ASHRAE Hong Kong Chapter:
AGM Technical Seminar

16 May 2011 (Mon)

Importance of Building Energy Codes for Promoting Energy Efficiency

1911-2011

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- Why energy efficiency?
- Why building energy codes?
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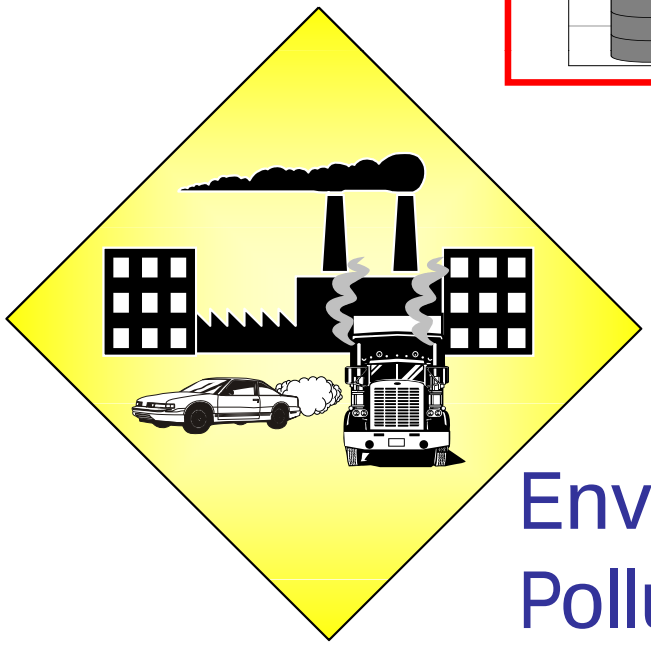
President Obama's Plan to Win the Future by Making American Businesses More Energy Efficient through the Better Buildings Initiative

- make commercial buildings 20% more energy efficient by 2020
- get twice as much of its electricity from clean energy sources by 2035

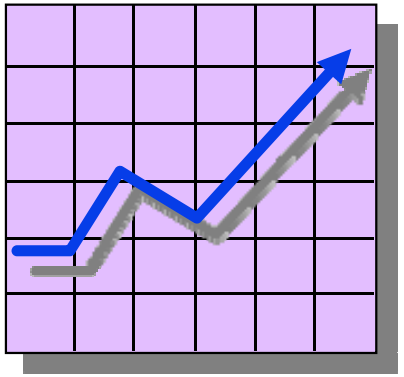
(Source: www.whitehouse.gov/blog/2011/02/03/winning-future-through-innovation-and-better-buildings)

The challenges facing us…

Growing
Petroleum
Consumption



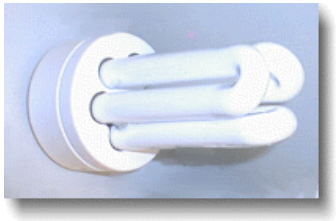
Environmental
Pollution



Economic
Competitiveness

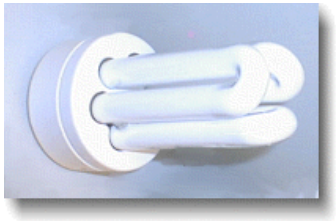
(Source: www.kostic.niu.edu)

Why energy efficiency?



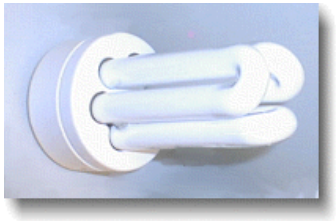
- **Energy** is important to every society
  - Economic, environmental & social impacts
  - It is also a key issue for ***sustainable development***
- Use energy …
  - Consume finite fossil fuels (oil, coal, natural gas)
  - Cause air pollution & environmental damage
  - Contribute to global warming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

Why energy efficiency?



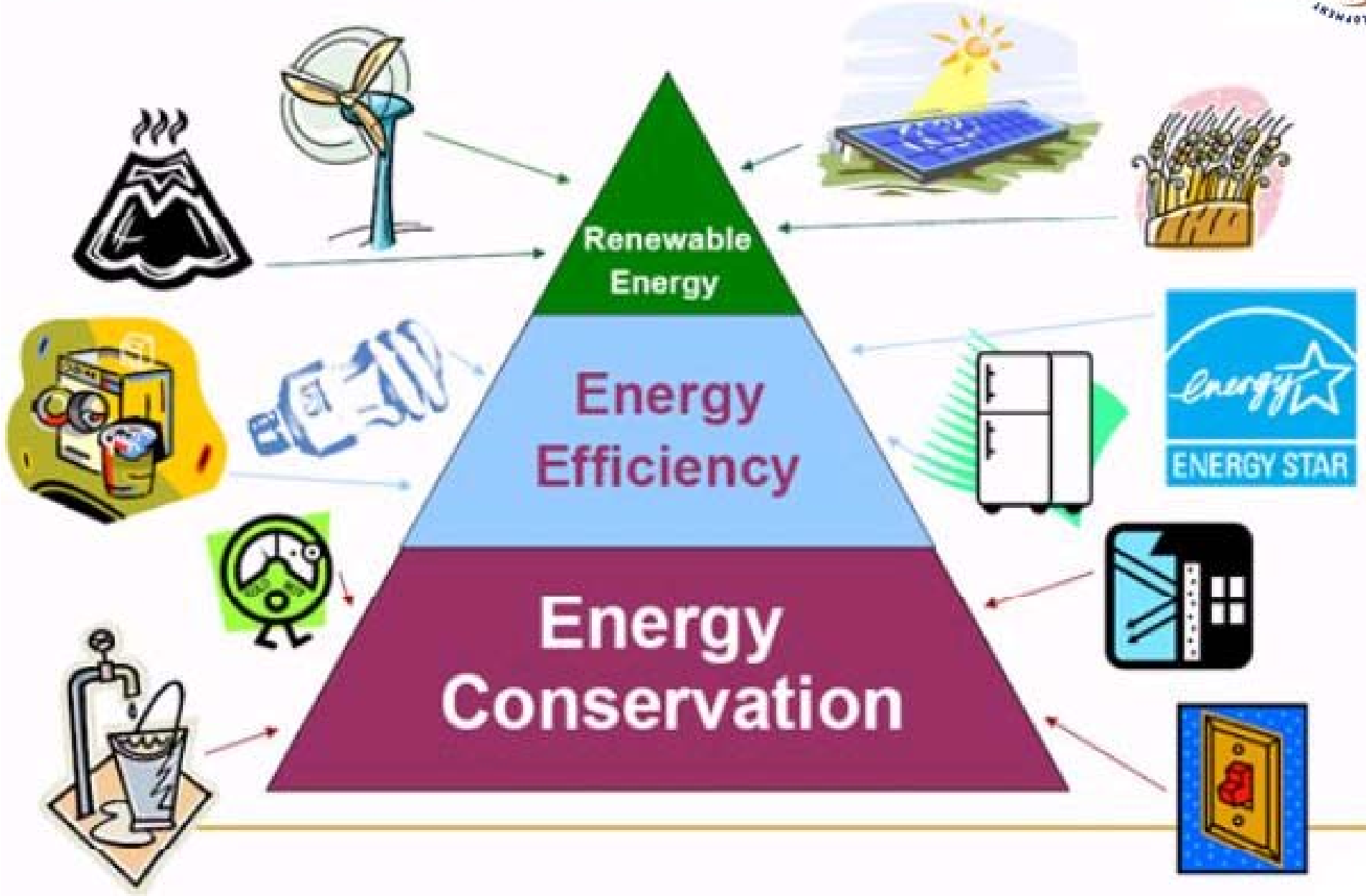
- Future energy options:
  - Coal, oil and natural gas
    - Resource depletion, environmental impacts, energy security, fuel price
  - Nuclear energy
    - After Fukushima nuclear accidents, safety is doubtful!
  - Renewable energy
    - Still limited and costly to develop
- Energy efficiency is an important, smarter and more practical option

Why energy efficiency?



- **EE = Energy Efficiency**
  - Efficient use of energy, also called the "*fifth fuel*"
  - Use less energy to provide the same level of energy service (*Doing More with Less*)
  - Achieved by more efficient technology or process
  - According to the International Energy Agency (www.iea.org), energy efficiency in the following 3 sectors could reduce the world's energy needs in 2050 by one third:
    - Buildings, industrial processes, transportation

The Energy Pyramid



(Source: www.kostic.niu.edu)

Building Energy Codes

Important energy sector

Energy Efficiency
- Buildings
- Industries
- Transport
- Appliance
- Utilities
- Energy management

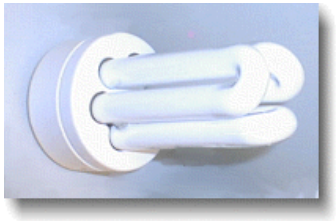
Energy Supply
- Coal
- Oil
- Natural gas
- Nuclear
- Electricity
- Renewable energy

Energy Resources
- Coal
- Oil
- Natural gas
- Nuclear energy
- Renewable energy

Other Issues
- Energy security
- Energy and environment
- Energy economics

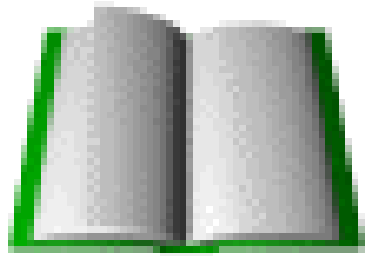
Building sector in the overall energy policy

Why energy efficiency?

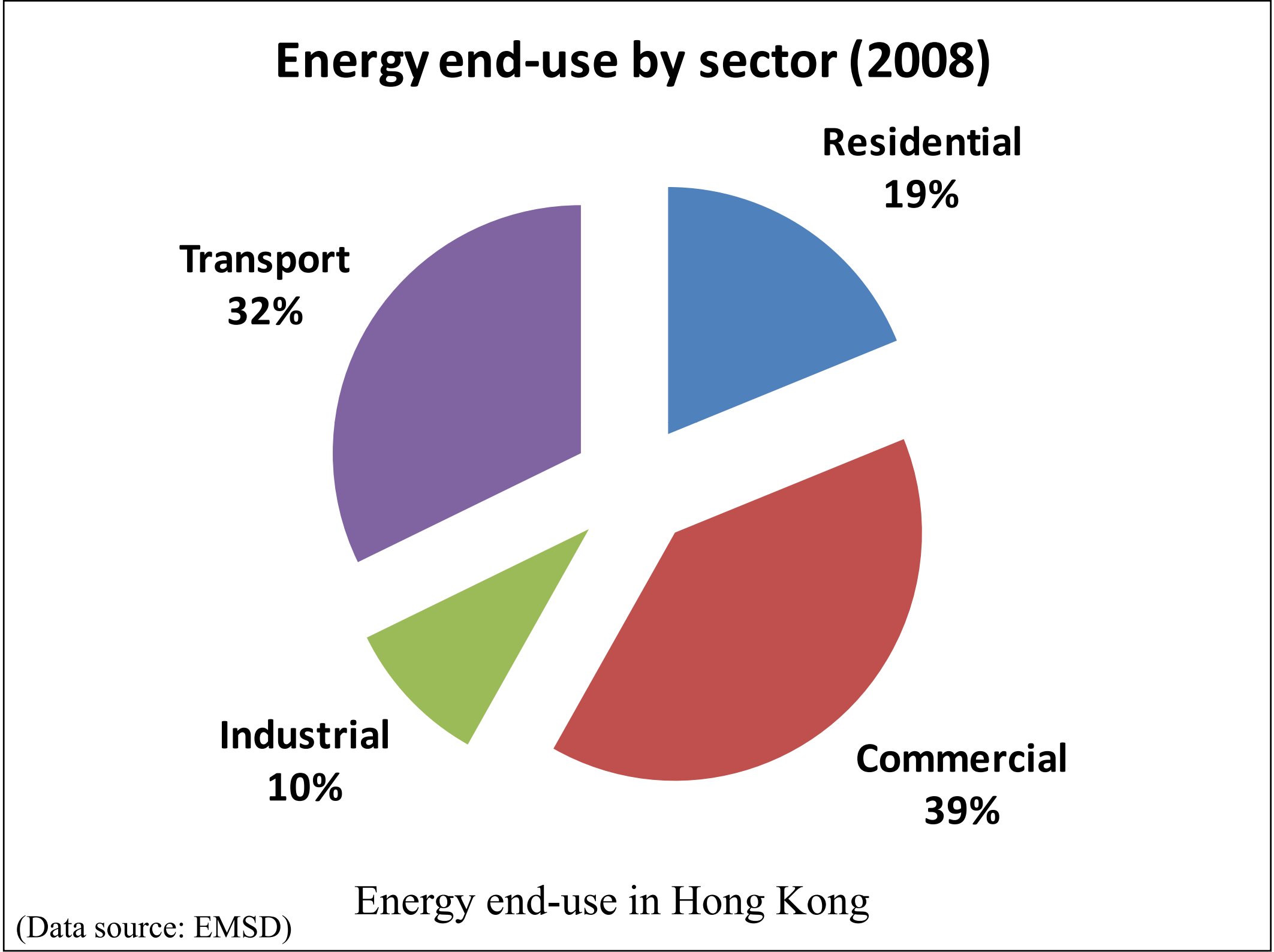


- Possible benefits from energy efficiency:
  - Improved building design and operation
  - Better working environments
  - Life-cycle cost savings
  - Added market value of buildings
  - Reduced CO_2 emissions and consumption of finite fossil fuels
  - Reduced capital cost by better integration of building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

Why building energy codes?



- In Hong Kong, buildings constitute 60-70% of total energy end-use and 58% of final energy requirements
  - Residential + commercial + industrial
- The potential for energy saving is large
- But the barriers to promoting energy efficiency in buildings are yet to overcome
- Energy efficiency is often discounted and hard to sell in a commercial free market



Energy end-use in Hong Kong

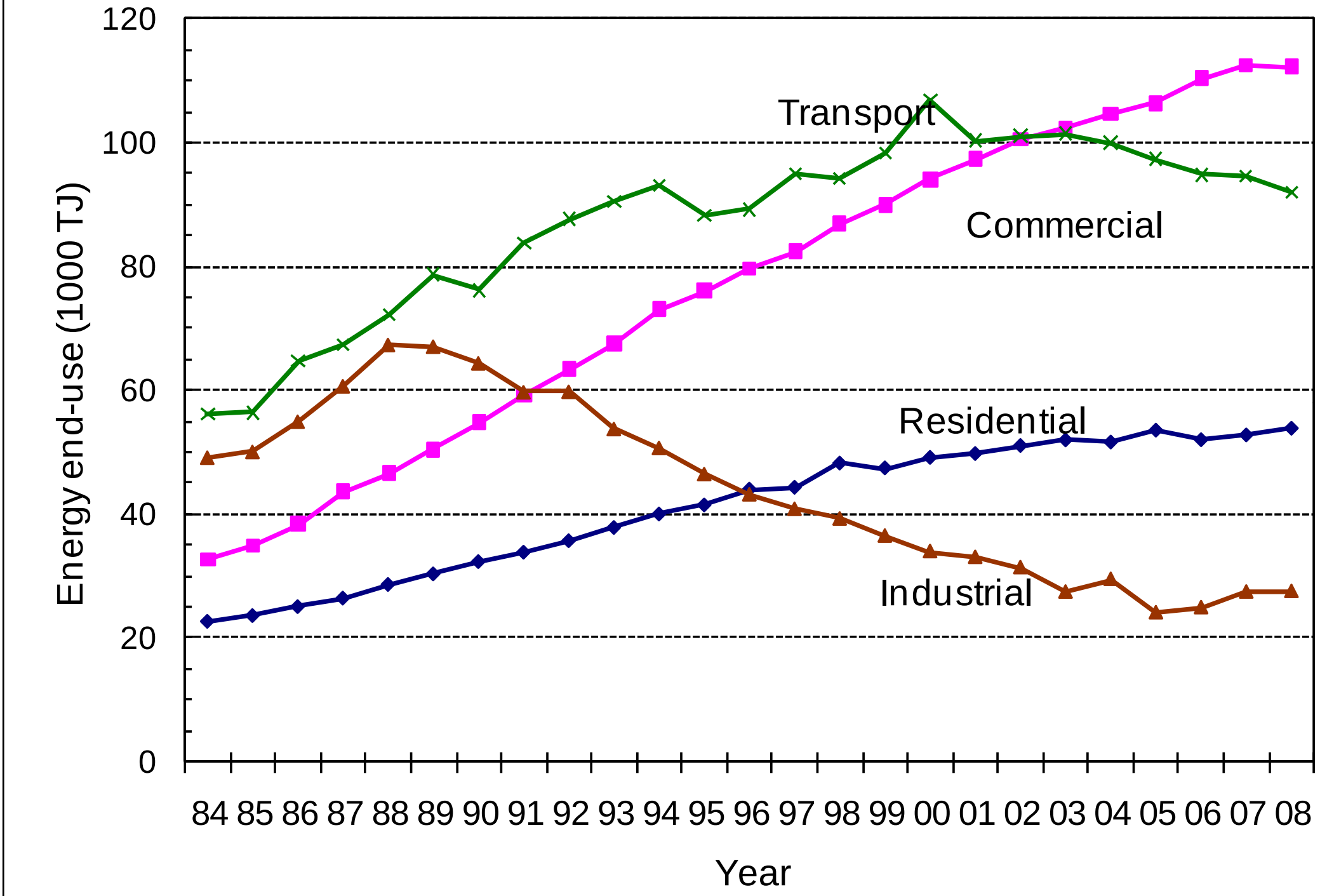
(Data source: EMSD)

Table 1 - Final energy requirements (FER) in Hong Kong (year 2009)

Unit: MJ	**Commercial**	**Residential**	**Industrial**	**Total**
Electricity	98 860 (66%)	38 972 (26%)	11 143 (8%)	148 975 (100%)
Town gas	11 069 (41%)	15 303 (56%)	902 (3%)	27 274 (100%)
Elec. + town gas	109 929	54 275	12 045	176 249
% in total FER	35.8%	17.7%	3.9%	57.5%

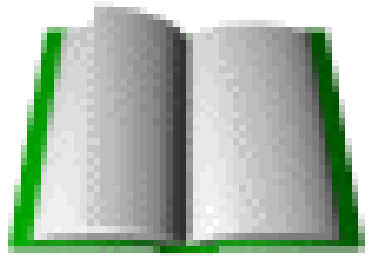
Total FER for 2009 = 306 774 TJ

(* Data Source: *Hong Kong Energy Statistics 2009 Annual Report*)

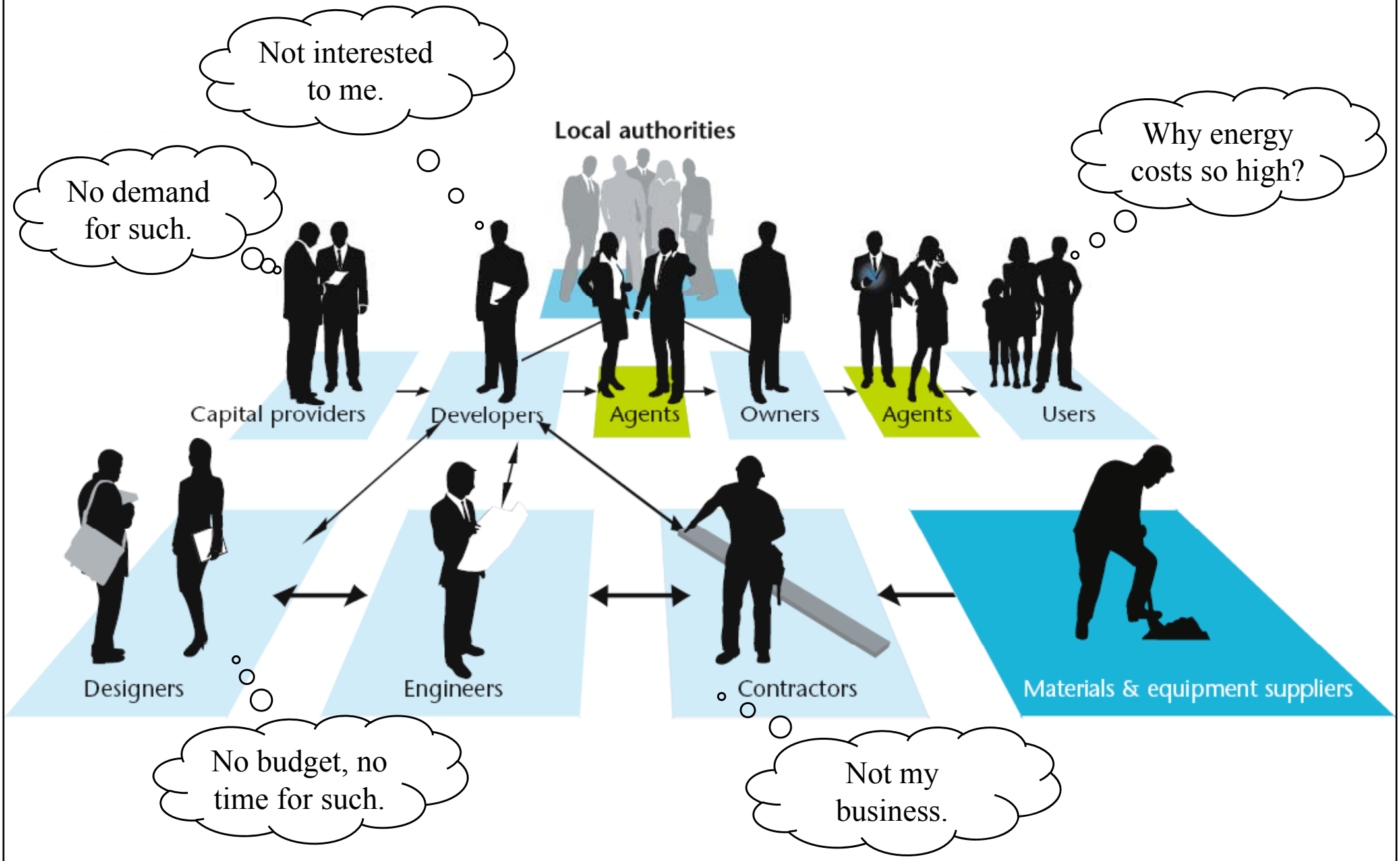


(Data source: EMSD) Energy end-use in Hong Kong by sectors, 1984-2008

Why building energy codes?



- Barriers to energy efficiency
  - Developers and builders not interested to save energy for tenants and end-users
  - Utilities not encouraged to end-use energy efficiency (because it may reduce their profits)
  - Lack of efficiency attitudes and awareness
  - Lack of information on energy performance
  - Perceived riskiness of efficiency measures
  - Limited access to capital



The complex value chain in the building sector

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

Top ten reasons for building energy codes

10. They establish a common foundation for evaluating, regulating, and incentivizing building performance, technologies, design, and construction.	**5.** They provide a common basis upon which to educate the building design and construction community in energy efficiency.
9. They support more widespread decisions and actions that lead to efficient buildings.	**4.** They safeguard owners and tenants from long-term financial burdens that can result from short-term design and construction decisions.
8. They help drive the development and deployment of new building technologies and design strategies.	**3.** They continue to progress in terms of stringency, scope, and enforcement emphasis -- which will enhance the skills of the current workforce.
7. They provide a cost-effective step toward mitigating problems associated with growing demand for energy and power resources.	**2.** They help protect the natural environment from unnecessary emissions.
6. They can lock in the use of energy efficient technologies that have been proven through incentive programs, freeing up resources to focus on additional technologies.	**1.** They reduce the vast amount of energy that is needlessly consumed each year for commercial and residential buildings that lack adequate energy efficiency features.

(Source: Adapted from www.energycodes.gov)

Characteristics of BEC

- Building Energy Codes (*BEC*)
  - Set out minimum energy consumption objectives
  - Form part of the energy policy
  - Control building design and/or operation
- Energy audit requirements (in some countries)
  - Essential for existing buildings
- Energy management programmes
  - Promote good practices in design and operation

Characteristics of BEC

- Basic functions of BEC:
  - Raise concerns and awareness of energy efficiency
  - Promote energy efficient design & operation
  - Facilitate energy conservation products & services
  - Provide a basis for building energy performance
  - Help achieve energy policy goals
- Code requirements
  - Prescriptive approach
  - Performance approach

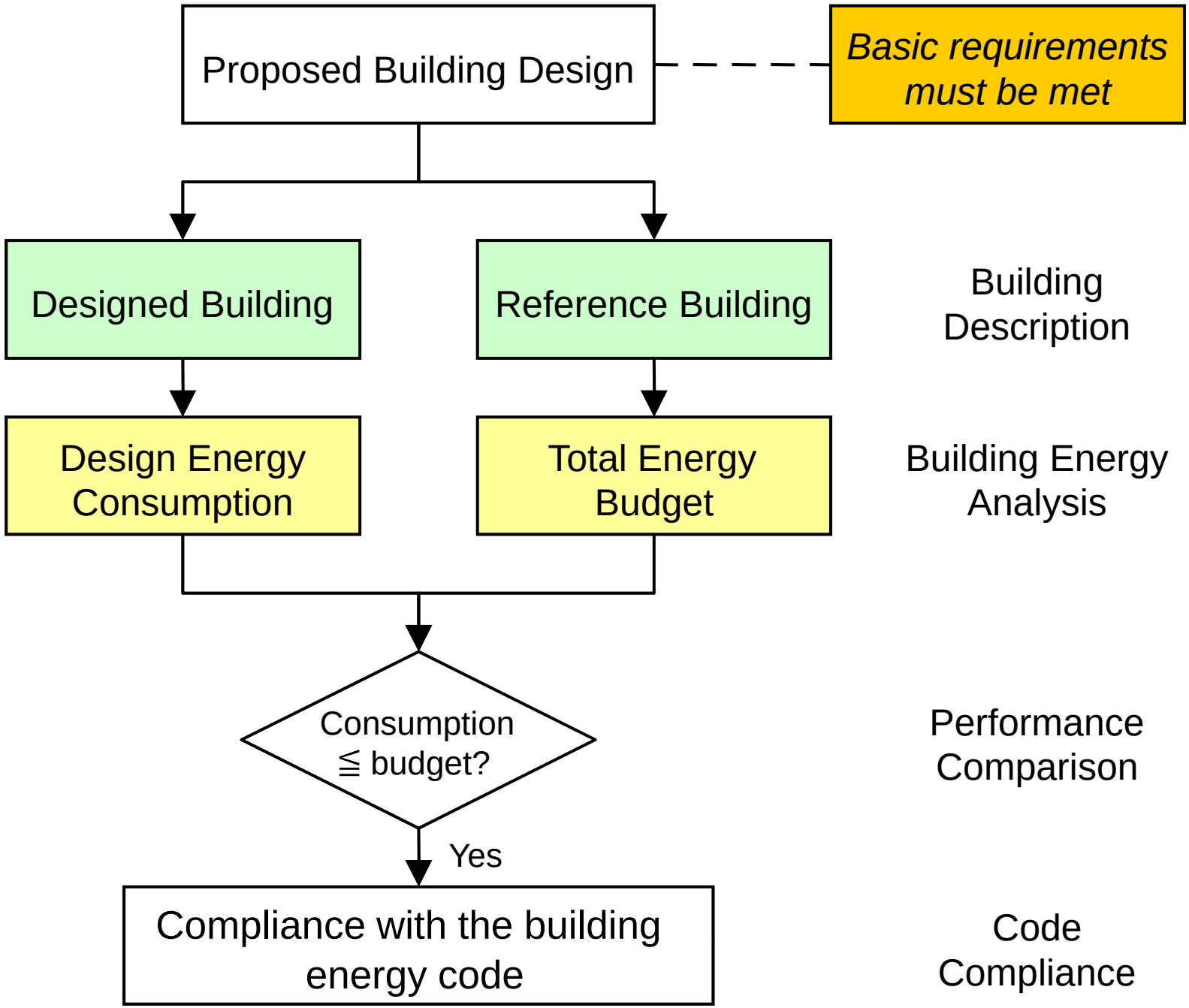
Characteristics of BEC

- Prescriptive approach
  - Specifies for each building component the minimum requirements to satisfy the code
  - Advantages:
    - Simple to use & follow
    - Easy to check & enforce
  - Drawbacks:
    - Rather restrictive
    - Barrier to innovation & performance optimisation
    - Hinder cross-country product trading

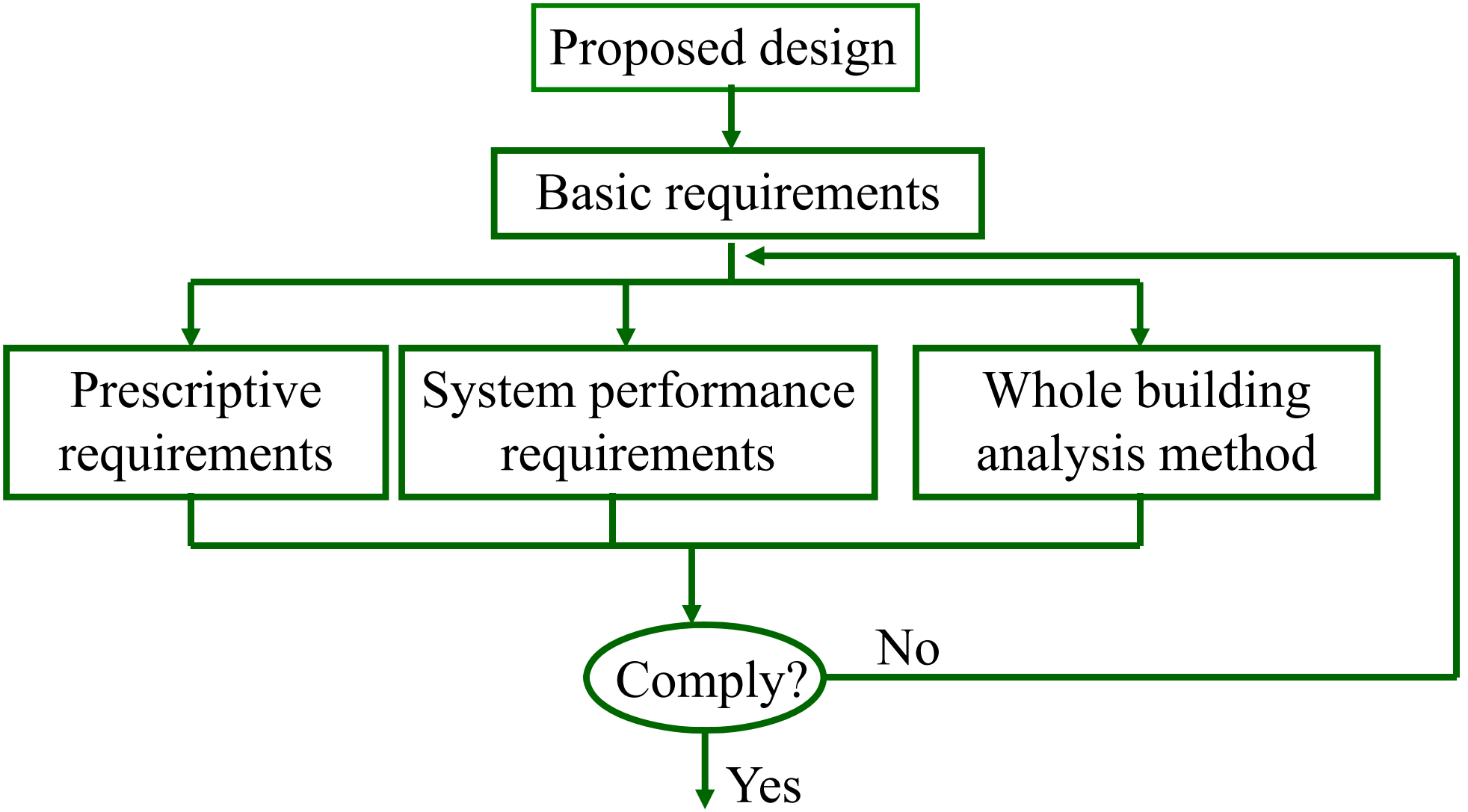
Characteristics of BEC

- Performance approach
  - State the goal(s) and allows the use of any solution to demonstrate compliance
  - Advantages:
    - More clearly explains what the code intends
    - Permits innovation & alternative solutions
    - More flexible regulatory environment, easily updated
    - Encourage building/technology research
  - Drawbacks:
    - Often more efforts are needed for analysis/compliance
    - Can be very complex & require more expertise

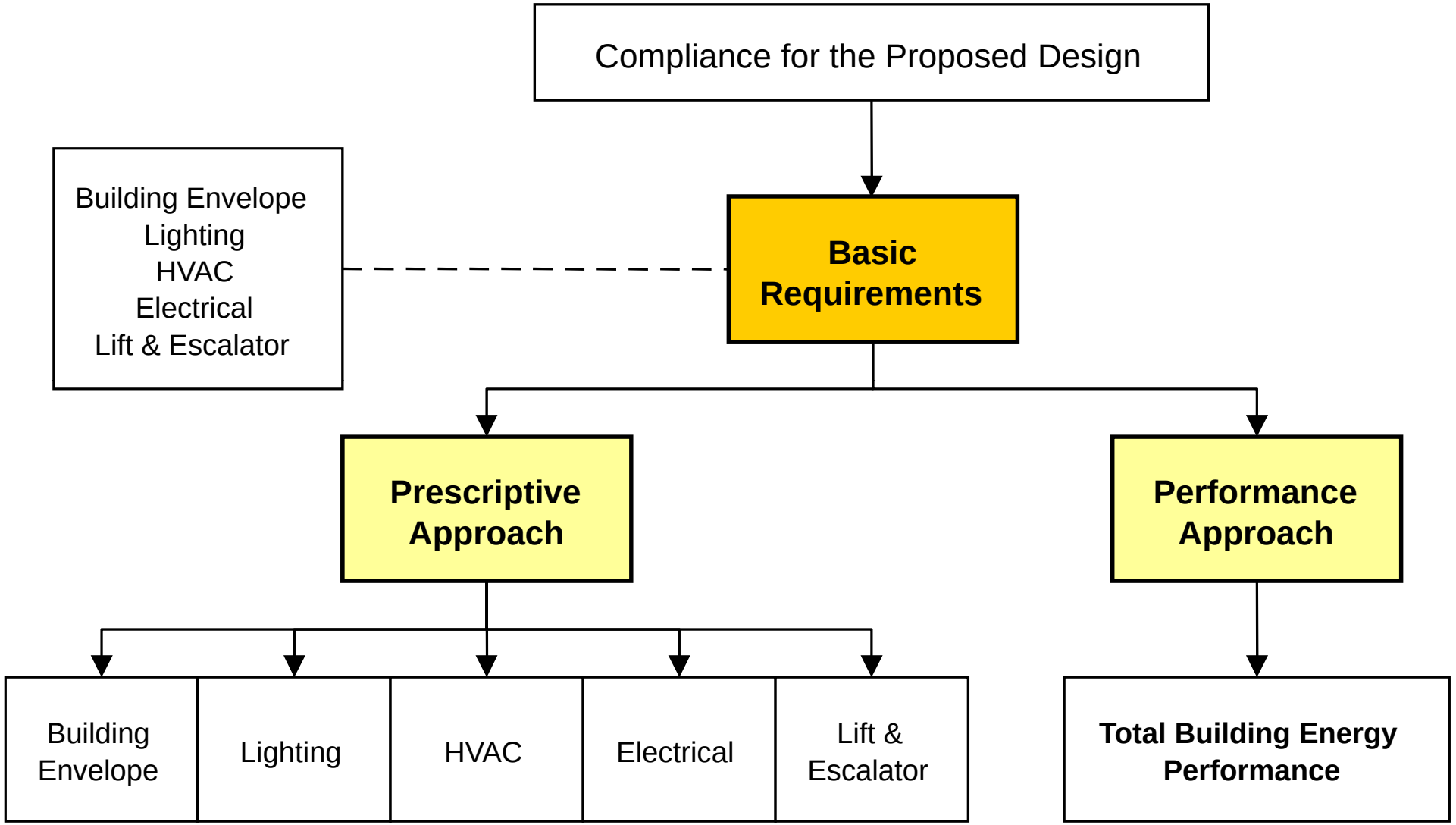
Compliance method for performance approach



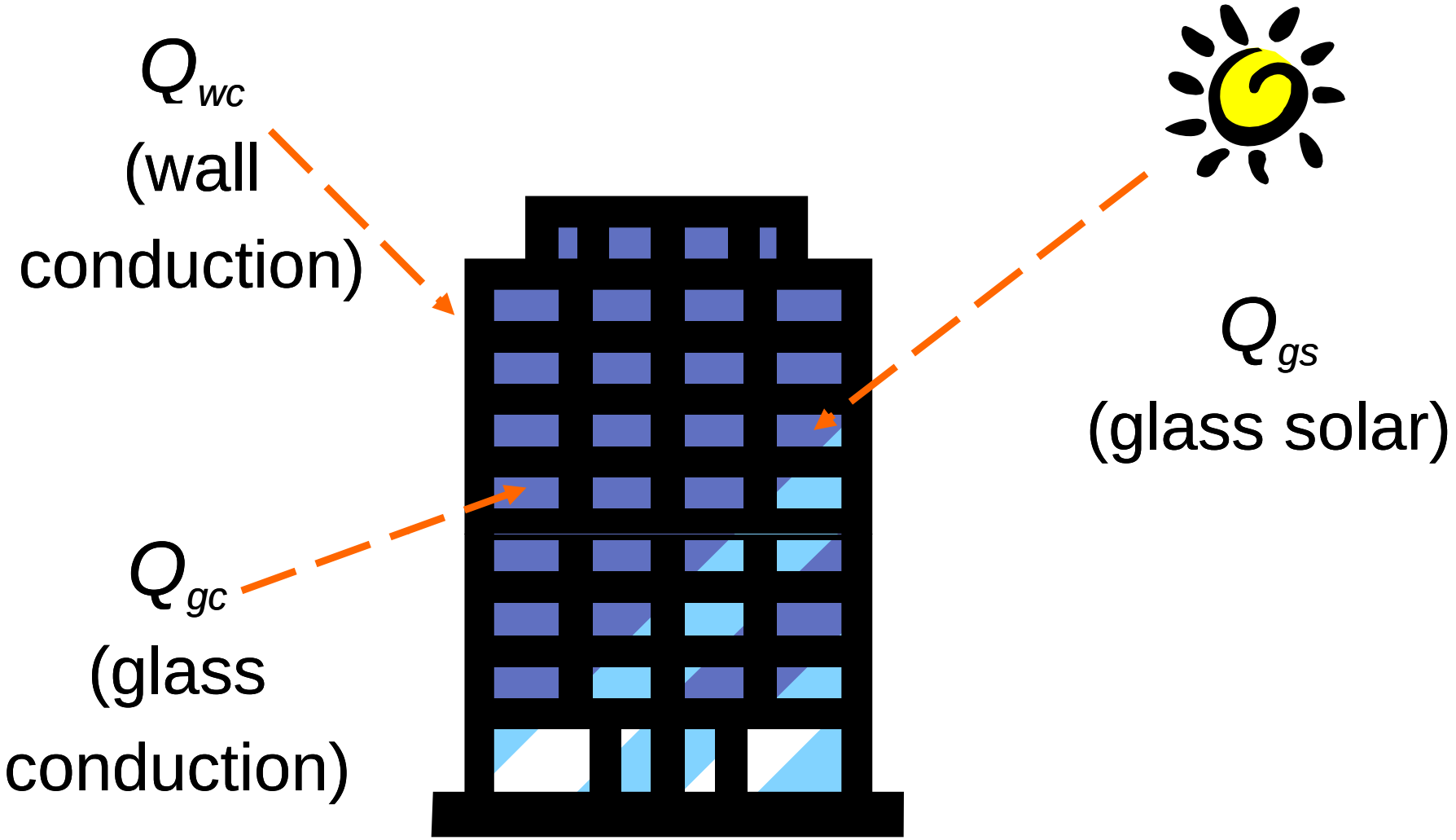
Compliance paths in building energy codes



Proposed framework of the comprehensive BECs in Hong Kong



(Source: EMSD)



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

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

Characteristics of BEC

- 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

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

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

Hong Kong's
Buildings Energy Efficiency Ordinance

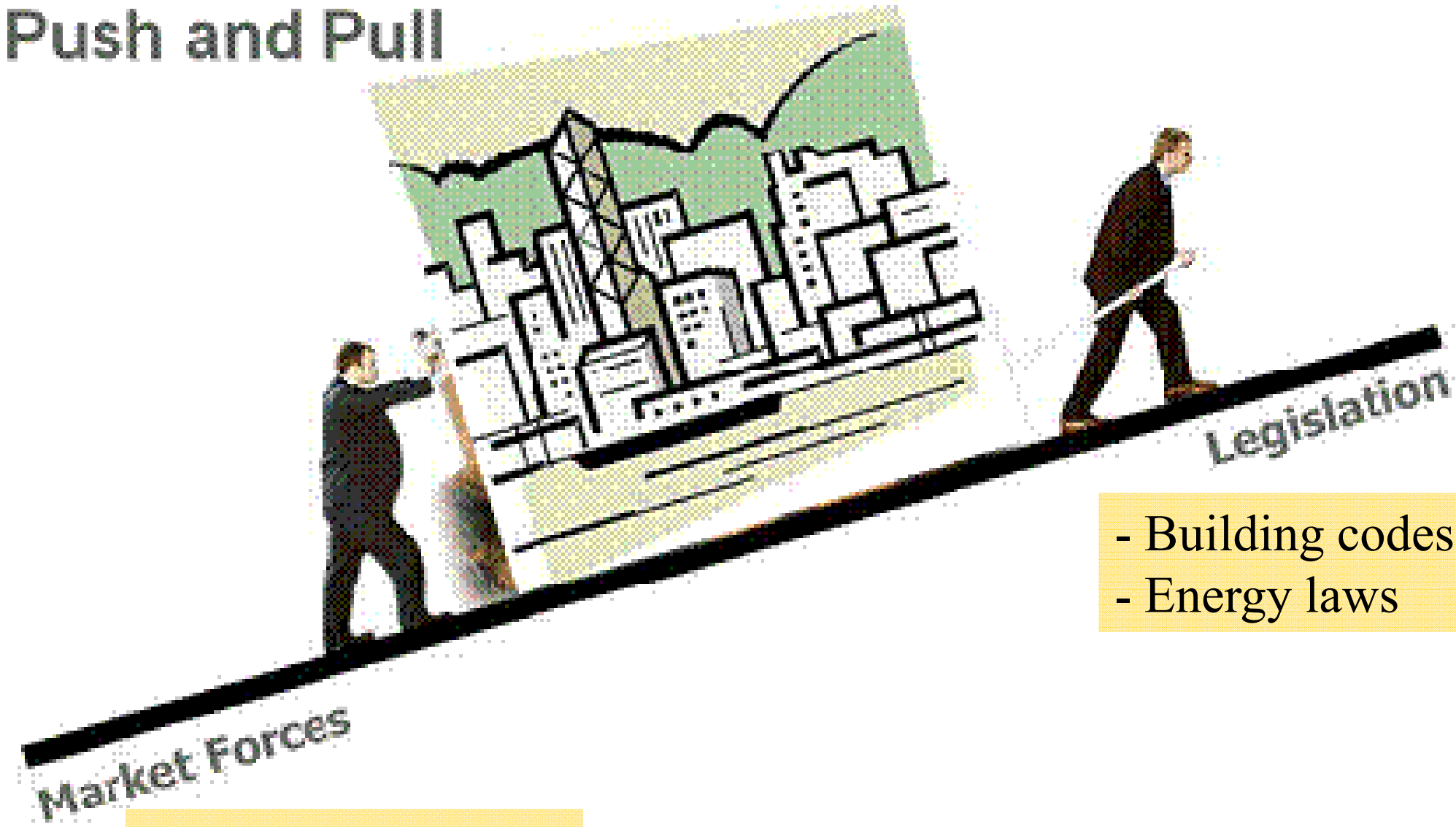
- The Bill for mandatory implementation of the Building Energy Codes (BEC) was passed by the Legislative Council on 24 Nov 2010. Together with the amendments they were gazetted to be the Buildings Energy Efficiency Ordinance (BEEO) (Cap. 610) on 3 Dec 2010
- The Ordinance (except Parts 2 to 6) would come into operation on 21 Feb 2011. Vetting of the subsidiary regulations detailing the fees and registration of Registered Energy Assessor (REA) will be completed in the 1st quarter of 2011 and then the registration of REA will commence in the 2nd quarter of 2011
- There will be 18-month grace period for Parts 2 to 6
- BEEO will be fully implemented in mid-2012

(Source: www.emsd.gov.hk)

Implementation issues

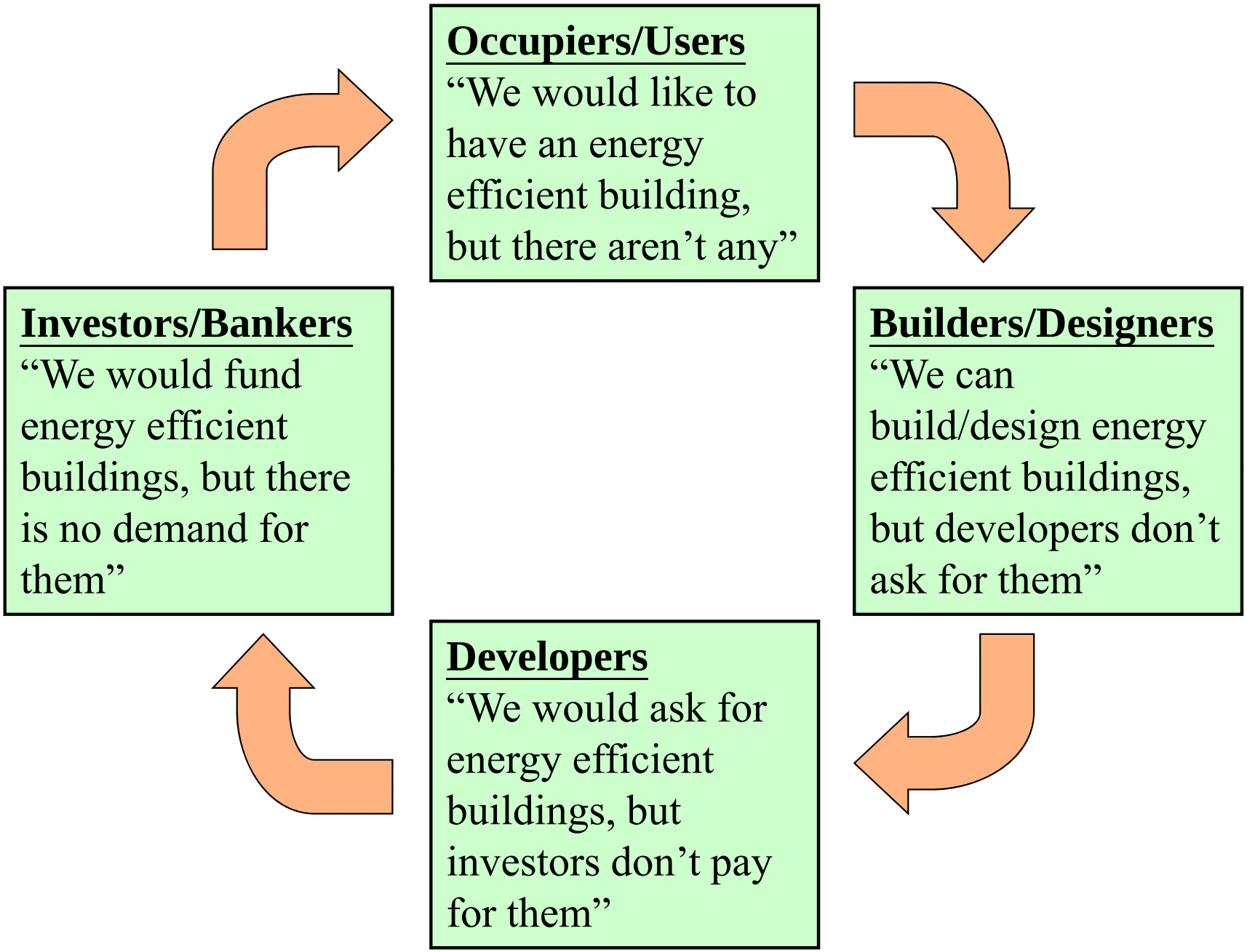
- **Strategy for promoting energy efficiency**
  - Legislation (**PULL**)
    - Building codes, energy laws
  - Market forces (**PUSH**)
    - Improve awareness & information
- Reverse the vicious circle
  - Change market behaviour & overcome barriers
  - Increase investments in energy efficiency measures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

Strategy for promoting energy efficiency in buildings

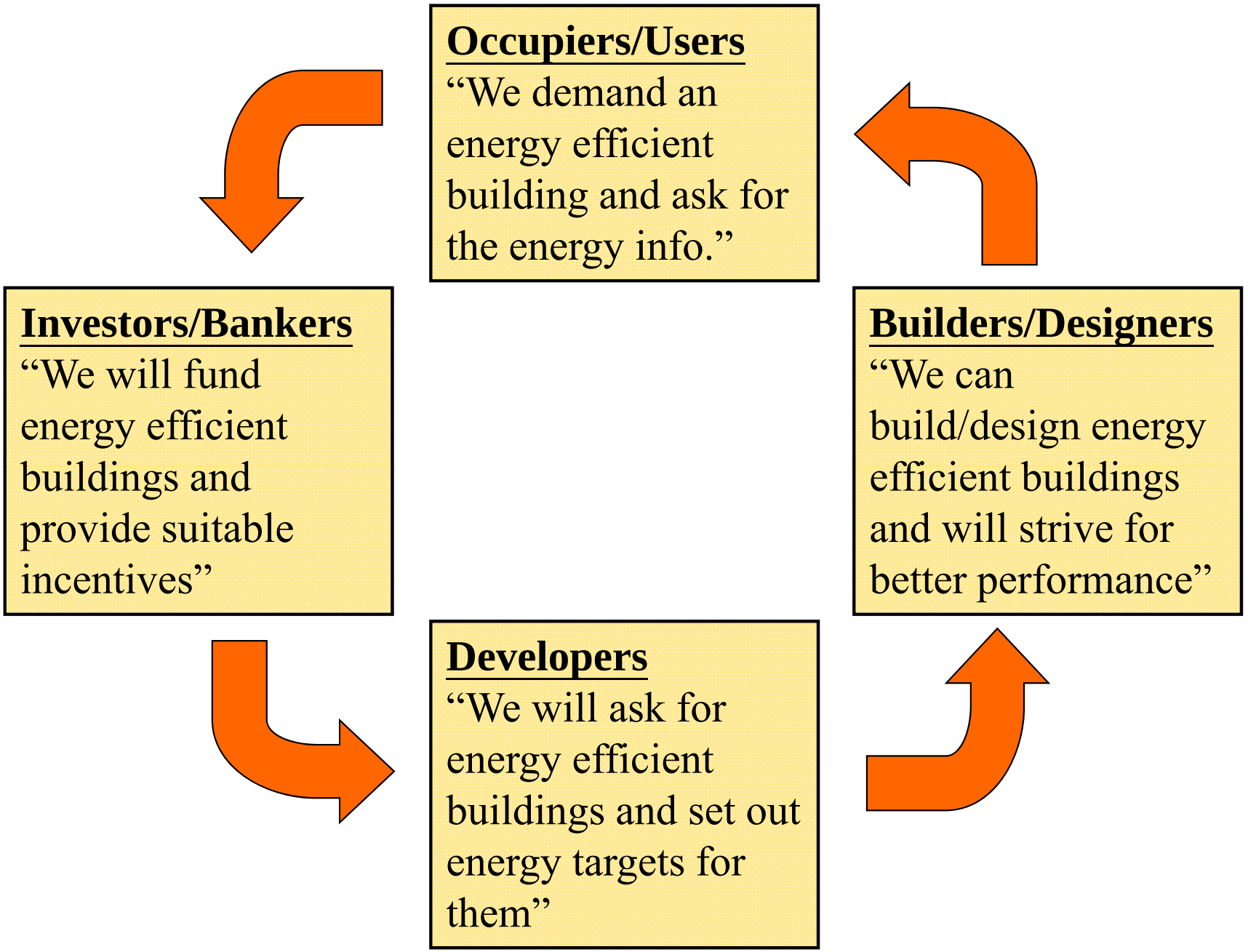


- Building codes
- Energy laws

- Energy labels
- Voluntary schemes

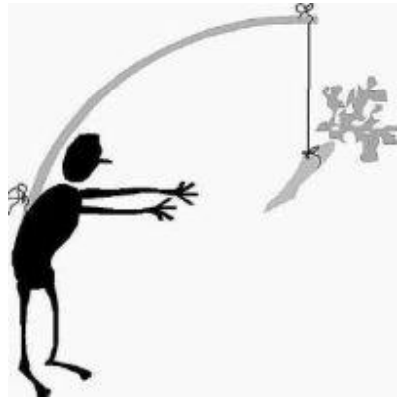


The vicious circle of energy efficient buildings
(From EU studies)



Reverse the viscous circle and overcome market barriers

Implementation issues



- Mandatory vs Voluntary
  - "Stick and carrot" approach
  - Voluntary method only is not effective in commercial markets like Hong Kong
- Strategy for code promotion & enforcement
  - Legislation and incentives
  - Information and education
  - Energy professionals (e.g. Registered Energy Assessor) and technology development

Implementation issues

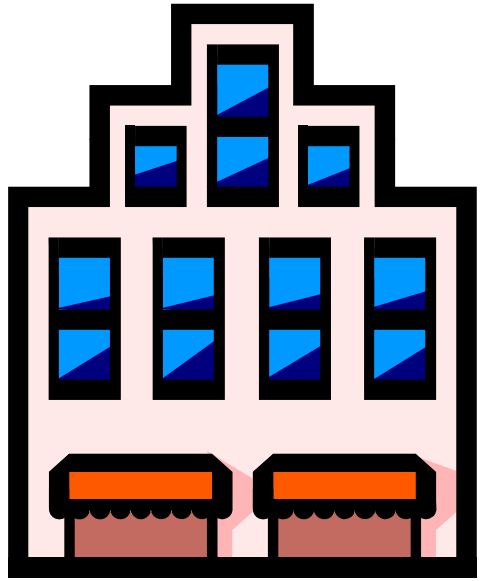
- Good and effective BEC
  - Encourages more efficient design & operation
  - Relatively easy to understand & enforce
  - Gives designers maximum discretion without compromising efficiency
  - Developed with cooperation and input from a variety of stakeholders
  - Accounts for interactions among systems
  - Reviewed and updated regularly

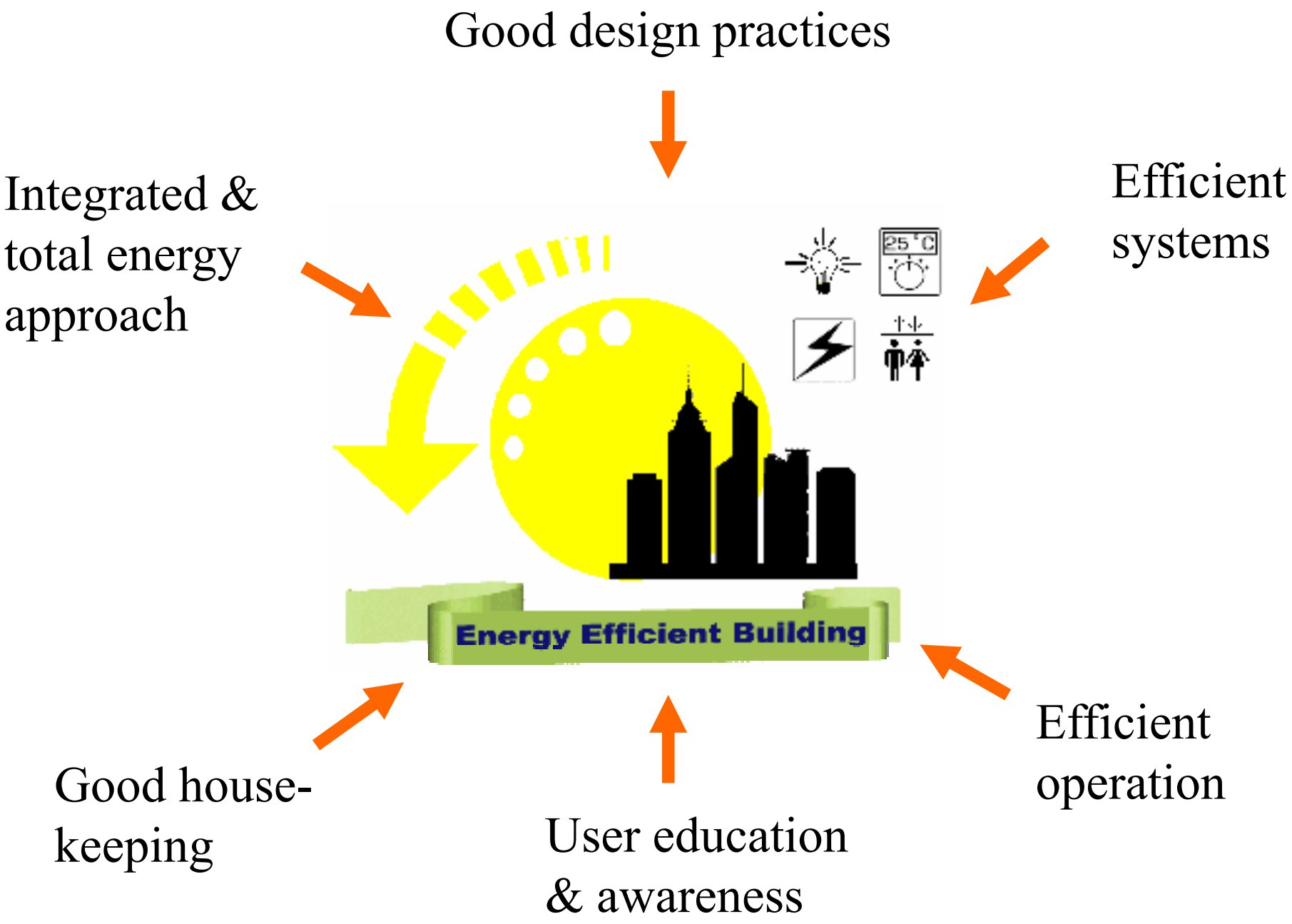
Implementation issues

- Potential drawbacks to BEC
  - Costly bureaucratic burdens on design & construction
  - Can invite abuse (i.e. graft)
  - Are difficult to enforce
  - Typically more “stick” than “carrot”
- Difficulties in developing BEC
  - Every building is unique; not standardised products
  - Must reflect & be responsive to different climates
  - Can be difficult to achieve consensus without compromising stringency

Implementation issues

- 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



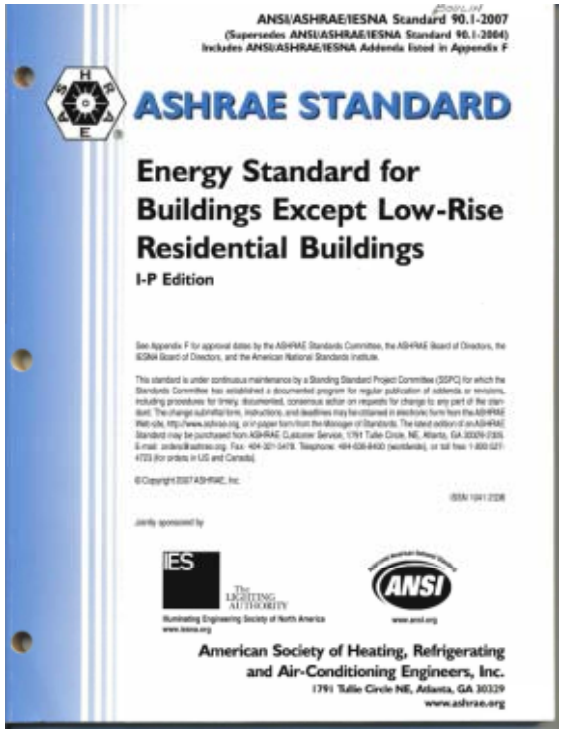

Good design practices
Integrated & total energy approach
Efficient systems
25 °C
Energy Efficient Building
Good house-keeping
User education & awareness
Efficient operation

ASHRAE 90.1

- Study the advanced standards (e.g. ASHRAE 90.1) to enhance the current BEC
  - ASHRAE 90.1: Energy Standard for Buildings Except Low-rise Residential Buildings
  - A reference standard for USA and many other countries in the world
  - It is the professional “standard of care” set by ASHRAE consensus
  - Also, adopted for LEED green building assessment

ASHRAE 90.1

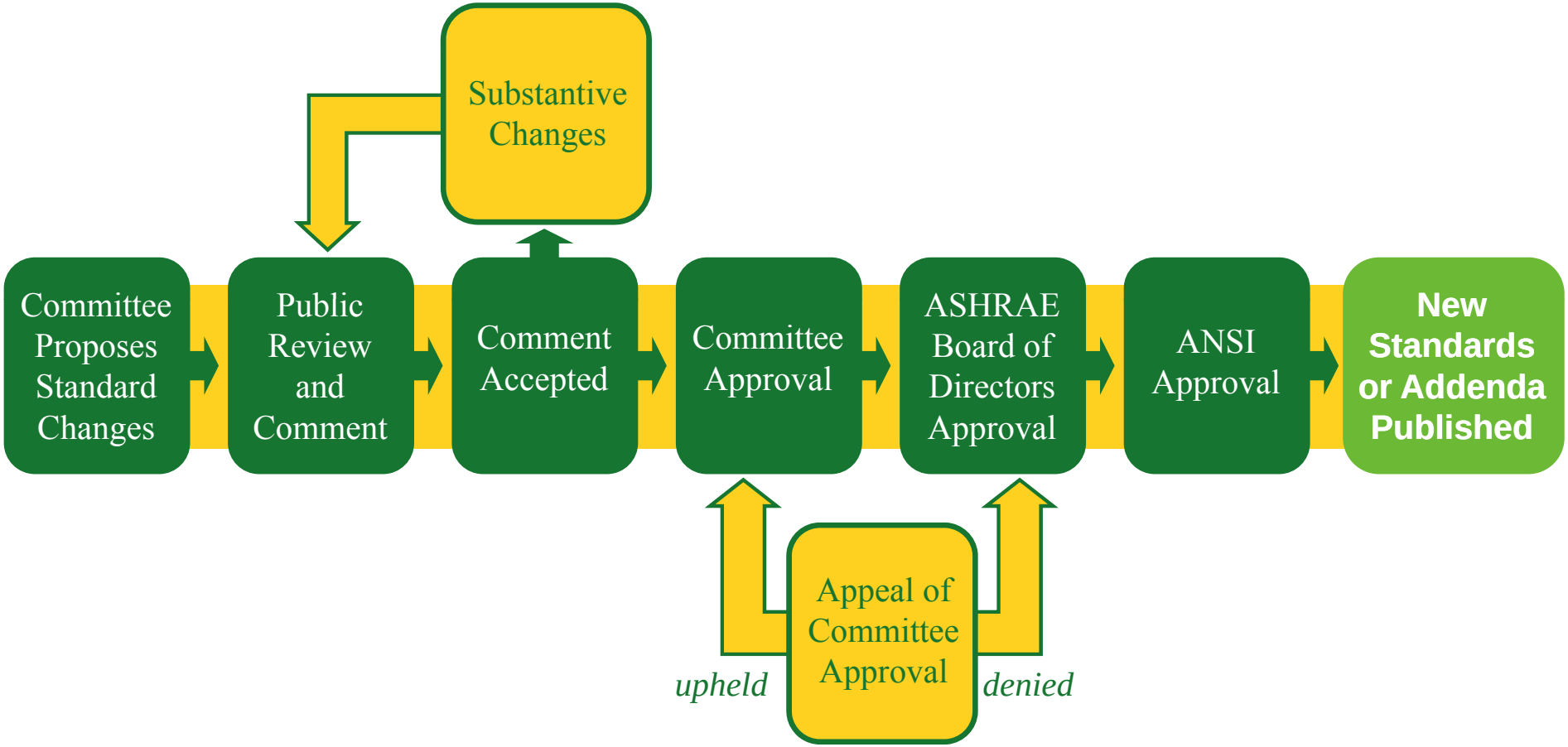
- ASHRAE 90.1 timeline:
  - 90-1975: first issued
  - 90A-1980: updated
  - 90.1-1989: updated
  - 90.1-1999: major rewrite
  - 90.1-2001: minor revisions
  - 90.1-2004: updates, reorganization
  - 90.1-2007: updates



ASHRAE 90.1

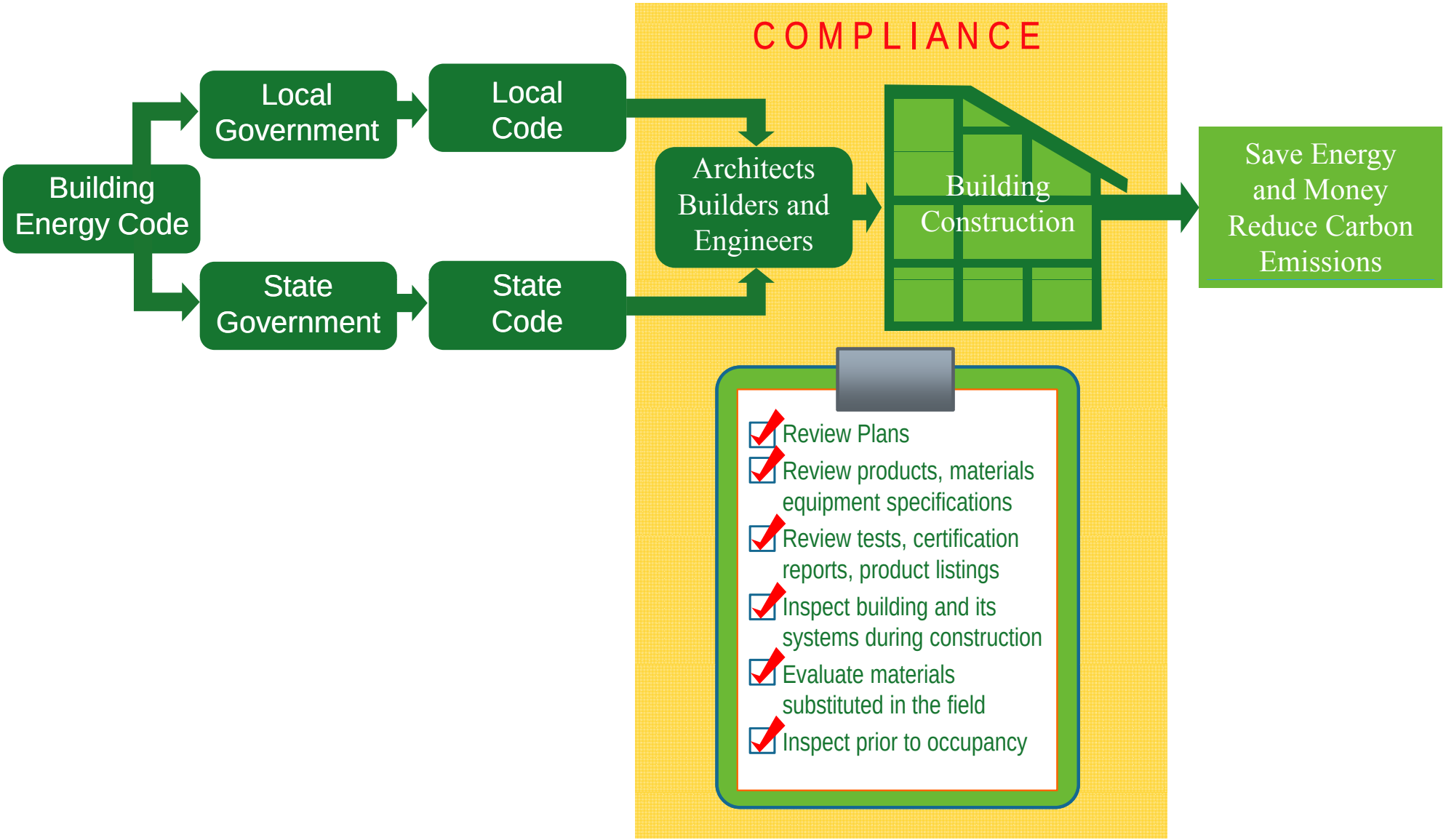
- ASHRAE 90.1-2010 (current version)
  - Goal: to achieve 30% energy savings compared to 90.1-2004
  - May not be met for all buildings types in all locations
- Standard 90.1 is on a 3-year cycle under a "continuous maintenance process"
  - Ongoing changes through "addenda"

ASHRAE 90.1 development process



(Source: US Department of Energy)

Code compliance and the building process in USA



(Source: US Department of Energy)

ASHRAE 90.1

- Structure of Standard 90.1-2010
  - Section 1 - Purpose
  - Section 2 - Scope
  - Section 3 - Definitions, Abbreviations, and Acronyms
  - Section 4 - Administration and Enforcement
  - Section 5 - Building Envelope
  - Section 6 - Heating, Ventilating, and Air Conditioning

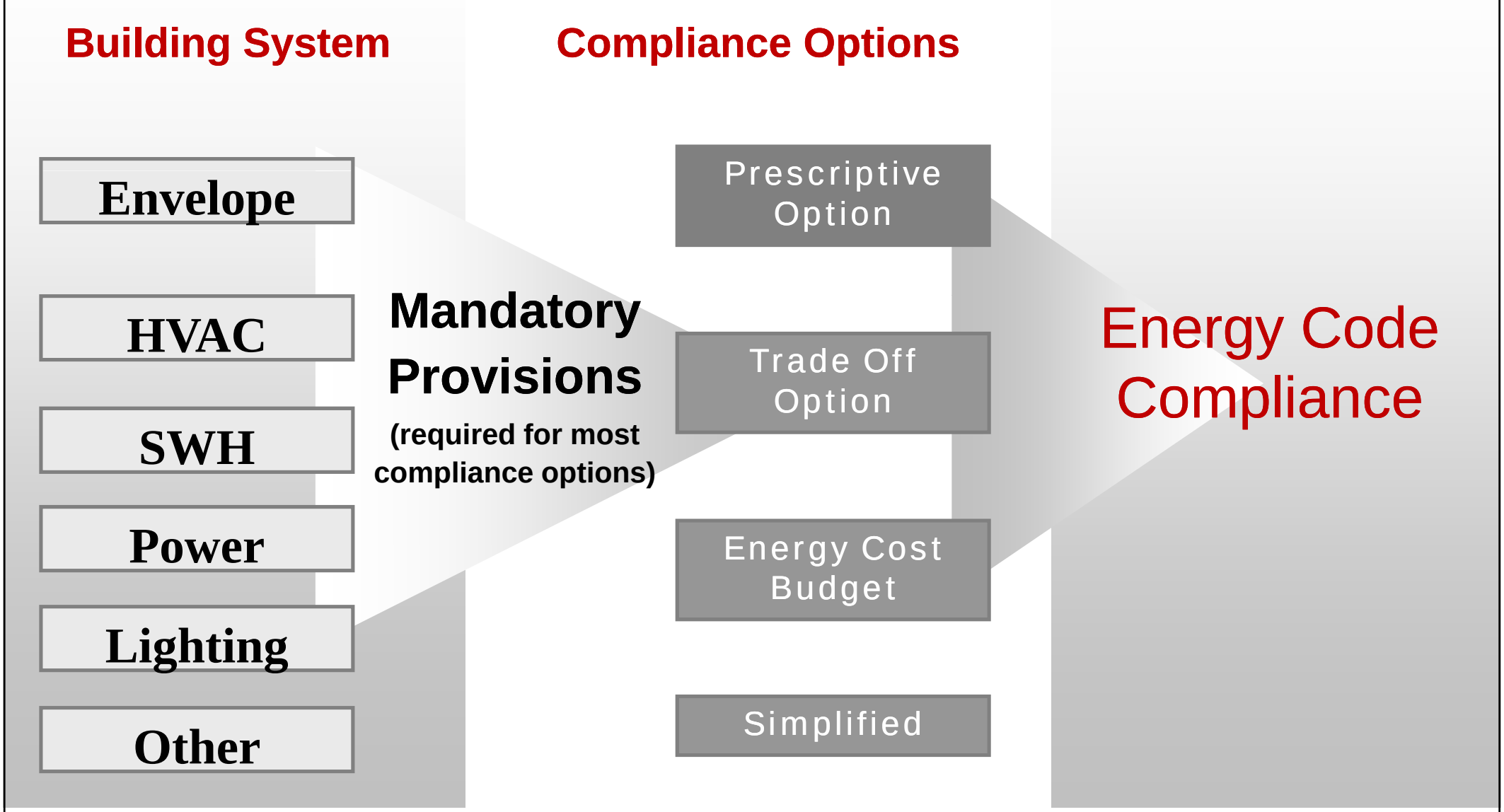
ASHRAE 90.1

- Structure of Standard 90.1-2010 (cont'd)
  - Section 7 - Service Water Heating
  - Section 8 - Power
  - Section 9 - Lighting
  - Section 10 - Other Equipment
  - Section 11 - Energy Cost Budget Method
  - Section 12 - Normative References

ASHRAE 90.1

- Standard 90.1-2010 Appendices
  - Building envelope
    - A – Rated R-Value of Insulation and Assembly U-Factor, C-Factor, and F-Factor Determinations
    - B – Building Envelope Climate Criteria
    - C – Methodology for Building Envelope Trade-Off Option
  - D – Climatic Data
  - E – Informative References
  - F – Addenda Description Information
  - G – Performance Rating Method

ASHRAE 90.1 compliance approaches

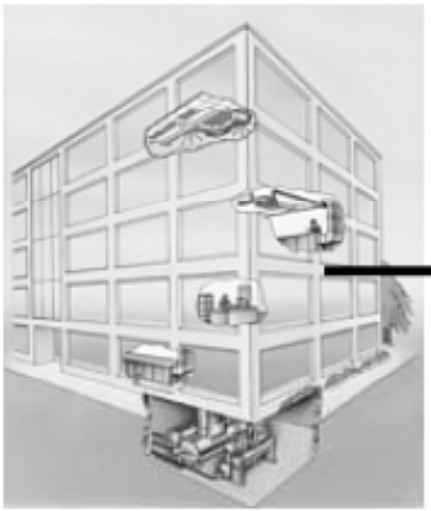


(Source: US Department of Energy)

ASHRAE 90.1

- Building envelope prescriptive option:
  - Window-to-wall ratio (WWR) ≤ 40%, skylight-roof ratio ≤ 5%
  - 8 Criteria sets for different climate types
    - Insulation level, fenestration criteria
- Building envelope trade-off option:
  - Envelope performance factor (EPF) of proposed building ≤ EPF of budget building
    - ENVSTD and ComCheck software

HVAC compliance paths



proposed HVAC design

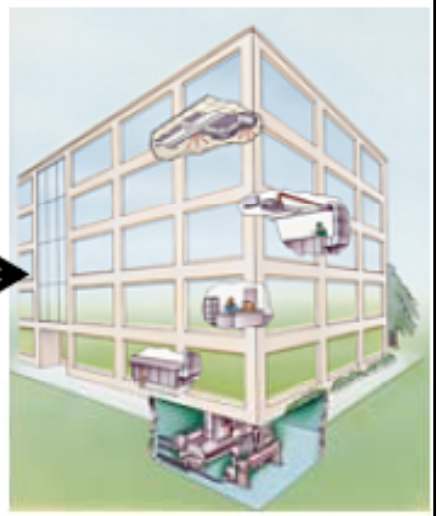
mandatory provisions (§6.4)

prescriptive requirements (§6.5)

Energy Cost Budget Method (ECB, §11)

Simplified Approach Option (§6.3)

(small buildings only)



90.1-compliant HVAC system

(Source: US Department of Energy)

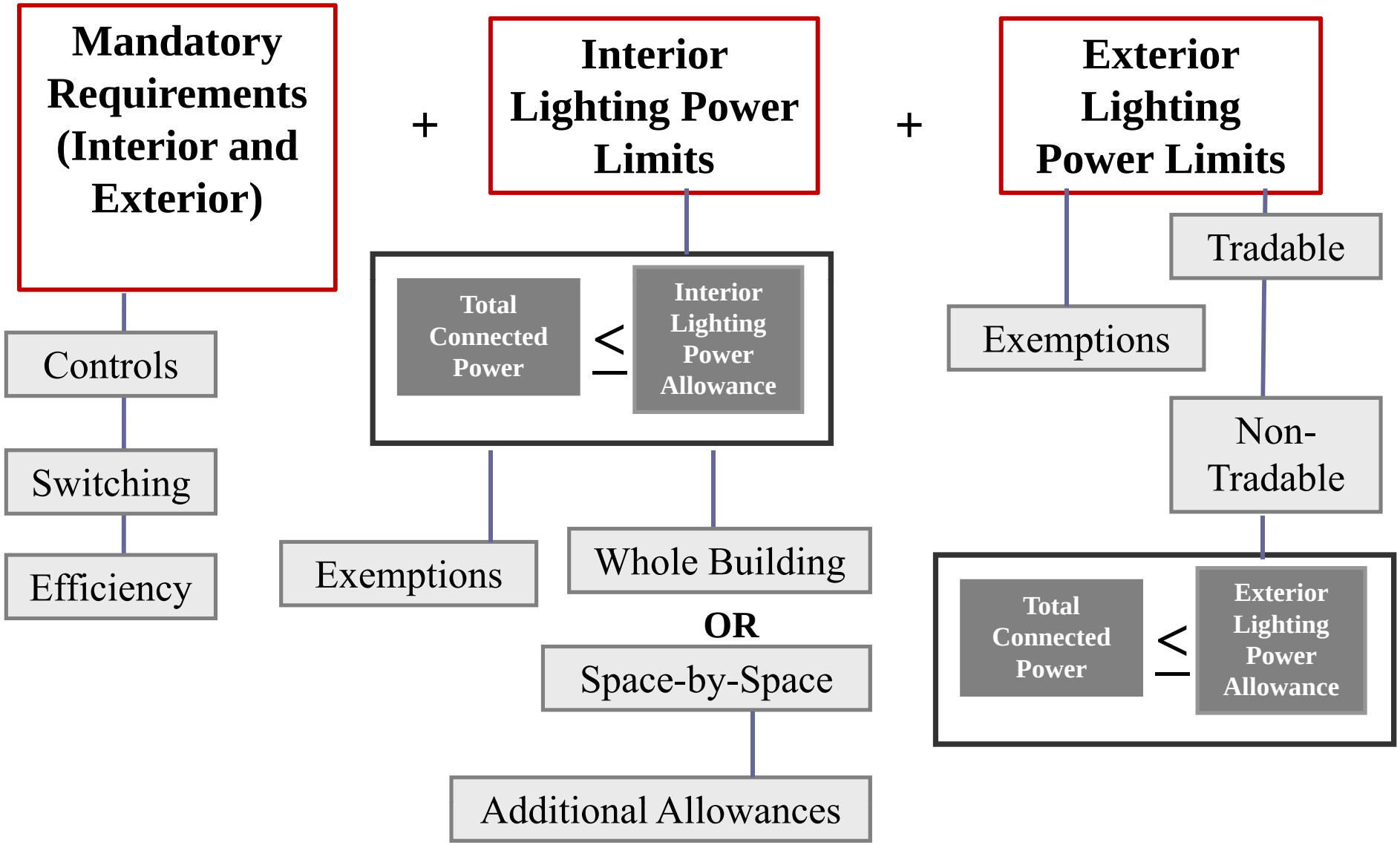
ASHRAE 90.1

- HVAC simplified approach option:
  - Limited to small buildings (< 2,500 sq.m)
- HVAC mandatory provisions:
  - Minimum equipment efficiency
  - Load calculations
  - Controls
  - HVAC system construction and insulation
  - Completion requirements

ASHRAE 90.1

- HVAC prescriptive path:
  - Economizers
  - Simultaneous heating and cooling limitation
  - Air system design and control
  - Hydronic system design and control
  - Heat rejection equipment
  - Energy recovery
  - Exhaust hoods, radiant heating systems
  - Hot gas bypass limitation

Lighting compliance requirements



(Source: US Department of Energy)

ASHRAE 90.1

- Interior lighting power
  - Building area method
    - For whole building, grossed area
  - Space-by-space method
    - For projects w/ well defined space types
- Exterior lighting power
  - Lamp efficacy
  - Exterior lighting power wattage limits

Conclusions

- Energy efficiency is very important to every society in the world
- Building energy codes can help promote energy conservation and set the baseline & ratings for building energy performance
- We could learn from advanced standards (e.g. ASHRAE 90.1) to enhance the BEC
- More education & training on BEC are needed

THANK YOU

Examples of energy efficient buildings