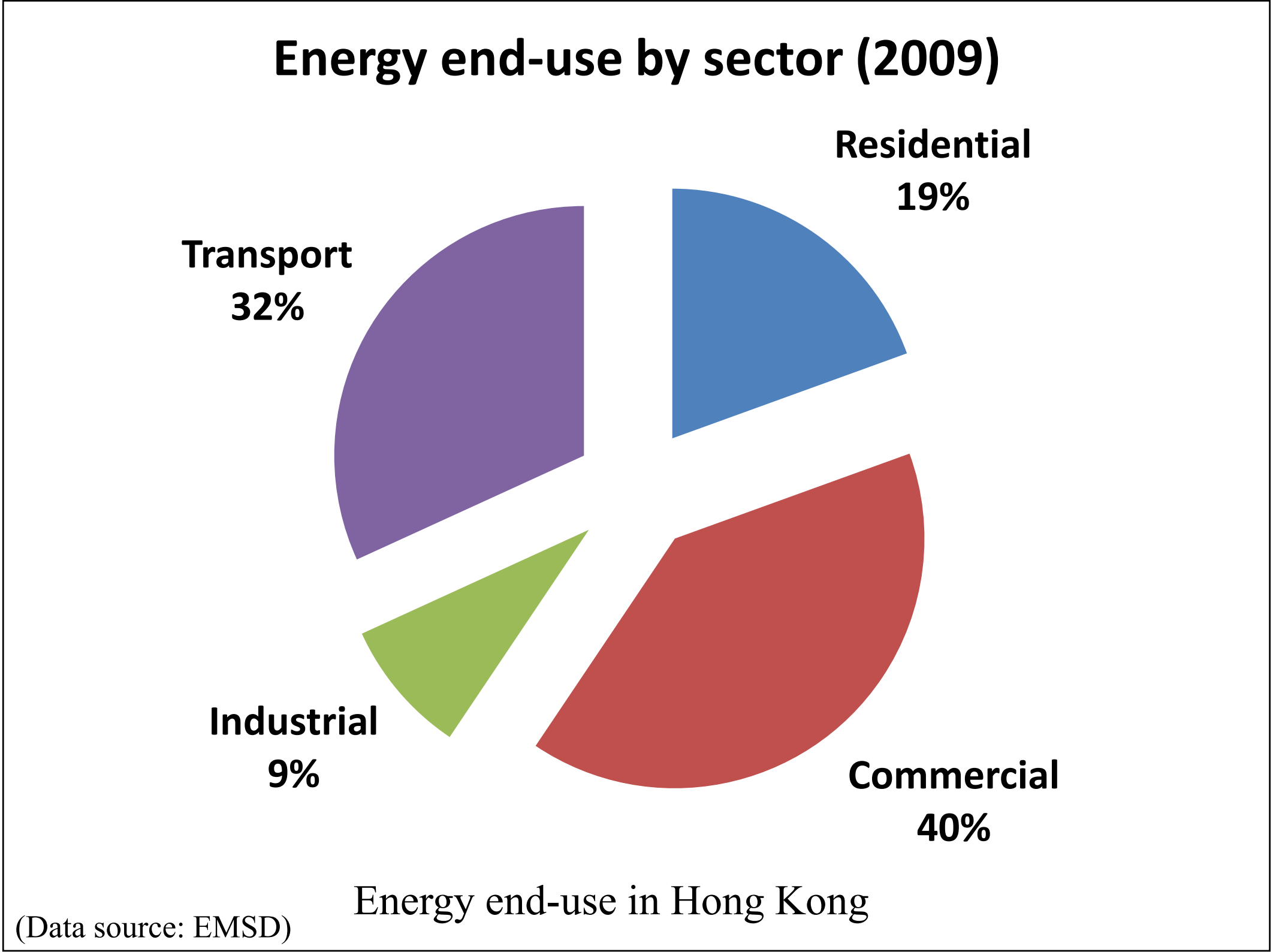
Unit: MJ	**Commercial**	**Residential**	**Industrial**	**Total**
Electricity	100 280 (67%)	39 344 (26%)	11 080 (7%)	150 705 (100%)
Town gas	11 389 (41%)	15 272 (55%)	917 (3%)	27 578 (100%)
Elec. + town gas	111 669	54 616	11 997	178 283
% in total FER	37.5%	18.4%	4.0%	59.9%

Total FER for 2010 = 297 488 TJ

(* Data Source: *Hong Kong Energy Statistics 2010 Annual Report*)

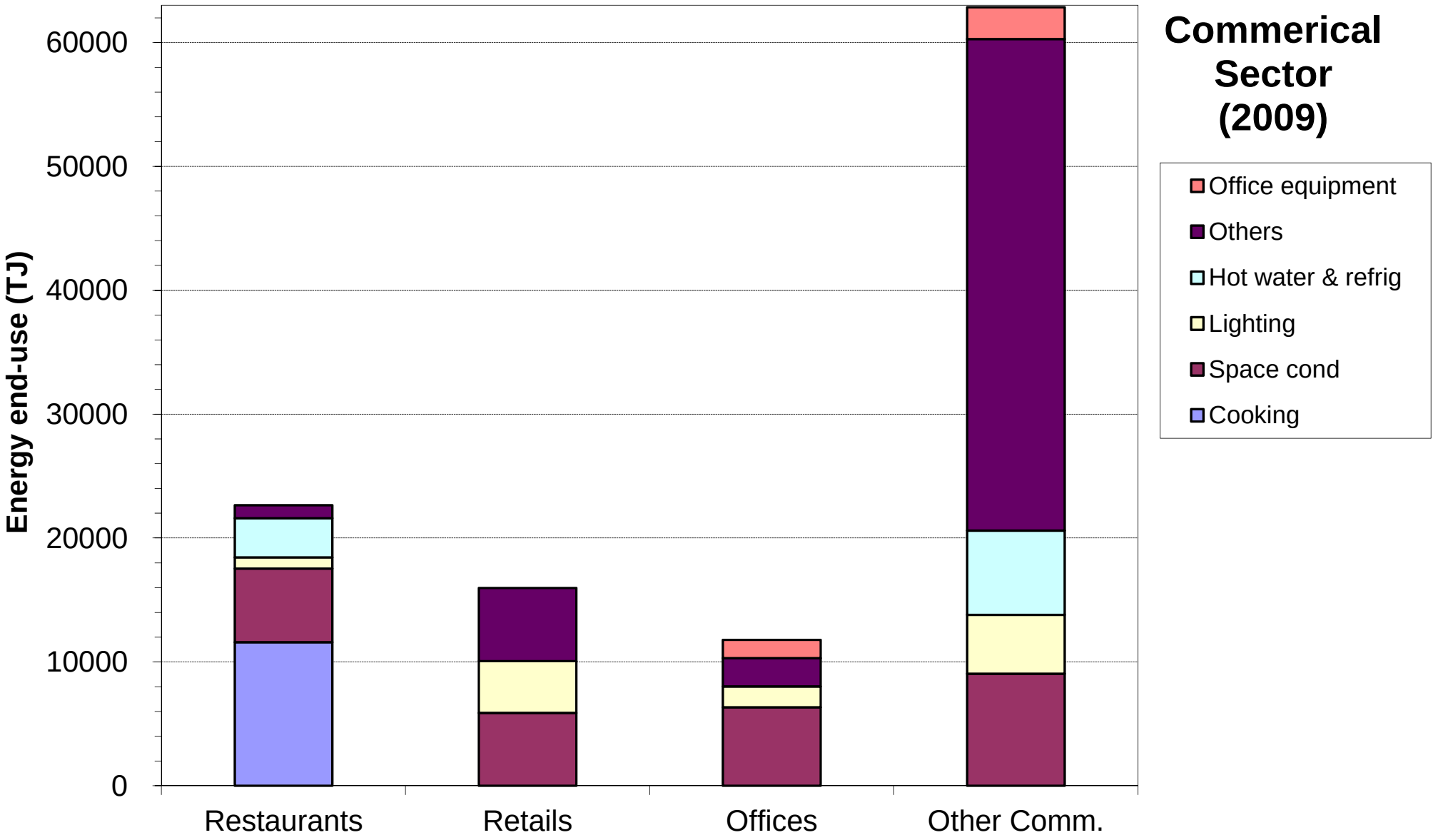


(Data source: EMSD) Energy end-use in Hong Kong by sectors, 1984-2009

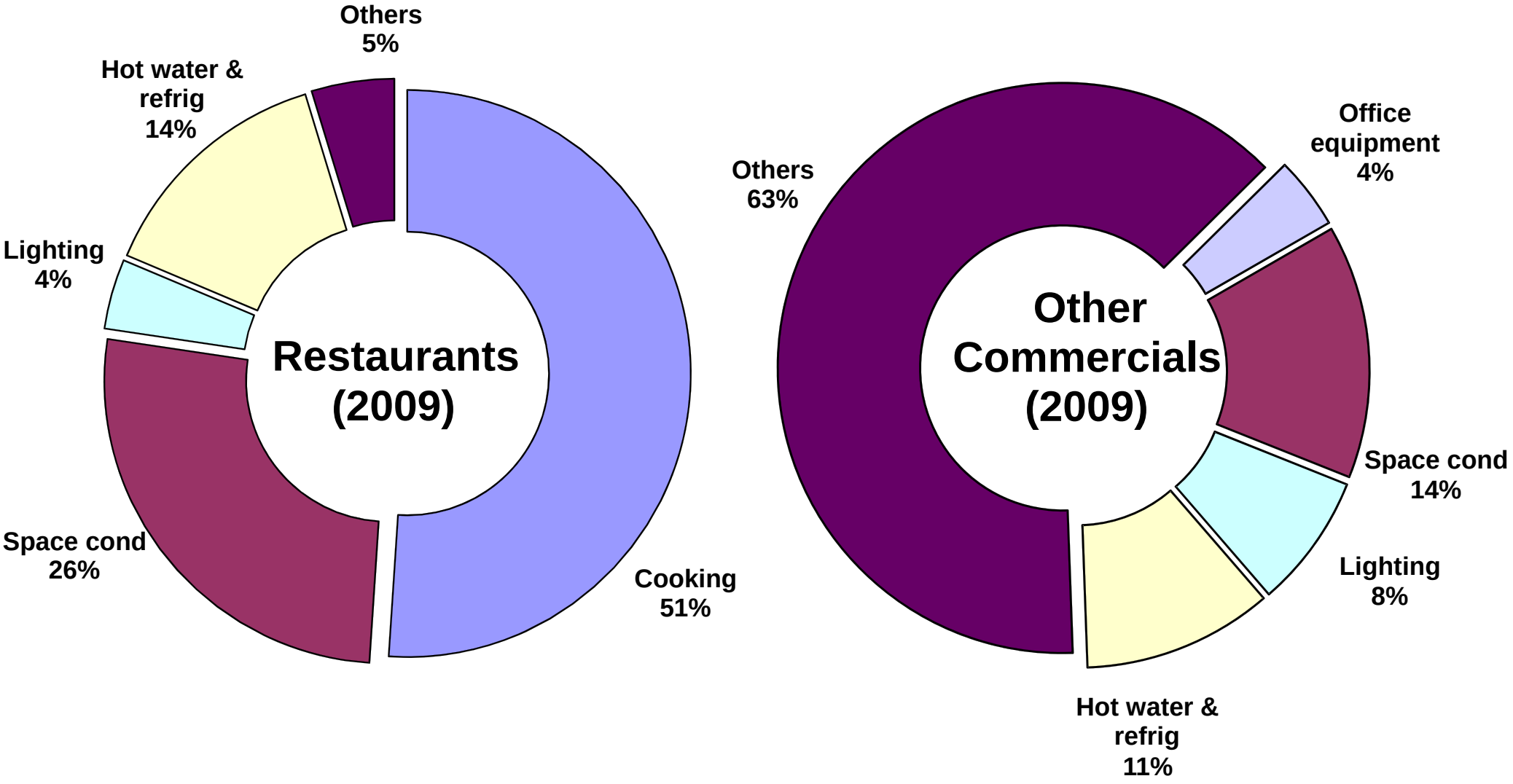


Energy end-use in Hong Kong

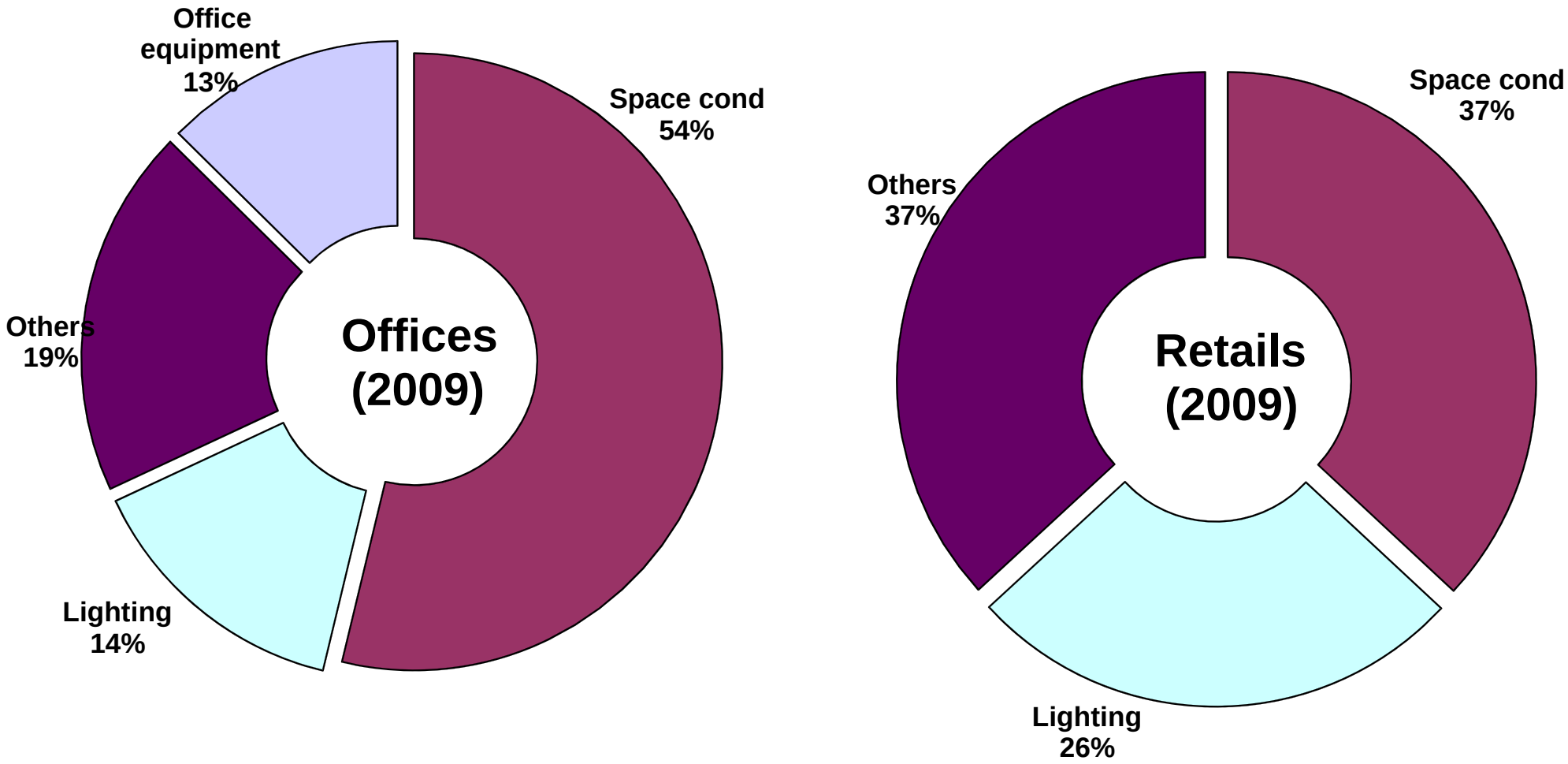
(Data source: EMSD)



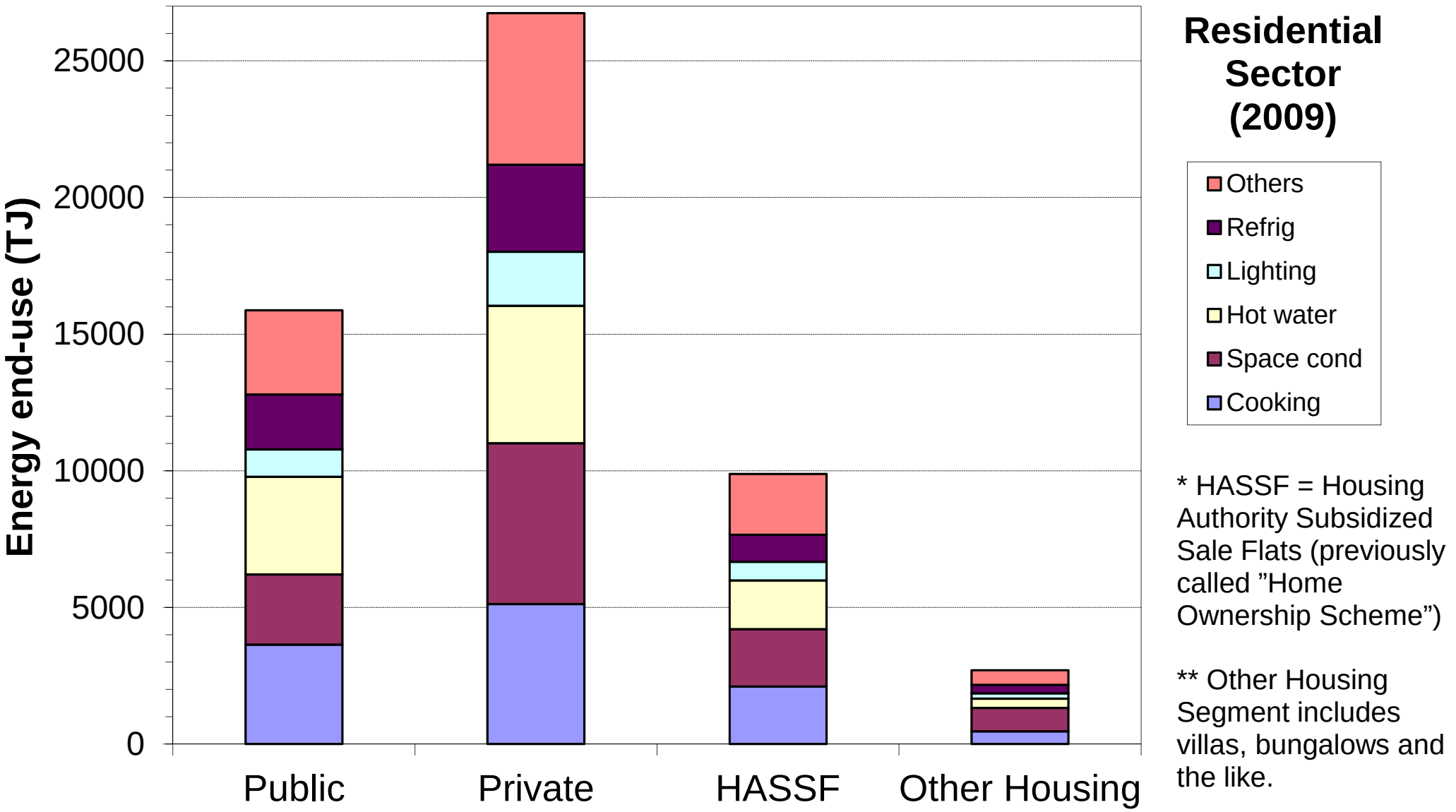
Energy end-use in commercial sector, 2009
(Data source: Energy Efficiency Office, HK)



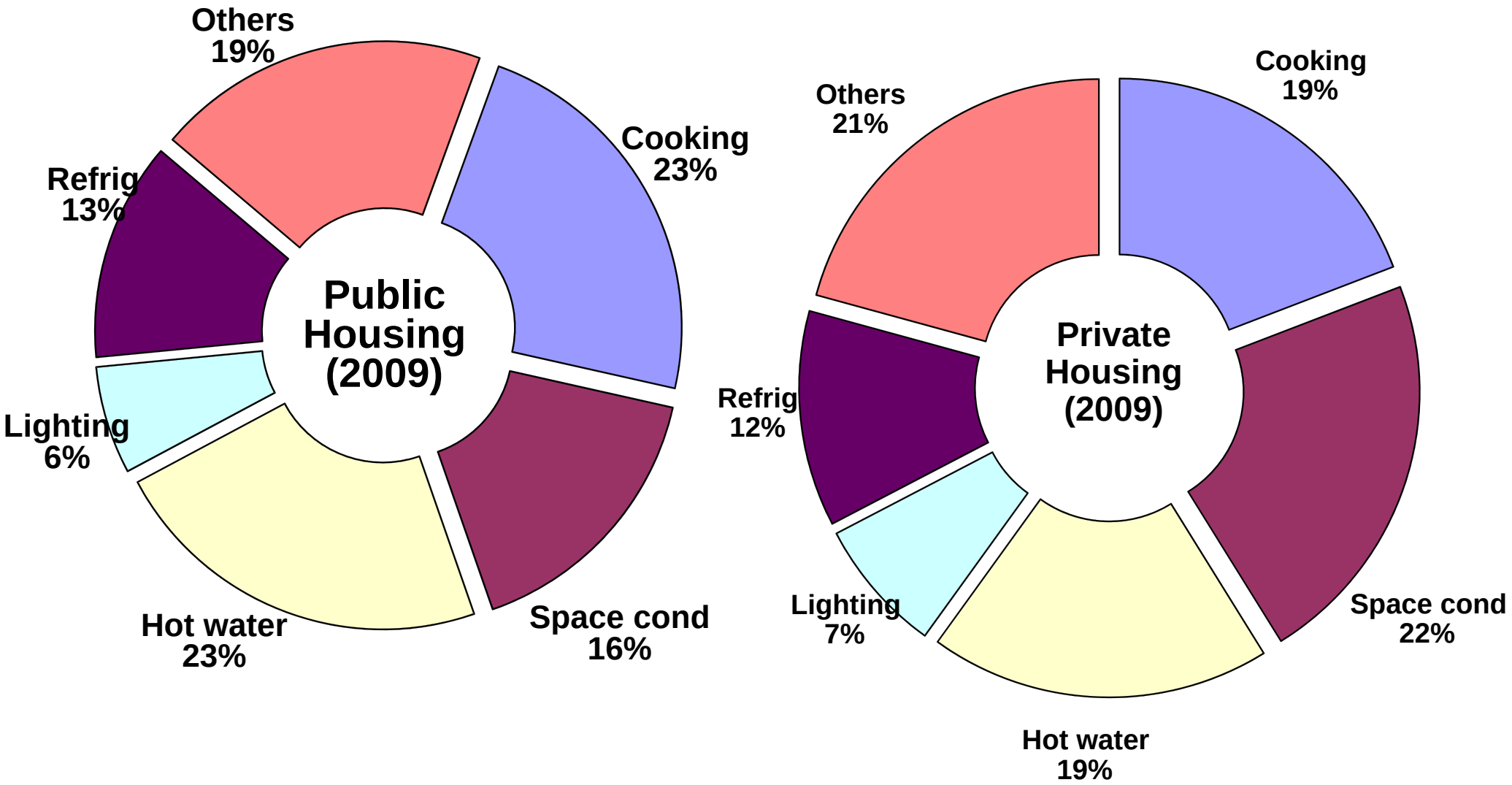
Energy consumption patterns in other commercial buildings
(Data source: Energy Efficiency Office, HK)



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



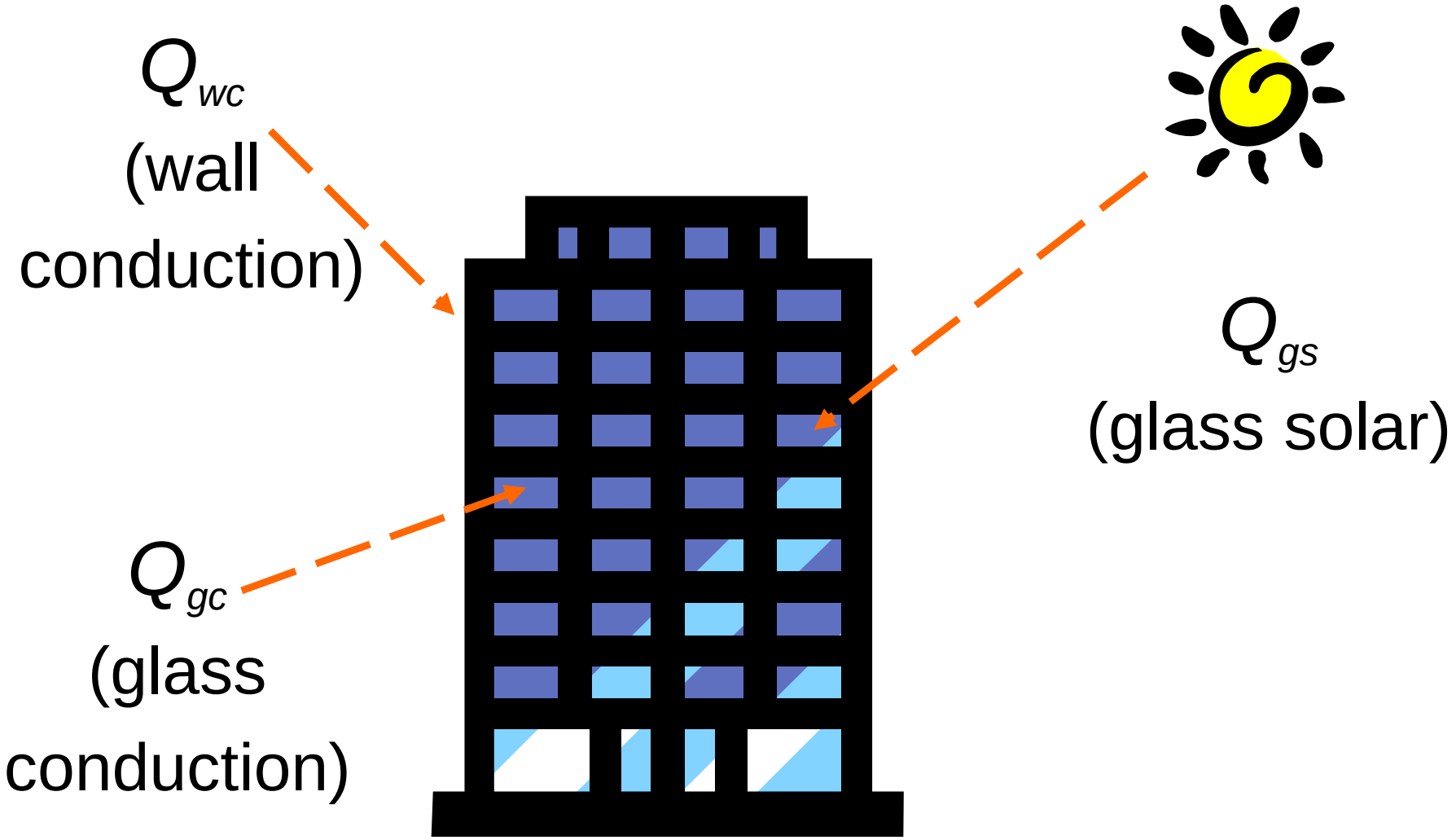
Energy end-use in residential sector, 2009
(Data source: Energy Efficiency Office, HK)



Energy consumption patterns in residential buildings
(Data source: Energy Efficiency Office, HK)

Energy efficiency codes

- First energy efficiency regulation in HK
  - *Building (Energy Efficiency) Regulation*, Cap. 123 sub. Leg. M [implemented in July 1995]
    - http://arch.hku.hk/research/BEER/bee-reg.htm
  - Using Overall Thermal Transfer Value (OTTV) method for building envelope design control
    - www.bd.gov.hk/english/documents/code/e_ottv.htm
  - Applied mainly to commercial buildings and hotels; requirements revised in 2000 and 2011
    - Building tower: OTTV $\leq$ 24 W/m^2; podium: OTTV $\leq$ 56 W/m^2



$$OTTV_i = \frac{Q_{wc} + Q_{gc} + Q_{gs}}{A_i}$$

$$= \frac{(A_w \cdot U_w \cdot TD_{eq}) + (A_f \cdot U_f \cdot DT) + (A_f \cdot SC \cdot SF)}{A_i}$$

Energy efficiency codes

- OTTV equation for Hong Kong:

$$OTTV_i = \frac{(A_w \cdot U_w \cdot \alpha \cdot TD_{eq}) + (A_f \cdot SC \cdot ESM \cdot SF)}{A_i}$$

- Two major differences from the general form:
  - Glass conduction term was omitted
  - Solar absorptivity and external shading multipler were introduced

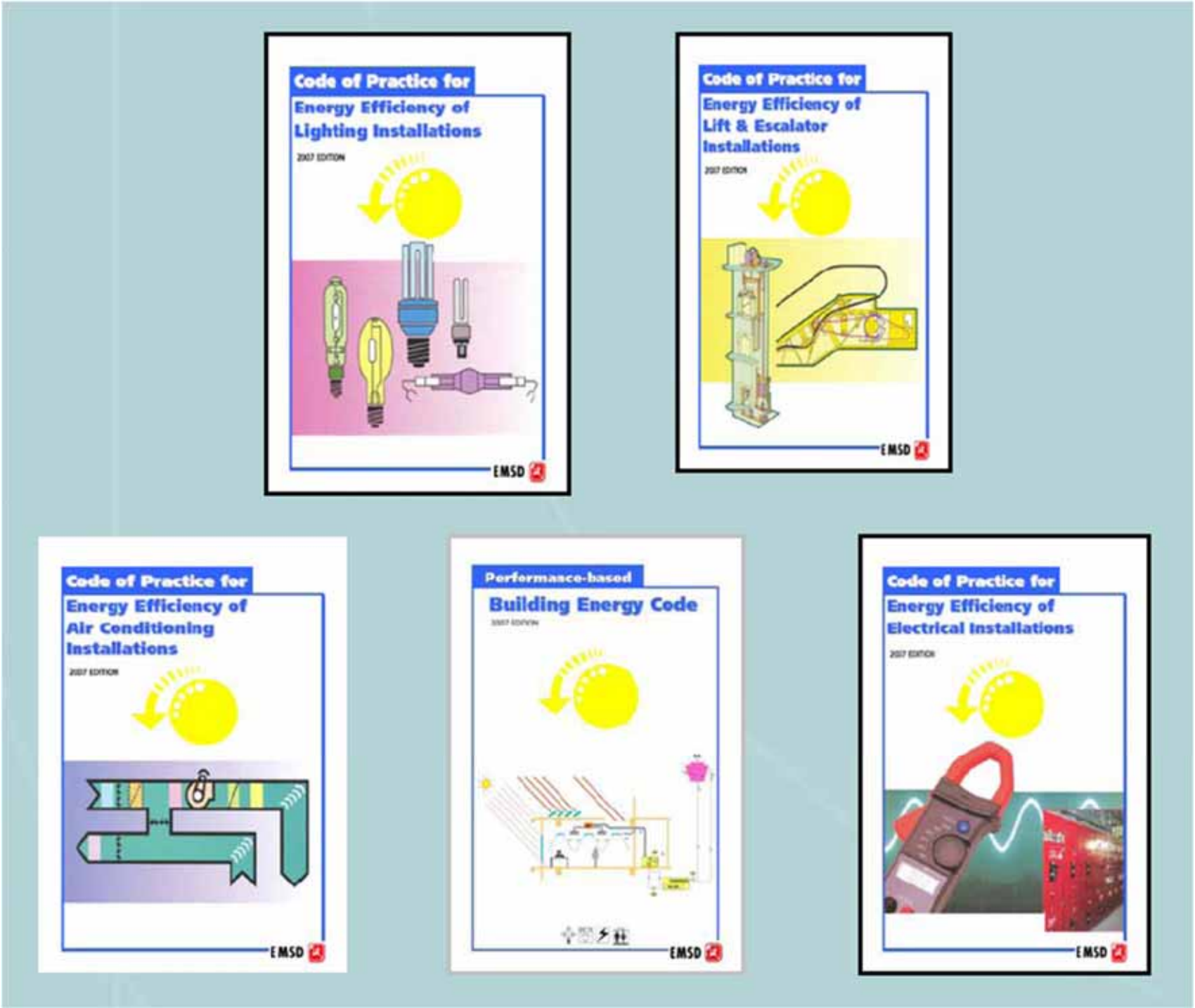
Energy efficiency codes

- HK Building Energy Codes (BEC)
  - Lighting
  - Air-conditioning
  - Electrical
  - Lifts & escalators

  } Prescriptive

  - Performance-based code

- Previously under Hong Kong Energy Efficient Building Registration Scheme (HKEEBRS)
  - Become mandatory in 2011



Building Energy Codes in Hong Kong

(Source: www.emsd.gov.hk)

Building energy codes in Hong Kong

Energy Code	Date Implemented	Scope
OTTV	Jul 1995 (Mandatory)	Comm bldgs & hotels
Lighting	Jul 1998 (Voluntary)*	All bldgs except domestic, indust. & medical
Air conditioning	Jul 1998 (Voluntary)*	All bldgs except domestic, indust. & medical
Electrical	Feb 1999 (Voluntary)*	All buildings
Lifts & escalators	Dec 1999 (Voluntary)*	All buildings
Performance-based code	2004 (Voluntary)*	Comm bldgs & hotels

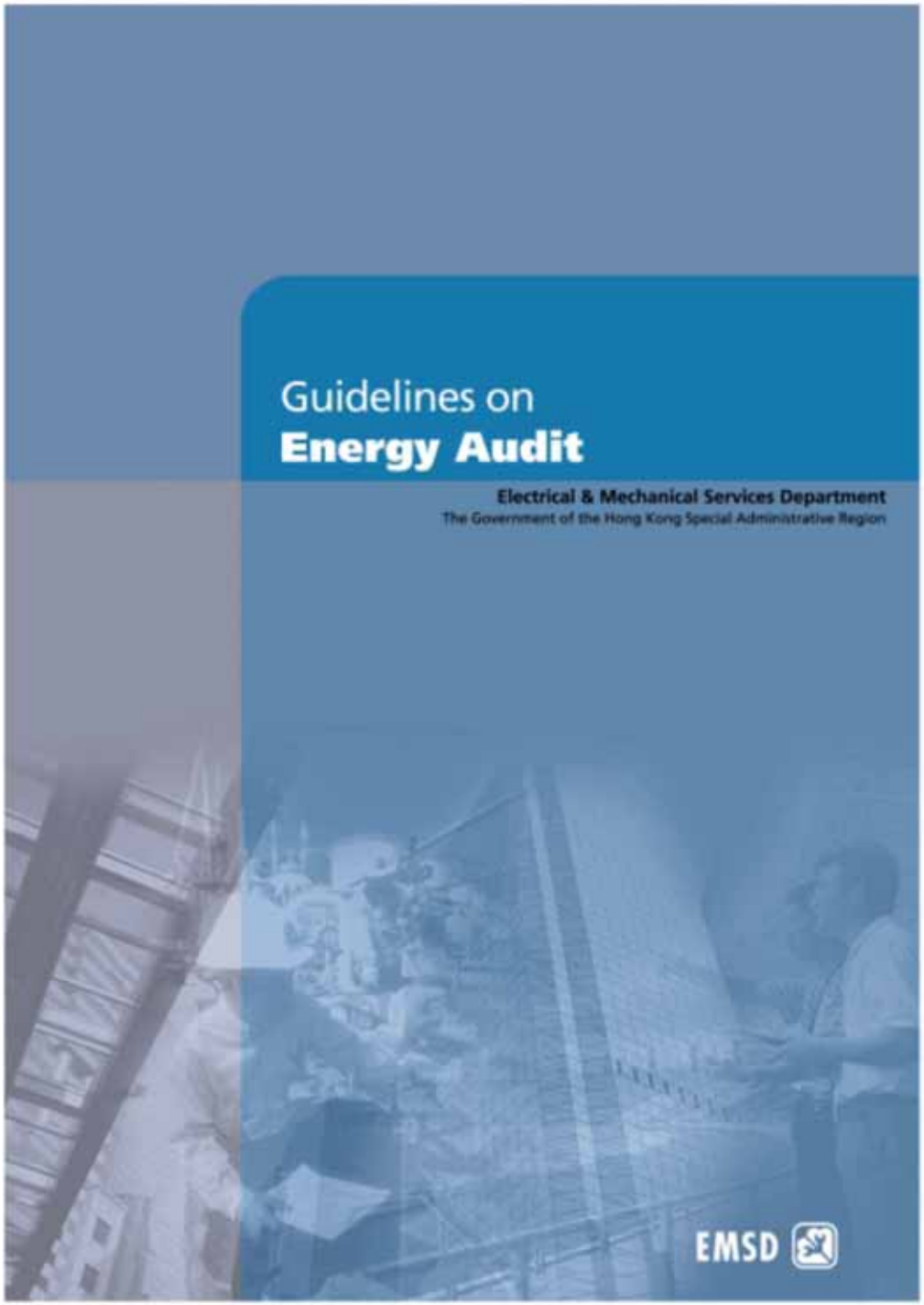
* Become mandatory in 2011 under the *Buildings Energy Efficiency Ordinance*.
(See www.emsd.gov.hk/emsd/eng/pee/mibec.shtml for details)

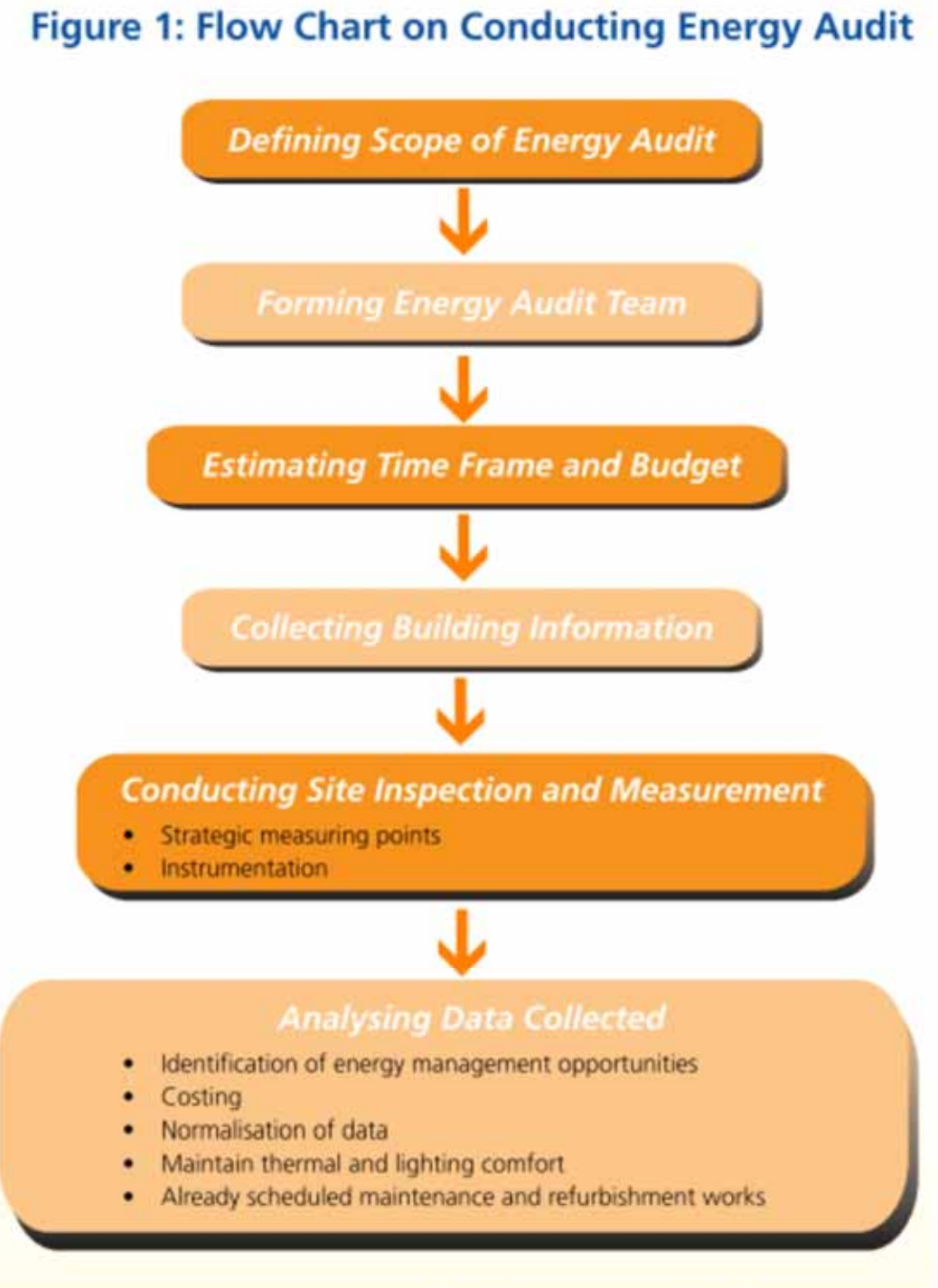
Energy efficiency codes

- The Buildings Energy Efficiency Ordinance (BEEO) (Cap. 610) had been enacted in November 2010 and will come into full operation on 21 September 2012
  - Mandatory implementation of Building Energy Code (BEC) in prescribed buildings
  - Mandatory implementation of energy audit according to the Energy Audit Code (EAC) in commercial buildings and portions of composite buildings that are for commercial use

Energy efficiency codes

- Building Energy Code (BEC)
  - Stipulates the minimum energy efficiency design standards for 4 key types of building services installations (air-conditioning, electrical, lighting and lift & escalator installations)
- Energy Audit Code (EAC)
  - Stipulates the minimum technical requirements of energy audit for 4 key types of central building services installations (air-conditioning, electrical, lighting and lift & escalator installations)

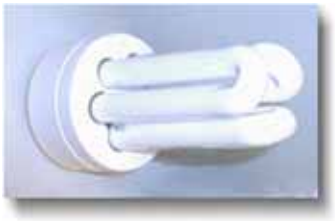




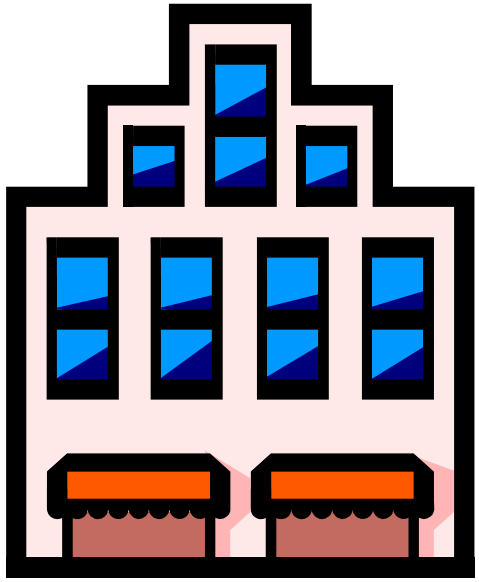
Guidelines on energy audit in Hong Kong

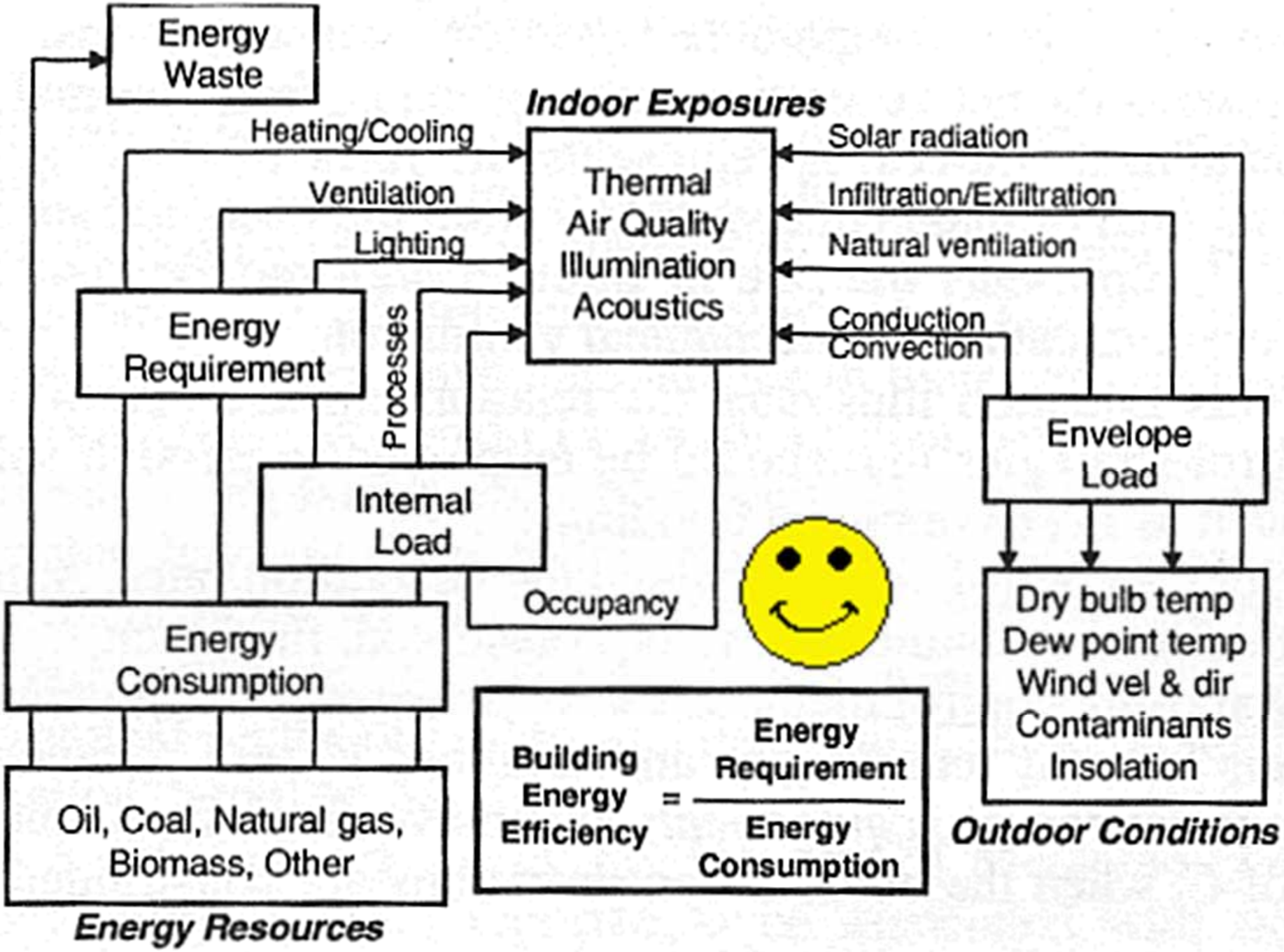
(Source: EMSD)

Key factors



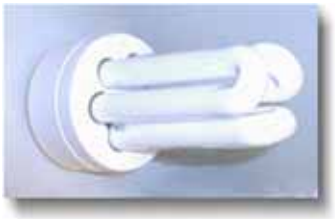
- For new buildings
  - Designing the building
    - Design strategy
    - Control strategies
    - Commissioning
- For existing buildings
  - Operating and upgrading the building
    - Building management
    - Refurbishment/renovation/retrofitting
    - Maintenance and monitoring



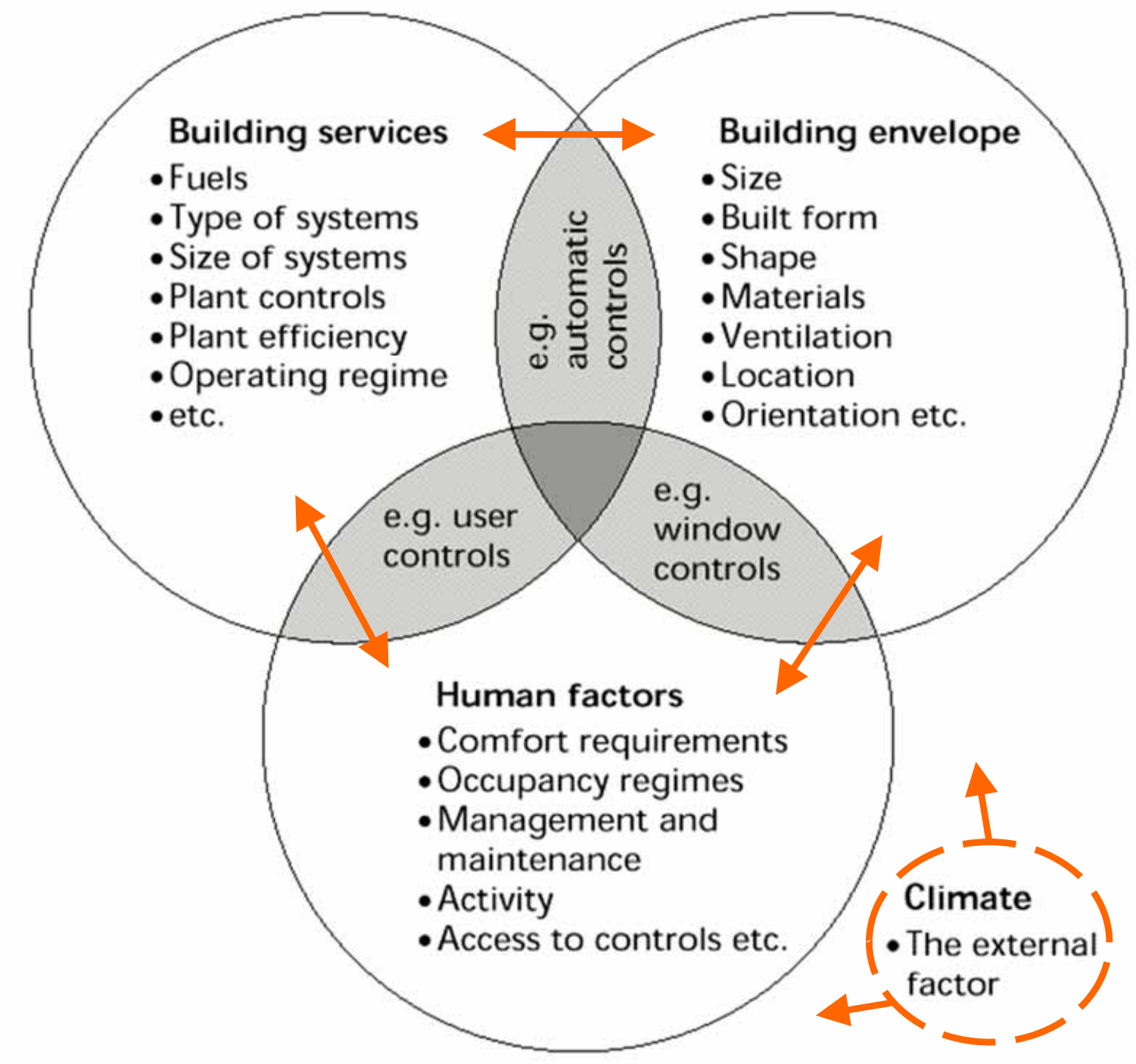


Energy flow and concept in buildings

Key factors

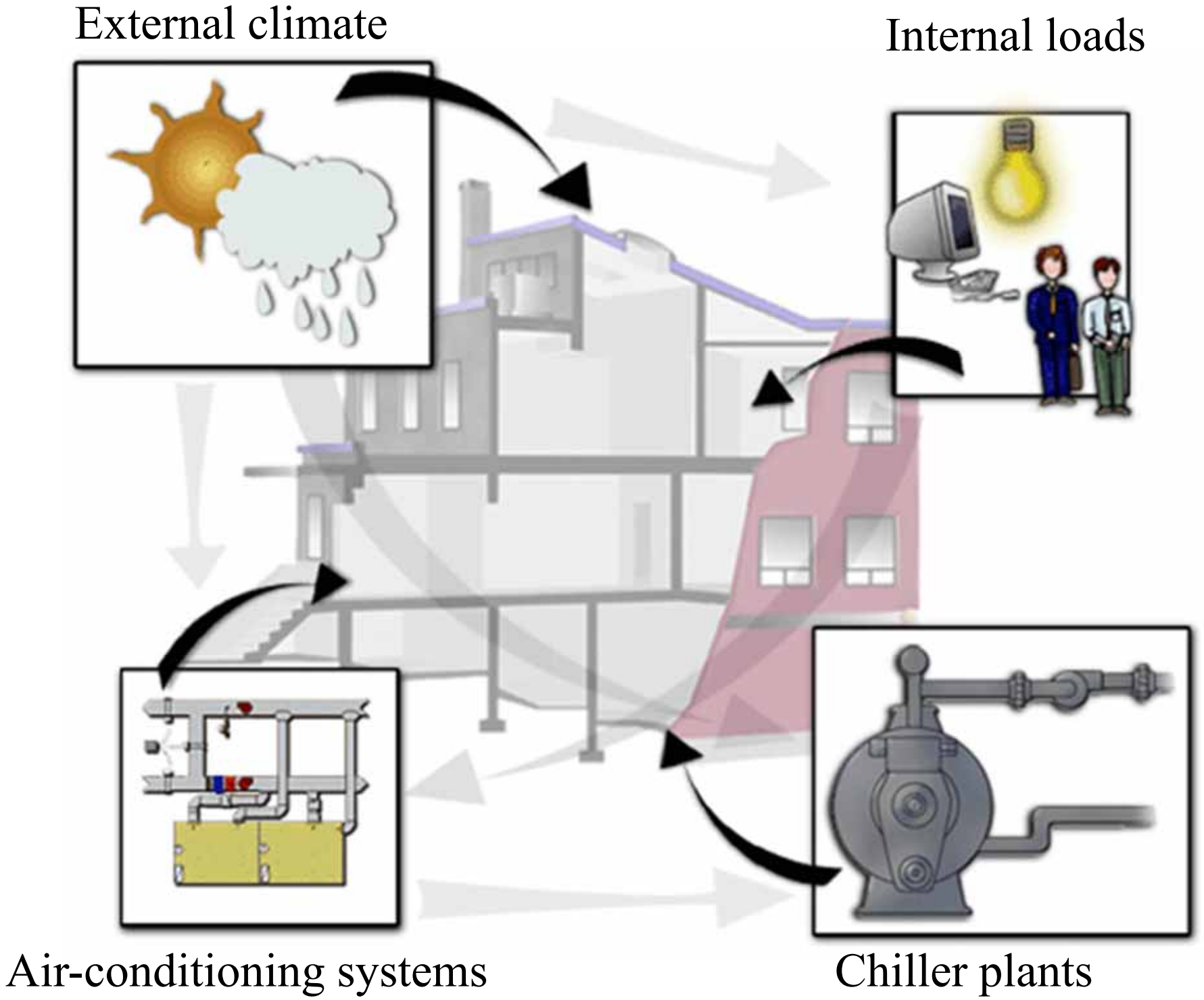


- Efficient use of energy
  - Reduce energy consumption
  - Optimise building's performance
- Three types of energy efficiency measures
  - No-cost/low-cost: require no investment appraisal
  - Medium cost: require only a simple payback calculation
  - High capital cost: require detailed design and a full investment appraisal



Key factors influencing energy consumption

(Source: Energy Efficiency in Buildings: CIBSE Guide F)


External climate
Internal loads
Air-conditioning systems
Chiller plants

Good design practices

Integrated & total energy approach

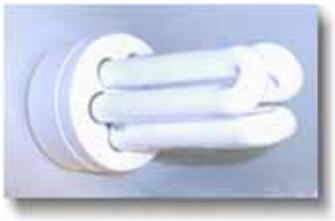
Efficient systems

Good house-keeping

User education & awareness

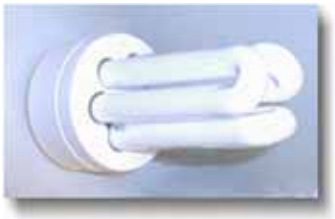
Efficient operation

Key factors

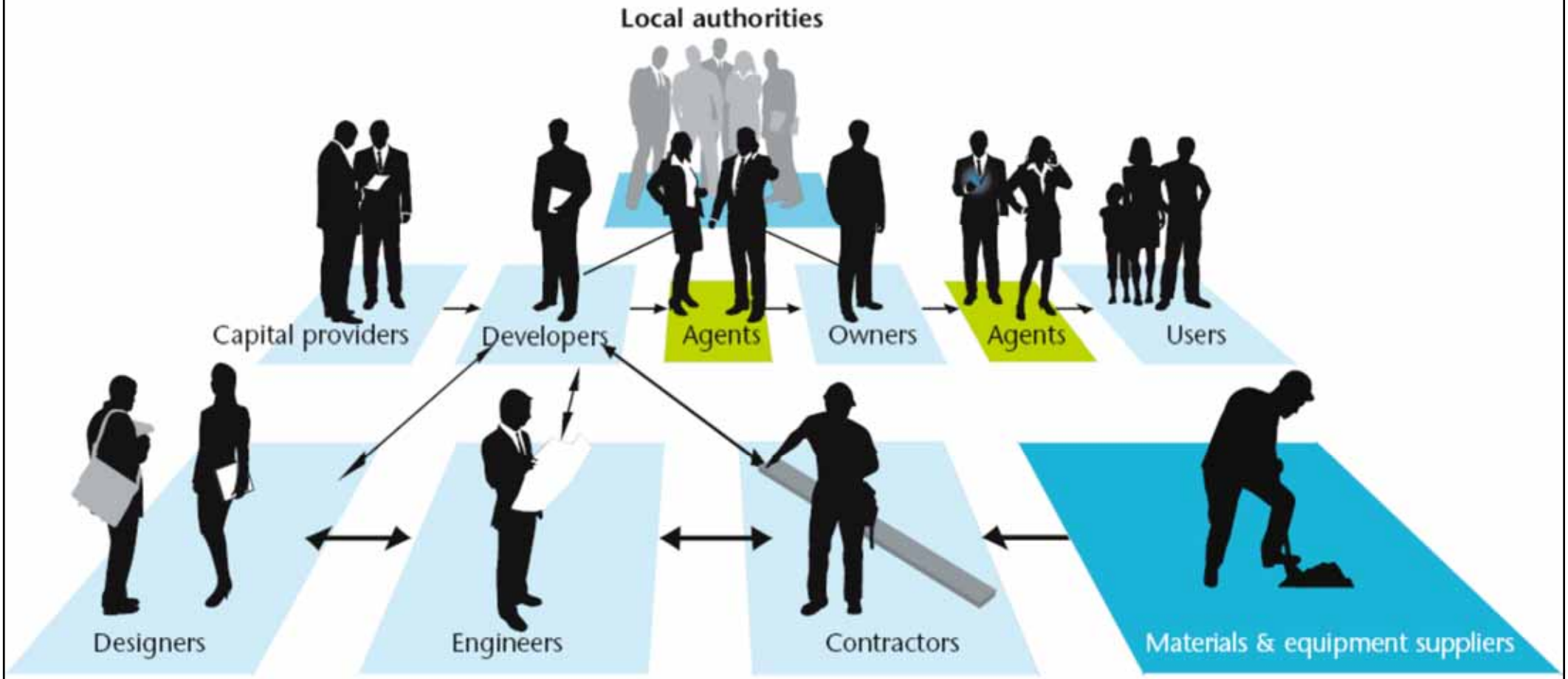


- Wider benefits from energy efficiency:
  - Improved building design and operation
  - Better working environment and comfort
  - Life-cycle cost savings
  - Added market value of buildings
  - Reduced capital cost by better integration of building fabric and systems
  - Reduced CO_2 emissions and consumption of finite fossil fuels

Key factors



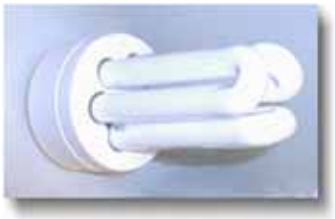
- Barriers to achieving energy efficiency
  - Insufficient information
  - Insufficient finance for efficiency improvement
  - Split incentives and interests (developers/tenants)
  - User's lifestyle choices
  - Multiple decision makers & complex value chain
- Key persons in building energy efficiency
  - Building developer (Client), architect, building engineer, facility manager, end-users



The complex value chain in the building sector

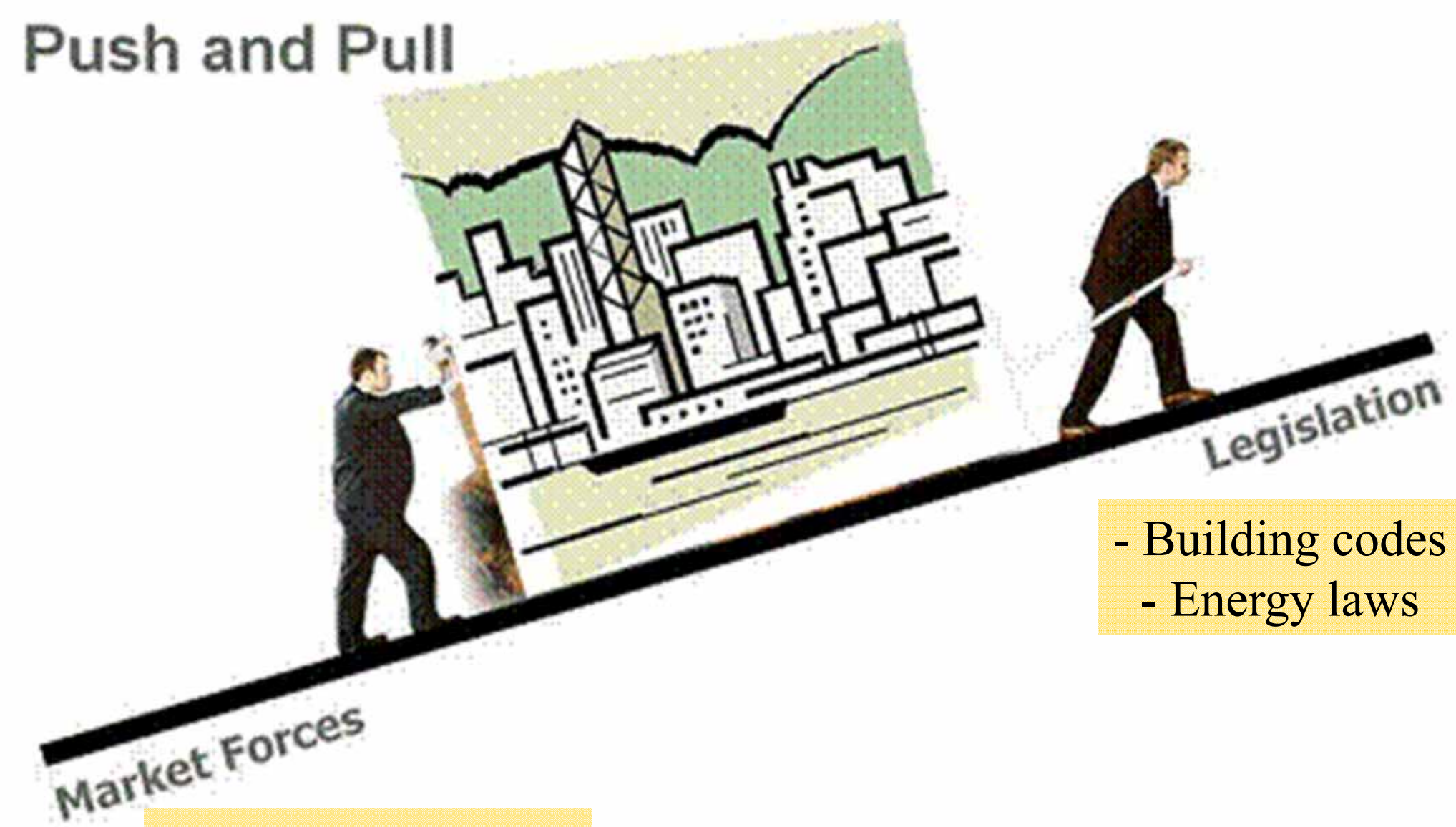
(Source: World Business Council for Sustainable Development, www.wcbsd.org)

Key factors



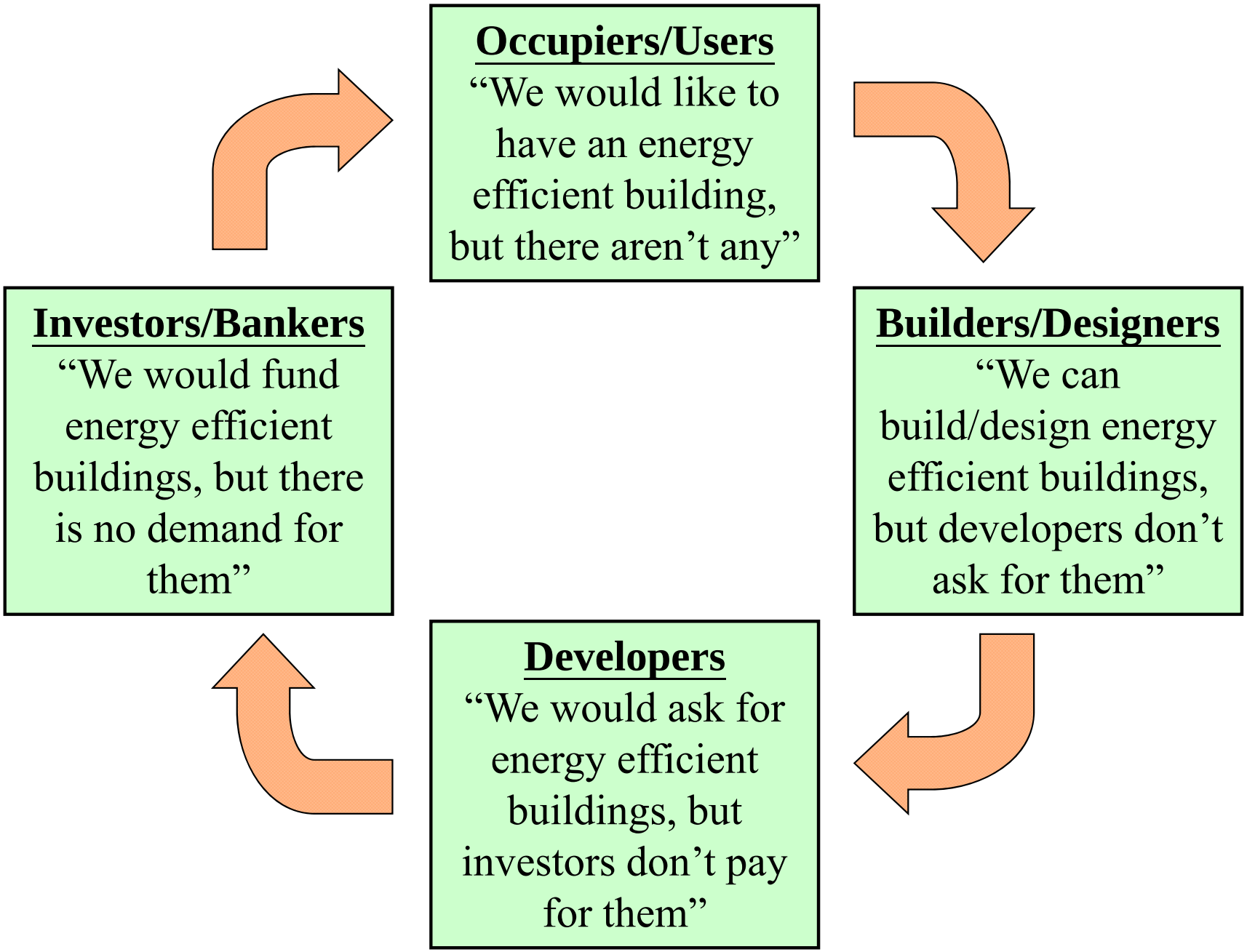
- Strategy for promoting energy efficiency
  - Legislation (**PULL**)
    - Building codes, energy laws
  - Market forces (**PUSH**)
    - Improve awareness & information
- Reverse the vicious circle
  - Change market behaviour & overcome barriers
  - Increase investments in energy efficiency measures among the stakeholders

Strategy for promoting energy efficiency in buildings

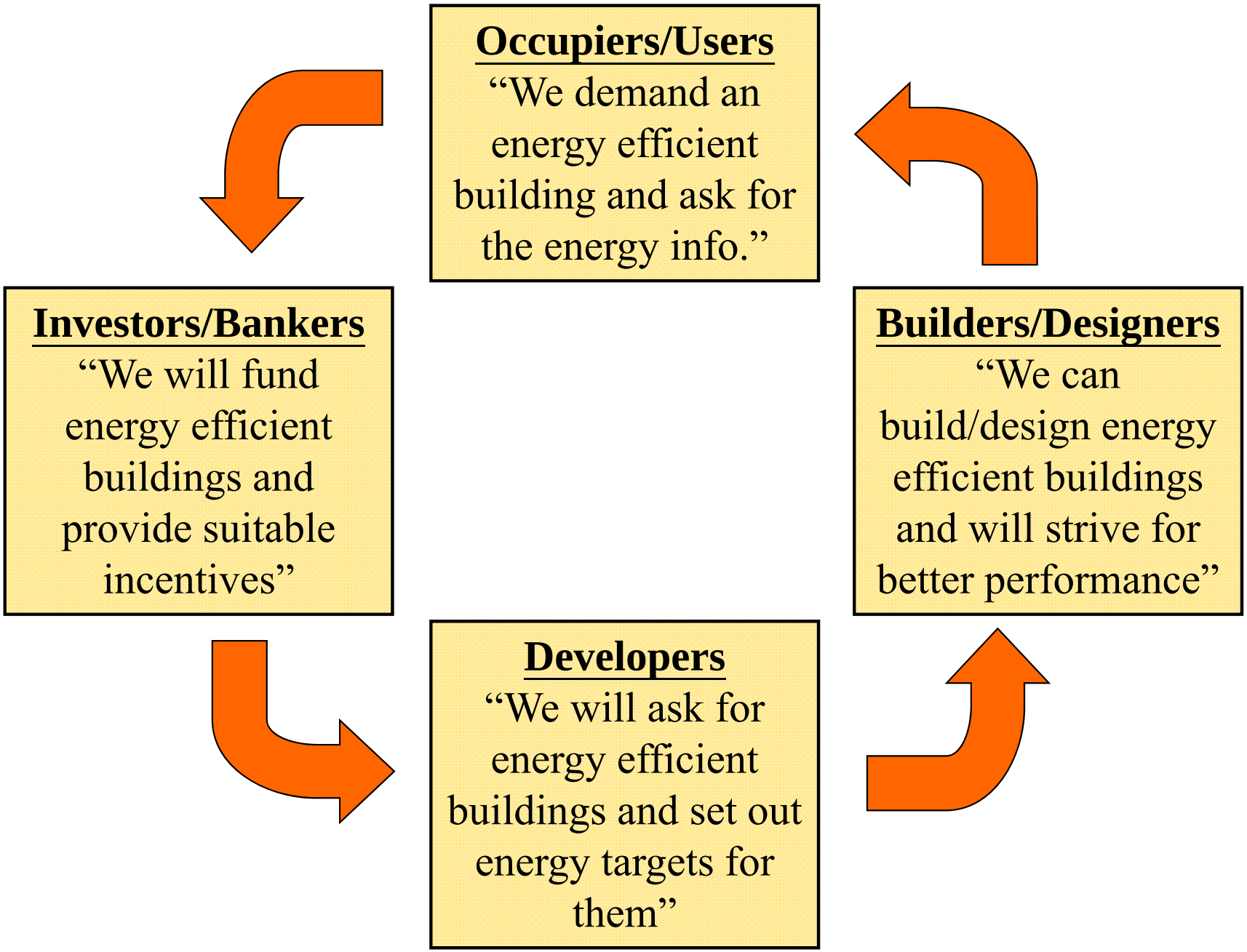


- Building codes
- Energy laws

- Energy labels
- Voluntary schemes

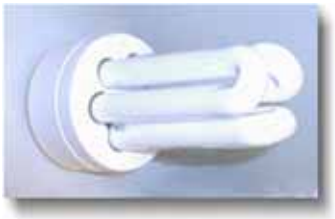


The vicious circle of energy efficient buildings
(From EU studies)



Reverse the viscous circle and overcome market barriers

Key factors



- To overcome the market barriers in efficiency, the following methods might be applied:
  - Building energy labelling or certification
  - Very best practice buildings with extremely low- or no-energy consumption (zero energy buildings)
    - Lead by examples; explore new technologies
  - Policies to raise buildings' energy efficiency beyond minimum requirements
    - Such as energy performance rating method
  - Energy savings performance contracting

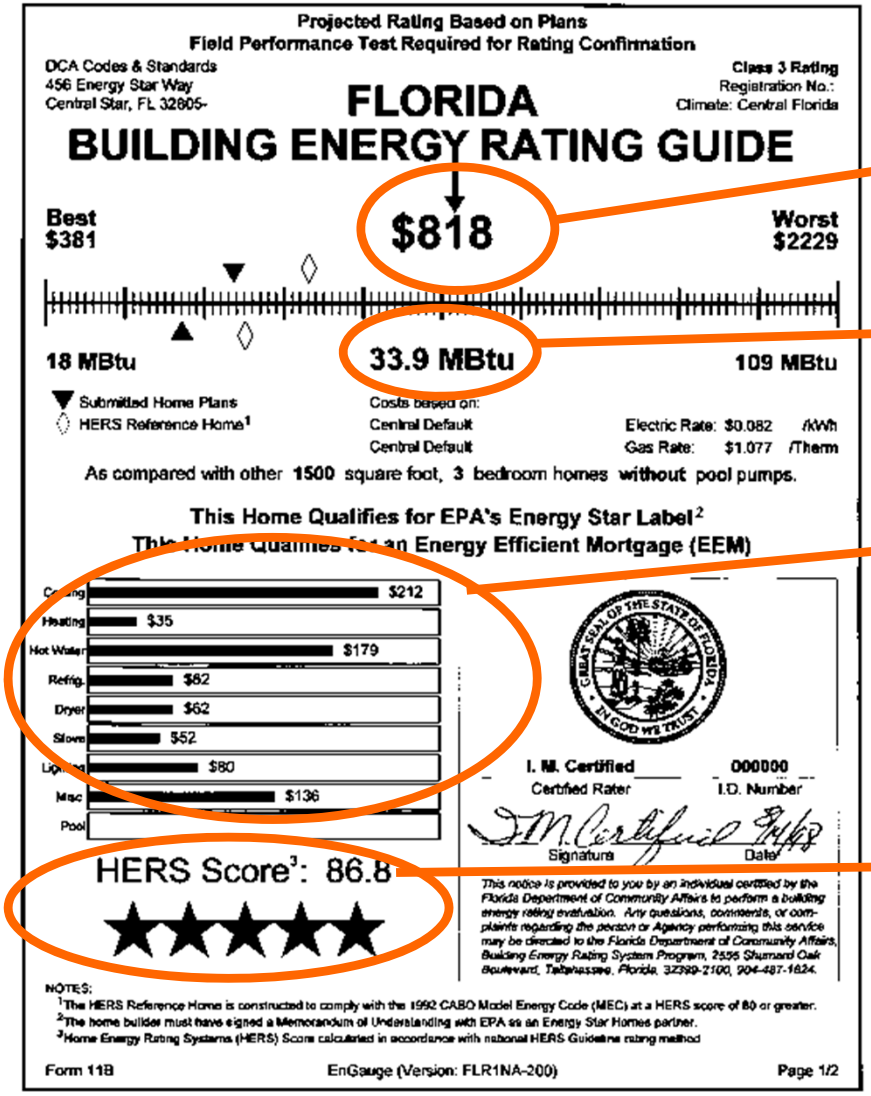
Energy label and rating systems for buildings in USA

Energy Star Label for Buildings

Buildings that rate in the top 25% of energy-efficient buildings in USA

http://www.energystar.gov/

Building Energy Rating System (Florida)



Energy cost

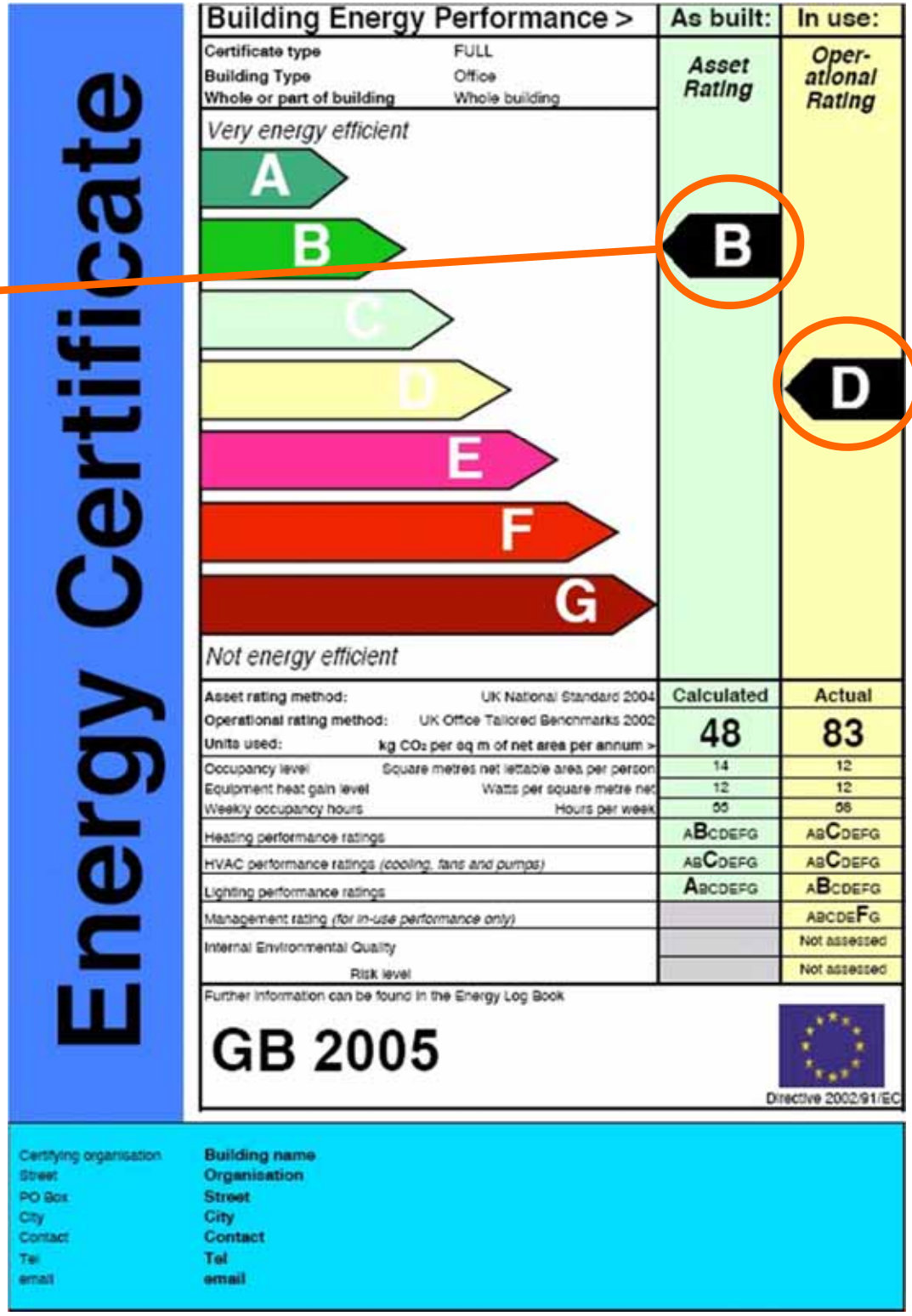
Energy consumption

Breakdown of energy use

Overall score

http://www.fsec.ucf.edu/ratings/

As built:
Asset rating
(calculated)

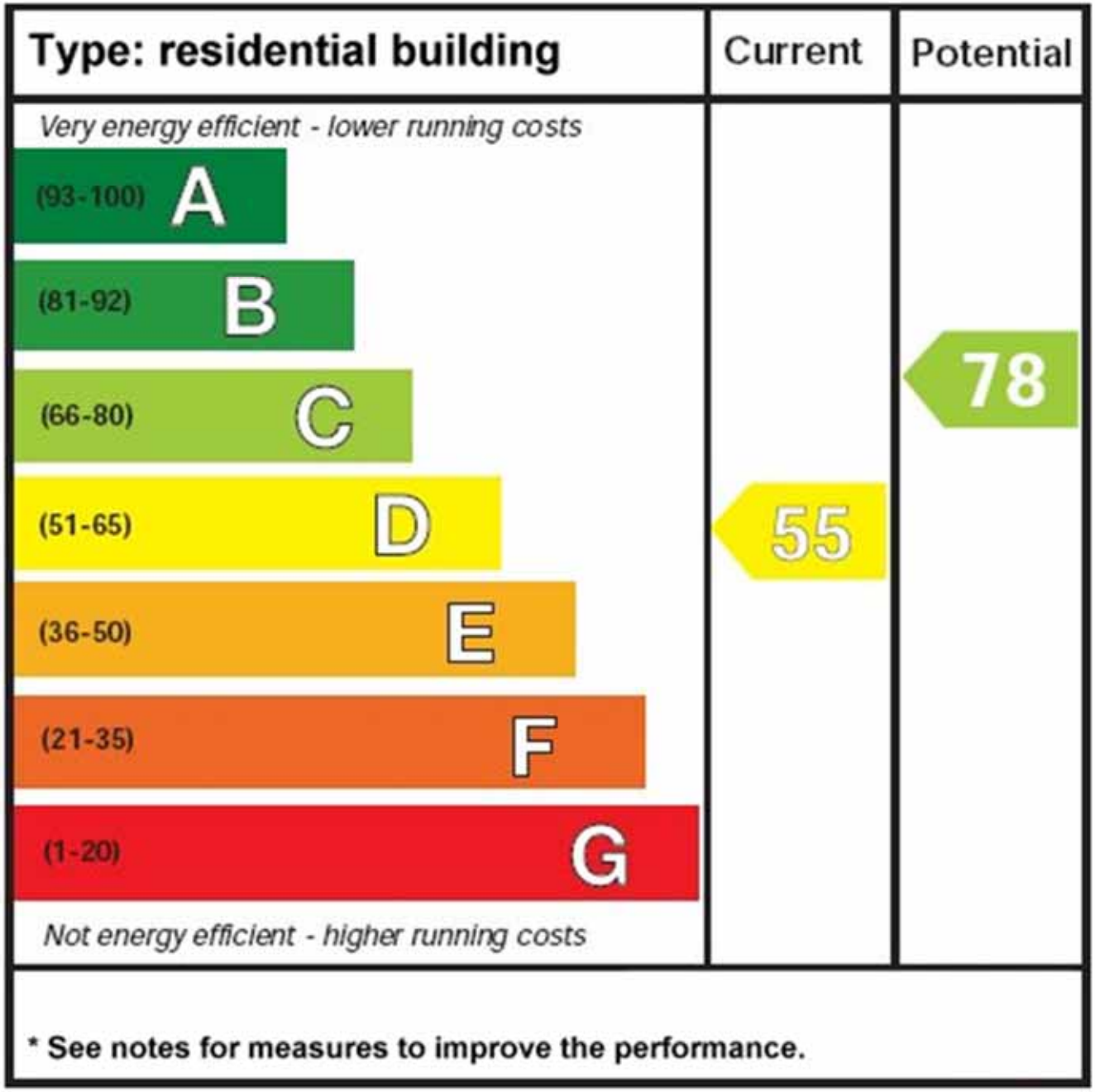


In use:
Operational
rating
(actual)

Proposed energy certificate of buildings in Europe
(source: ww.eplabel.org)

- Rating method & units
- Occupancy level
- Heating performance
- HVAC performance
- Lighting performance
- Management rating
- Internal environ. quality

Hong Kong Building Energy Label



Imagine what effect if we have this when buying or renting a flat?

Would you like to have this?

Examples of zero energy/carbon building projects in the world

Pearl River Tower, Guangdong, China [2010]

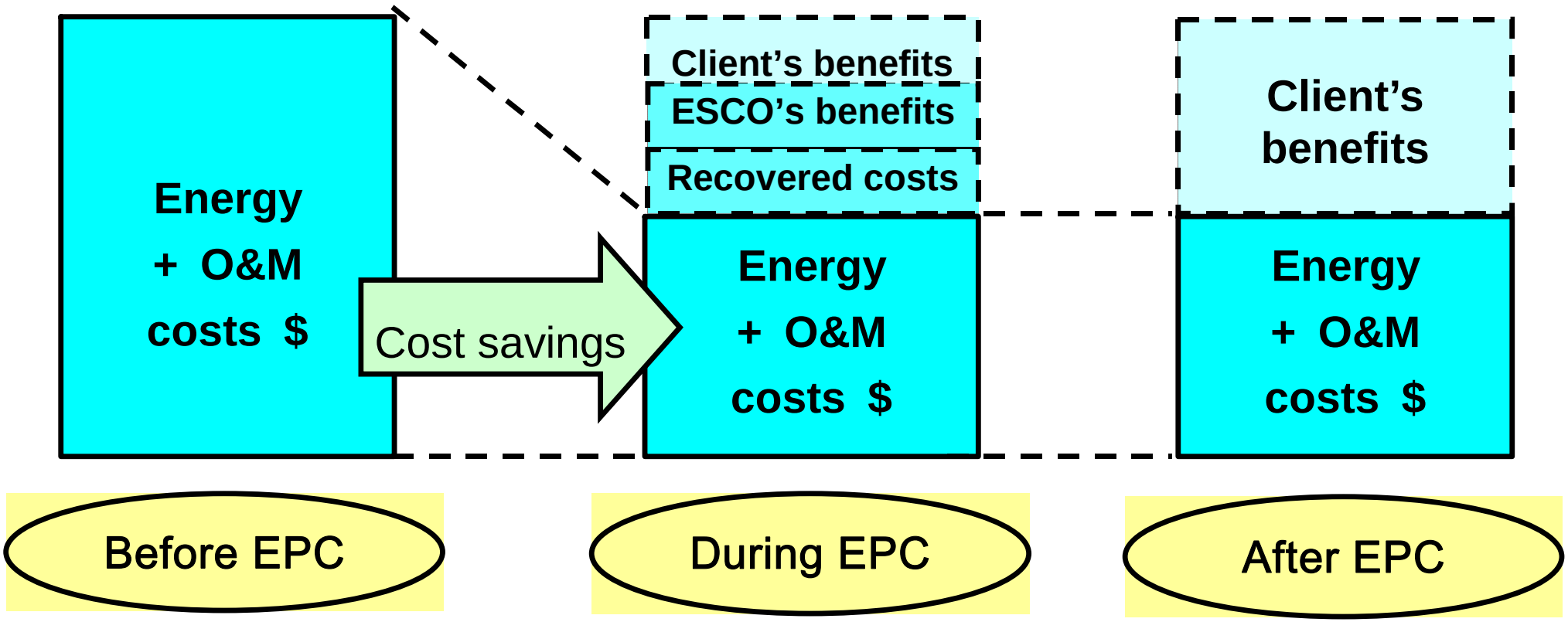
Self-sufficient solar house, Freiburg, Germany [1992]

Pusat Tenaga Malaysia's ZEO Building, Malaysia [2007]

BCA Academy, Singapore [2009]

Beddington Zero Energy Development (BedZED), London [2002]

The Barratt Green House in Watford, UK [2008]



Basic concept of energy performance contracting (EPC)

Overseas examples

- Existing building retrofitting
  - Empire State Building, New York City, USA
    - A model for optimizing energy efficiency, sustainable practices, operating expenses and long-term value in existing buildings
    - Rigorous eight-month iterative design process
    - Narrowed 60+ ideas to 8 recommended projects
    - Required the active engagement of an energy services company, the building owner, and building tenants
    - Used energy model eQUEST for cost/benefit analysis

Empire State Building: major energy efficiency improvement retrofit

- A US$20 million energy performance project
- Energy saving 38%
- Energy cost saving US$4.4 million annually
- LEED Gold for Existing Buildings certification
- Also buy wind-based carbon offsets totaling 55 million kWh per year (become carbon neutral)

Energy efficiency efforts:

1. Window light retrofit
2. Radiator insulation retrofit
3. Tenant lighting, daylighting and plug upgrades
4. Air handler replacements
5. Chiller plant retrofit
6. Whole-building control system upgrade
7. Ventilation control upgrade
8. Tenant energy management systems

Video: Greening the Empire State Building (2:23), http://youtu.be/QKnxDcIUfdY

(Data source: www.esbnyc.com)

Overseas examples

- In Japan, energy efficiency is not just a government policy, but a mindset of citizens established from high utility costs
- “Law Concerning the Rational Use of Energy”
- A mix of policies to promote energy conservation, e.g.
  - Mandatory energy conservation plans
  - “Top Runner Program” (a challenge demand for energy efficient products)

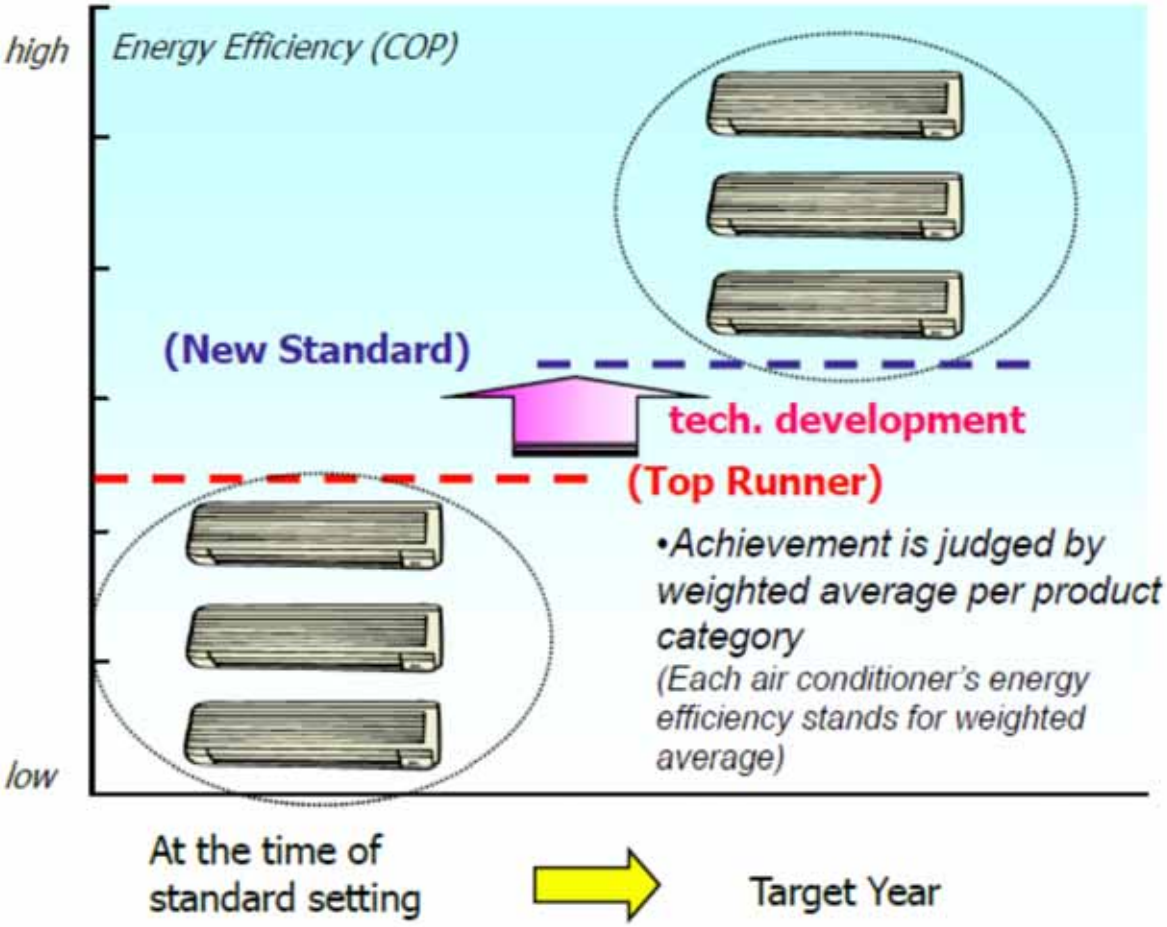
Overseas examples

- "Top Runner Program" (Japan)
  - Began in 1998, www.eccj.or.jp/top_runner/
  - Set energy conservation standards for home and office appliances and a fuel economy standard for automobiles
  - It searches for the most efficient model on the market and then stipulates that the efficiency of this top runner model should become the standard within a certain number of years

What is the Top Runner Program?

- Energy conservation law prescribes energy efficiency standards for appliances and vehicles according to the Top Runner method.
- The concept of the Top Runner Program is that standards are set higher than the best performance value of each product currently on sale in the market.
- Standard setting takes into account technological development.

Setting standard of Top Runner Program



Target products (21 products)

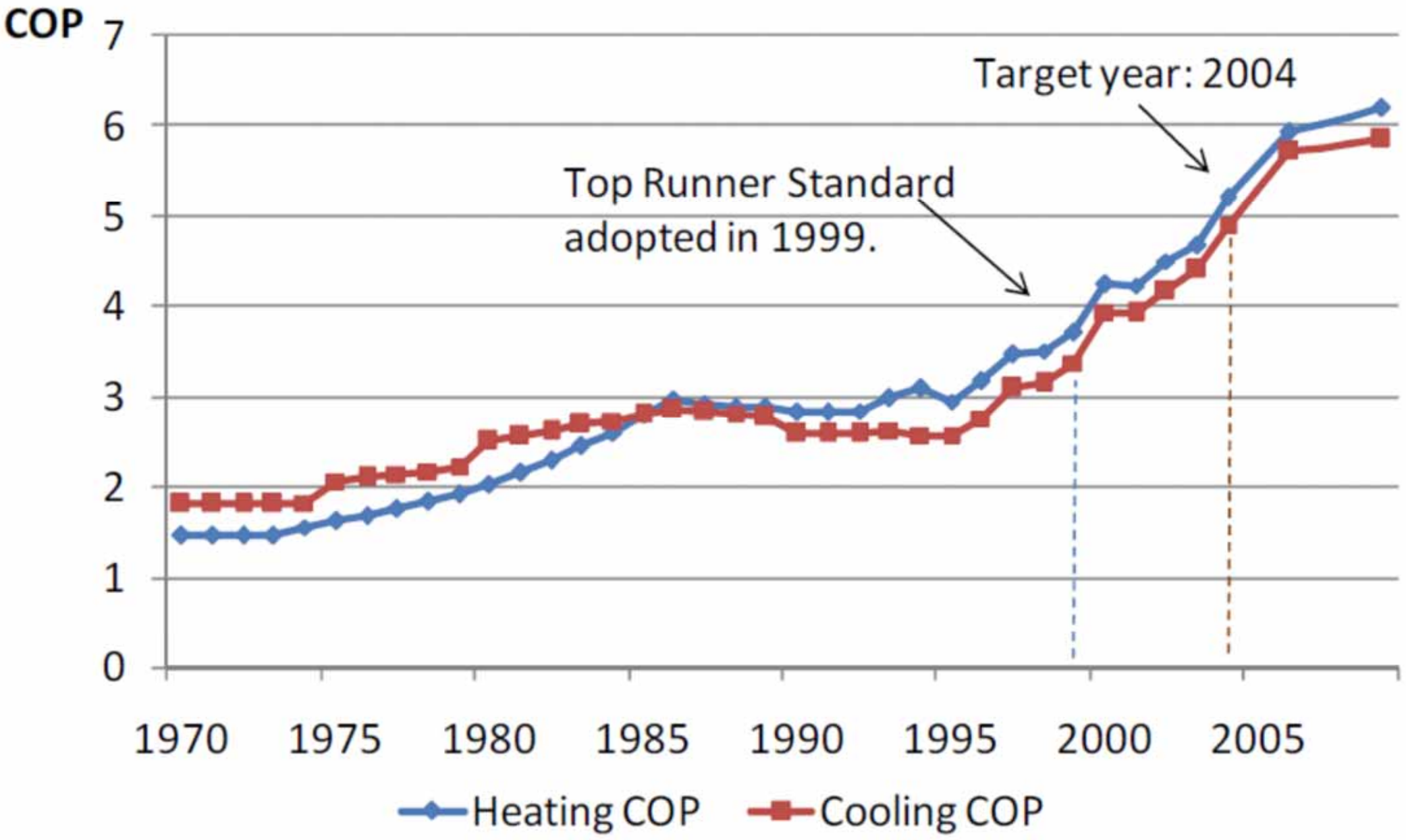
1 . Passenger vehicles
2 . Freight vehicles
3 . Air-conditioners
4 . TV sets
5 . Video-cassette recorders
6 . Fluorescent lights
7 . Copiers
8 . Computers
9 . Magnetic disc units
10 . Electric refrigerators
11 . Electric freezers
12 . Space heaters
13 . Gas cooking appliance
14 . Gas water heaters
15 . Oil water heaters
16 . Electric toilet seats
17 . Vending machines
18 . Transformers
19 . Electric rice cookers
20 . Microwaves
21 . DVD recorders

※1: Heavy vehicles weighing over 3.5ton (buses, trucks) were added for the target products in April 2006.
※2: LCDs and plasma display TVs were added for the target products in April 2006.

(Source: www.eceee.org and METI Japan)

COP = coefficient of performance

Long term trend of energy efficiency of room air conditioners (Japan Top Runner Program)



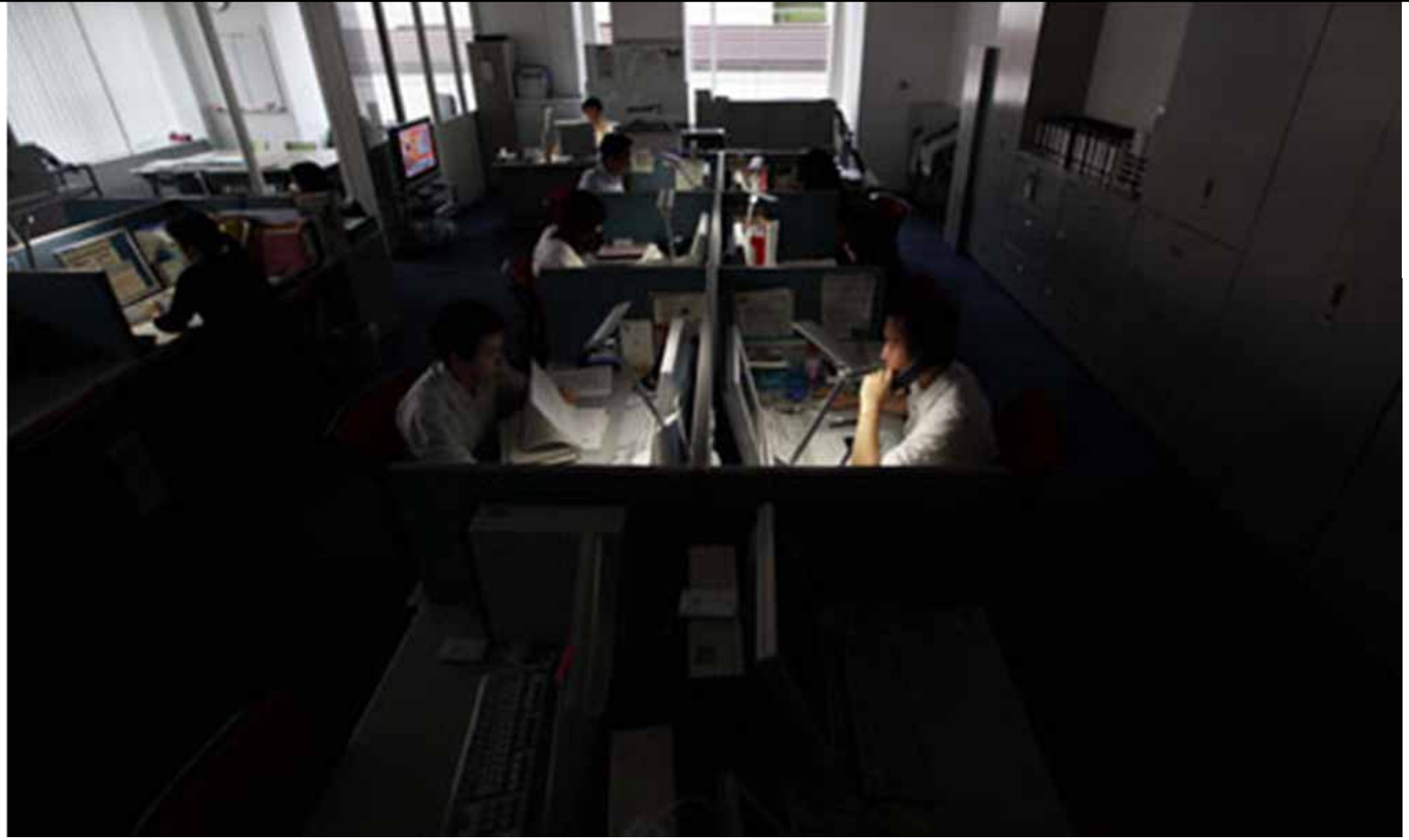
COP = coefficient of performance

(Source: www.climatepolicy.jp)

Japanese Energy Strategy: Hawaiian Shirts
"Super Cool Biz" campaign

(Source: The Wall Street Journal, http://online.wsj.com)

See also www.uniqlo.com/jp/supercoolbiz/



Workers using LED lamps instead of main lights, in an office in Tokyo. Such energy-saving measures, or 'setsuden' (節電) are sweeping Japan after the Fukushima nuclear disaster

See also http://setsuden.go.jp/

(Source: Guardian Environment Network, guardian.co.uk)

Conclusions

- An urgent need for promoting higher energy efficiency for buildings in Hong Kong
  - Should identify the key areas of improvements for different types of buildings
  - Consider the PULL-PUSH Strategy for promoting energy efficiency (to overcome the market failure)
- How high we can go, *if we really need to*? *If it is really motivated*?
  - The efficiency potential depends on our WILL.

THANK YOU

謝謝