A review of building energy standards and implications for Hong Kong

AN ENERGY EFFICIENCY OFFICE WAS FORMED IN HONG KONG IN 1994 AND REPRESENTS THE TERRITORY ON THE ASIA PACIFIC ECONOMIC CO-OPERATION WORKING GROUP ON REGIONAL ENERGY CO-OPERATION. IT IS HOPED THIS PARTICIPATION WILL ENABLE HONG KONG TO LEARN FROM THE EXPERIENCE OF OTHER COUNTRIES IN THE REGION

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The authors review the current work on energy efficiency in Hong Kong and discuss the prescriptive and performance-based approaches as well as looking at the obstacles and barriers in delivering energy efficiency to the marketplace. It is recognized that more research and development work needs to be done in the territory before comprehensive building energy codes can be introduced.

Les auteurs passent en revue les travaux actuellement en cours sur l'utilisation rationnelle de l'énergie à Hong Kong. Ils examinent les stratégies de caractère normatif ainsi que celles liées aux performances envisagées à cette fin; et mettent en lumière les obstacles rencontrés dans la sensibilisation du marché aux mesures permettant un meilleur rendement énergétique dans les immeubles. L'introduction à Hong Kong de normes relatives à la consommation énergétique dans les immeubles ne sera possible qu'avec une poursuite des travaux de recherche et de développement dans ce domaine.

Keywords: review, building energy standards, policy, commercial buildings, Hong Kong

Introduction

Electricity use in the commercial sector from 1970–1994 has been gathered and analysed. Energy use in commercial buildings has been growing at an average annual rate of 10% during this 25 year period. This is a priority area the Hong Kong government has focused on. The developments of energy efficiency programmes and building energy standards in Hong Kong and other countries have been reviewed, and implications for the development of a building energy code for commercial buildings in Hong Kong are discussed.

Buildings, energy and the environment are issues that the building professions have to address in many building development projects. This is partly due to the increased public awareness of environmental issues related to building developments, which, in turn, has resulted in increasing public pressure on the authority to provide better environmental protection and tighter legislation. In Hong Kong, there have been growing concerns about energy consumption and its implications for the environment. Hong Kong has no indigenous fuel resources. The territory has to import coal and oil products to meet energy needs. Most of the imported fossil fuels are used for electricity generation, about 70% in 1994. During the past two decades, Hong Kong saw a substantial rise in electricity consumption, particularly in the commercial sector. This is mainly due to increased business activities and the shift of the local economy from manufacturing-based to service-oriented. Most of the manufacturing business has moved north into mainland China because of much lower labour and land costs.

Figure 1 shows the electricity consumption in the commercial sector from 1970–1994 [1]. Electricity use rose at an average annual rate of 10%, from

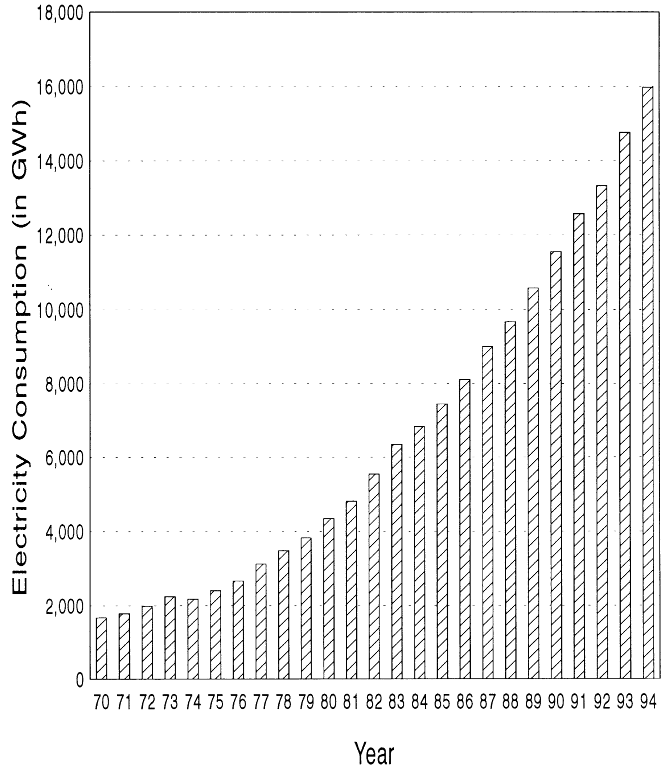

Fig. 1. Electricity consumption in the commercial sector from 1970–1994.

1673 GWh in 1970 to 15 975 GWh in 1994. Much of the electricity use is for artificial lighting and air-conditioning in commercial buildings such as offices, hotels and shops. To address the energy issues, the Energy Efficiency Advisory Committee (EEAC) was set up in April 1991 to advise the Hong Kong government on energy efficiency in the territory. Energy use in commercial buildings is one of the priority areas the EEAC has focused on. Previous work by Janda and Busch [2] has indicated that building energy standards, codes and guidelines, particularly for the commercial sector, are becoming more important in future national energy policies. This paper reviews the development of energy efficiency programmes and standards for buildings in Hong Kong and other countries, and discusses the implications for the energy-efficiency standards for commercial buildings in Hong Kong.

Review of building energy standards

The development and current status of building energy standards (BES) in the United States (US), five ASEAN (the Association of Southeast Asian Nations) countries and Hong Kong are briefly reviewed. ASEAN countries have been chosen for this study because, to a certain extent, their social structure and climate (cooling requirements) are similar to Hong Kong. Furthermore, like Hong Kong these countries have fast economic growth and rapid building and infrastructure development projects in recent years. The US is included because the ASEAN countries's BES development is largely based on US experience and methodology.

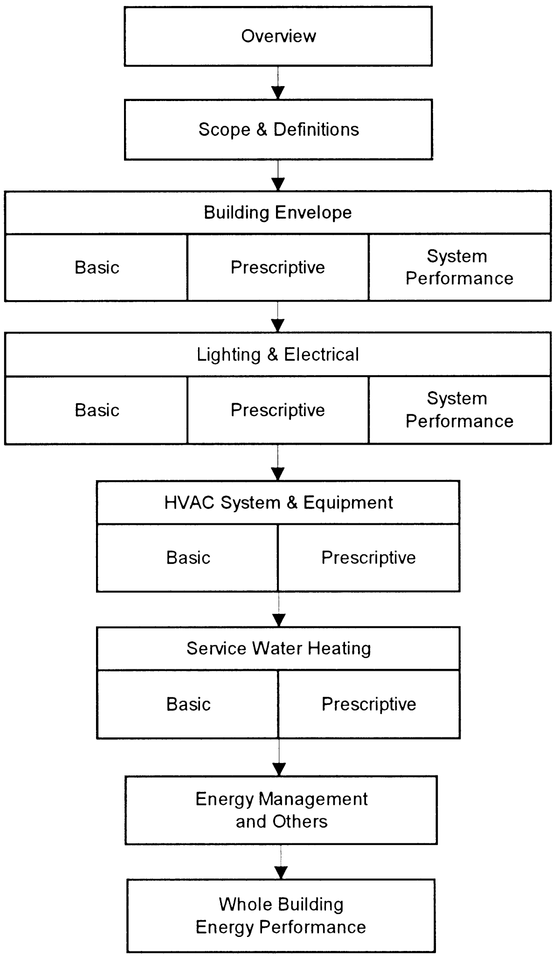

Fig. 2. Basic structure of the ASHRAE standard 90.1-1989.

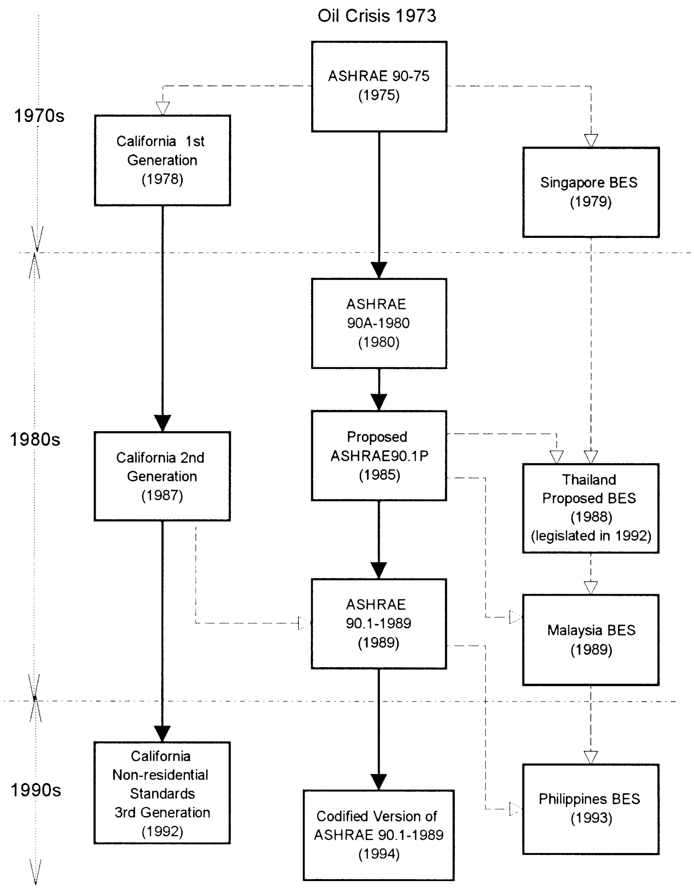

Fig. 3. Development of California, ASHRAE and ASEAN building energy standards.

United States

The US government plays an active role in the BES promotion and development. Major US federal laws affecting BES include: (a) 1975 Energy Policy and Conservation Act (EPCA), Public Law 94-163; (b) 1976 Energy Conservation and Production Act (ECPA), Public Law 94-385; and (c) 1992 Energy Policy Act (EPAct), Public Law 102-486.

The 1975 EPCA provided the basis for the exchange of information for international energy programmes, and directed states to adopt energy standards. The 1976 ECPA marked the initial involvement of the US federal government in developing mandatory building energy performance standards. BES proposals (known as '10 CFR Part 435') were prepared by the US Department of Energy (USDOE), the prime US agency for promoting energy standard-related activities.

The 1992 EPAct is the most important US Act on BES in the 1990s. Under the EPAct, every state was required to certify before October 1994 that its commercial BES provisions met or exceeded the requirements of the ASHRAE 90.1-1989 Standard developed by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) [3]. Geller *et al.* [4] have estimated that the EPAct will result in 20% energy savings in half of the new commercial buildings constructed during 1995–2010.

The ASHRAE Standards 90 series and the underlying principles are by far the most widely adopted model in the US and some countries in Asia. The first edition was published in 1975 after the first oil crisis [5], later revised in 1980 to contain three parts, 90A-1980, 90B-1975 and 90C-1977 [6]. In 1983, USDOE funded ASHRAE to form a Special Project to upgrade the 90A-1980 Standard to a new Standard 90.1. A draft ASHRAE Standard 90.1P was published in 1985 for consultations, and the ASHRAE Standard 90.1-1989 for commercial buildings [3] was finally published in 1989. The basic structure of ASHRAE 90.1-1989 is shown in Fig. 2.

Besides the federal laws and the ASHRAE energy standards, a wide range of different approaches are used in different states, ranging from simple thermal insulation requirements to advanced simulation-based building energy performance standards. California is particularly active in this area. Its building energy standard, known as 'California Title 24', is now in its third generation and often forms an important reference for advanced BES development, including the ASHRAE Standard 90 series. Figure 3 shows the development of the ASHRAE and California standards, and their relationship with the development of BES in some ASEAN countries.

ASEAN countries

The five ASEAN countries considered in this study are Indonesia, Malaysia, Philippines, Singapore and Thailand. Singapore was the first nation to develop BES which was implemented in 1979 for commercial buildings through the Building Control (Space, Light and Ventilation) Regulations. The development of Singapore's BES was largely based on the ASHRAE

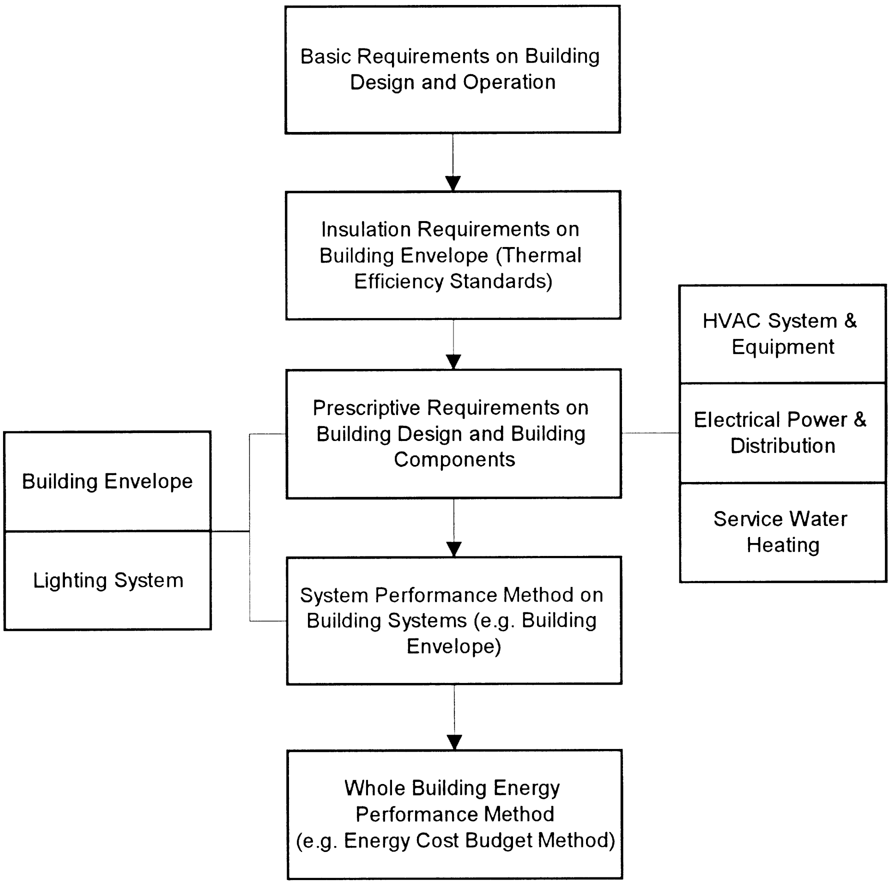

Fig. 4. Requirements and compliance of building energy standards.

Standards 90-75 [5] and 90-80A [6], but with some modifications to suit local climatic conditions and construction practices [7]. The Overall Thermal Transfer Value (OTTV) method originated from ASHRAE was adopted for legislative controls of the building envelope designs. OTTV is basically a measure of the amount of heat gain through the building envelope into the building. It is an index to compare the thermal performance of buildings – the larger the OTTV, the more the heat gain [8]. A handbook was published in 1979 (later revised in 1983) to assist practitioners in meeting the design requirements [9], and a set of code of practice (Singapore Standard CP24) on lighting and air-conditioning was developed to complement the regulations on building envelope designs.

The other four ASEAN countries started their research work in the 1980s using Singapore's development as a reference model. Indonesia [10], Malaysia [11], Philippines [12] and Thailand [13] have all developed guidelines for energy-efficient designs in commercial buildings. They have also made reference to the new generation of ASHRAE Standards 90 series, including the draft 90.1P and the completed 90.1-1989 (see Fig. 3). All of them adopted the basic OTTV concept on the building envelopes, but their OTTV methods have been refined to reflect local conditions and simplify compliance. The provisions for lighting, HVAC systems and electric power are similar in nature and follow the principles of the ASHRAE Standard 90 series.

An important supporting source for the BES development in the ASEAN countries is the ASEAN-USAID Building Energy Conservation Project which began in 1982. Important efforts provided by this project include:

1. Transfer of the DOE-2 programme [14] to ASEAN.
2. Training for ASEAN participants on the DOE-2 programme, energy analysis methods and energy auditing techniques.
3. Funding to support some 22 related research projects throughout ASEAN.
4. Research works and analyses conducted by the Lawrence Berkeley Laboratory in California in association with the local co-ordinators in ASEAN.
5. US consultants working with ASEAN government officials and private sector participants to design energy conservation programmes and policies.

Hong Kong

In 1980, a Joint Steering Committee on Energy Conservation in Buildings was set up by the government, architects and engineers to consider ways to conserve energy, and a pilot study was carried out by the Hong Kong Branch of the Chartered Institution of Building Services Engineers [15]. In October 1990, a consultancy study was commissioned by the Hong Kong government on the possibility of legislative controls of building envelope designs for air-conditioned commercial buildings; and the study was completed in August 1991 [16]. A draft OTTV handbook was produced in the following year, suggesting OTTV limits of 16 and

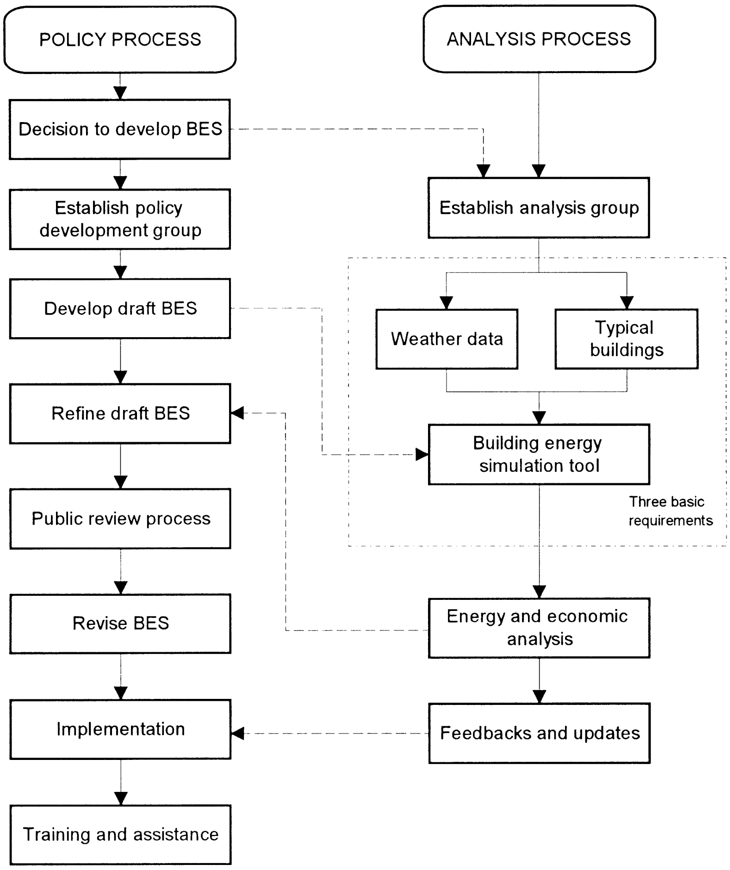

Fig. 5. Development process of building energy standards.

30 W per m^2 for commercial buildings and hotels, respectively [17].

The building professions expressed concerns about the proposed legislative controls. The architects considered the draft OTTV code too stringent and over-restrictive, and suggested it remain strictly for guidance purposes only [18]. The engineers also perceived the proposed code too stringent which could lead to considerable architectural constraint and environmental impact [19]. Lam *et al.* [20] proposed an alternative OTTV limit of 29 W per m^2 for commercial buildings (including hotels). It is believed that this proposed OTTV limit can achieve the aim of limiting heat gains into buildings through the building envelopes without imposing undue constraints on the prevailing local architectural designs and construction practices. After lengthy consultations with the building professions, an OTTV limit of 35 W per m^2 was agreed for commercial buildings (including hotels) and a much relaxed 80 W per m^2 was stipulated for podiums [21]. Podium refers to the lower part of a building which is within 15 m above street level. Most large commercial building developments have office towers on top of commercial podiums such as shopping arcades and restaurants. The OTTV legislative controls finally became effective on 21 July 1995, under the Building (Energy Efficiency) Regulations.

The OTTV legislation is only an initial step to develop a comprehensive building energy code covering all aspects of building and building services designs. Research and development work on lighting and air-conditioning are being conducted. It is envisaged that appropriate legislative controls of lighting and air-conditioning designs will be added onto the current Building (Energy Efficiency) Regulations if and when these are ready.

Comparisons of OTTV standards

OTTV is a measure of the heat transfer through the external envelope of a building and can be expressed as:

$$OTTV = \frac{Q}{A} \qquad (1)$$

where

$Q =$ total heat transfer through the building envelope (W)

$A =$ gross area of building envelope (m^2)

Three components of the heat gain are considered, namely conduction through opaque walls, conduction through window glass and solar radiation through window glass. The usual practice is to have two sets of OTTV – one for the exterior walls (including windows) and the other for the roof (including skylights, if any). The approach and equations for calculating the roof OTTV are similar to those for the walls. Calculation for the roof is often much simpler since the roof does not usually contain large amounts of glazing. As the walls at different orientations receive different amounts of solar radiation, the general procedure is to calculate first the OTTVs of individual walls with the same orientation and construction, then the OTTV of the whole exterior wall is obtained by the weighted average. Thus:

$$OTTV_i = \frac{Q_{wc} + Q_{gc} + Q_{sol}}{A_i} = \frac{(A_w \times U_w \times TD_{eq}) + (A_f \times U_f \times DT) + (A_f \times SC \times SF)}{A_i} \quad (2)$$

where

$OTTV_i$ = overall thermal transfer value of walls with the same orientation and construction (W/m^2)
Q_{wc} = heat conduction through opaque walls (W)
Q_{gc} = heat conduction through window glass (W)
Q_{sol} = solar radiation through window glass (W)
A_w = area of opaque wall (m^2)
U_w = U-value of opaque wall (W per m^2× K)
TD_{eq} = equivalent temperature difference (K)
A_f = area of fenestration (m^2)
U_f = U-value of fenestration (W per m^2× K)
DT = temperature difference or delta temperature between exterior and interior (K)
SC = shading coefficient of fenestration (dimensionless)
$= SC_{win} \times SSF$
SC_{win} = shading coefficient of window glass (dimensionless)
SSF = solar shade factor of external shading devices (dimensionless)
SF = solar factor of fenestration (W per m^2)
A_i = gross area of the walls (m^2) $= A_w + A_f$

and,

$$OTTV_{wall} = \frac{\sum_i (OTTV_i \times A_i)}{\sum_i A_i} \quad (3)$$

where $OTTV_{wall}$ = OTTV of the whole exterior wall (W per m^2)

Alternatively, Equation 3 can be written in a compact form using the term window-to-wall ratio (WWR):

$$OTTV_i = (1 - WWR) \times U_w \times TD_{eq} + WWR \times U_f \times DT + WWR \times SC \times SF \quad (4)$$

where WWR = window-to-wall ratio (gross wall area) $= A_f / A_i$

When applied in different countries, the general form of the OTTV equation may have been modified to eliminate unimportant terms and include additional variables. For example, the glass conduction component was dropped in Malaysia [11] and Hong Kong [21]. Furthermore, the OTTV parameters such as the temperature difference (DT) and solar factor (SF) are governed by the prevailing local weather conditions. Consequently, each location has its own specific values for DT and SF. A comparison of the OTTV standards is shown in Table 1.

Table 1. Comparison of OTTV standards in ASEAN and Hong Kong

	Singapore	**Malaysia**	**Indonesia**	**Thailand**	**Philippines**	**Hong Kong**
Latitude (North)	1° 20′ Singapore	3° 7′ Kuala Lumpur	6° 11′ Jakarta	13° 41′ Bangkok	14° 35′ Manila	22° 18′ Hong Kong
Year adopted	1979	1989	Proposed	1992	1993	1995
Current status	Mandatory	Voluntary	Proposed	Mandatory	Voluntary	Mandatory
OTTV limits for walls (W per m^2)	45	45	45	45	48	Tower : 35, podium: 80
OTTV limits for roof (W per m^2)	45 (max. U-value if no skylights)	25 (max. U-value if no skylights)	N/A	25 (max. U-value if no skylights)	Max. U-value if no skylights	(average for walls and roof)
TD_{eq} for walls (K)	10–15	19.1α	10–15	9–18	12.65α (office) 5.4α (hotel)	1.4–7.5
TD_{eq} for roof (K)	16–24	16–24	N/A	12–32		7.9–18.6
DT for walls (K)	5	neglected	N/A	5	1.1–3.35	neglected
DT for roof (K)	5	neglected	N/A	5		neglected
Average SF for walls (W per m^2)	130	194	147	160	161 (office) 142 (hotel) 151 (store)	160
Average SF for roof (W per m^2)	320	488	N/A	370	—	264
Consider exterior shading?	Yes	Yes	N/A	Yes	No	Yes
Daylighting credits?	No	Yes (10% or 20%)	N/A	N/A	Yes (10%)	No

Notes: 1. OTTV = overall thermal transfer value; TD_{eq} = equivalent temperature difference (for walls or roof); DT = temperature difference (for windows); α = solar absorptivity of walls; SF = solar factor.
2. Average SF for walls is calculated for the four principal directions (N, E, S, W).

Table 2. Summary of variables for reference building envelope

Wall	Opaque wall	U-value	2.5 W per m^{2}K
		Absorptivity	0.7
	Window	U-value	6 W per m^{2}K
		Shading coefficient	0.35
		Window-to-wall ratio	44%
Roof	Opaque roof	U-value	0.6 W per m^{2}K
		Absorptivity	0.7
	Skylight	U-value	6 W per m^{2}K
		Shading coefficient	0.35
		Skylight-to-roof ratio	15%

The OTTV standards of Singapore, Thailand and Hong Kong are mandatory while those for Malaysia and Philippines are voluntary (the one for Indonesia is a proposal). It is interesting to note that the magic number 45 W per m^2 is often used as the wall OTTV limit in ASEAN, although the OTTV parameters in their OTTV equations are not all the same [22]. The OTTV limits for Hong Kong are 35 W per m^2 for tower and 80 W per m^2 for podium. One cannot compare Hong Kong's 35 W per m^2 literally with the 45 W per m^2 OTTV limit in say Singapore, and conclude that Hong Kong's OTTV standard is more stringent because it is 10 W per m^2 lower. This is because the OTTV parameters are different. To illustrate this, a reference building envelope which meets the 35 W per m^2 OTTV limit in Hong Kong is developed for comparison. It is proposed that reflective glass with a shading coefficient of 0.35 would be reasonable (most of the reflective glass has a shading coefficient between 0.3 and 0.4 in Hong Kong). A U-value of 2.5 W per m^2 is proposed for the opaque wall (e.g. typical concrete wall with tiles and rendering and with no thermal insulation), and 0.6 W per m^{2}K for roof (e.g. typical roof construction with 50 mm thermal insulation). For glazing, the actual U-value depends mainly on the inside and outside surface resistances. For simplicity, a U-value of 6 W per m^{2}K is assumed for single glazing in the present study. These proposed building variables are summarized in Table 2.

Based on this proposed reference building envelope and the Hong Kong OTTV parameters [21], OTTVs for the wall and the roof have been found to be 28.5 and 18.6 W per m^2, respectively. Both the wall and the roof are assumed to be of medium to heavy weight construction.

To gain some idea of how the proposed reference building envelope would fare when compared with requirements stipulated in ASEAN OTTV standards, OTTVs for the reference building envelope have been calculated using parameters given in the respective ASEAN OTTV standards. These are summarized in Table 3. It can be seen that the proposed reference building envelope meets the Singapore roof limit but exceeds the wall limit of 45 W per m^2 by about 2 W per m^2. In other words, although numerically, the Singapore OTTV limit is higher than the Hong Kong OTTV limit, Singapore is more stringent than Hong Kong. For the Malaysian Standard, the proposed envelope exceeds both wall and roof OTTV limits. Comment on Thailand is similar to that on Singapore.

Implications for Hong Kong

Building energy standards can help raise concern and awareness of building energy conservation, promote energy-efficient designs and operation in buildings, encourage the development of energy-conservation building products and services industry, and form a basis for assessing energy performance and developing energy efficiency programmes. Generally speaking, there are two types of BES, prescriptive and performance-based. The prescriptive approach specifies the minimum requirements for each building component to satisfy the standards, such as minimum insulation levels and equipment efficiencies. Prescriptive standards are simple to use and relatively easier to implement, but their effect on building energy conservation is indirect since none of them deal with the building as a whole. Old versions of BES are often prescriptive in nature. The Hong Kong OTTV standard is prescriptive.

Performance-based approach, on the other hand, sets a maximum allowable energy consumption level without specifying the methods, materials and processes to be employed to achieve it, but with a statement of the requirements, criteria and evaluation methods. It is concerned with what the building (or building product) is required to do, rather than prescribing how it is to be constructed. The onus will be on the designer to present a design solution together with appropriate predictive evidence of its energy behaviour. It is envisaged that the comprehensive building energy code, which the Hong Kong government is working on, will be performance-based.

Although the benefits of efficient energy use are realized by most people, the marketplace and government policies are not always structured in a way that encourages efficient use of all available energy resources. The obstacles and barriers to delivering energy efficiency to the market have been discussed by Fitzsimons [23]. The difficulties can be categorized into three main areas:

1. *Separation of interests* – building developers usually bear the costs with energy efficiency investment while savings accrue to building

Table 3. Comparing OTTV limits with the OTTVs of the reference building envelope (RBE)

		Singapore	Malaysia	Thailand	Hong Kong
Wall OTTV (W per m^2)	Limit	45	45	45	35
	RBE	47.1	48.5	54.3	28.5
Roof OTTV (W per m^2)	Limit	45	25	45	35
	RBE	29.5	38.3	34.1	18.6

owners and tenants. Unless for an owner-occupied building with energy-conscious users, energy conservation is usually not taken as a major item in the overall budget of building development projects.

2. *Imperfect market structure* – the business market mechanism for energy efficiency is imperfect with various time and capital constraints. The problems of imperfect information and transaction costs may bias rational consumers to purchase devices that use more energy and the market alone will never ensure optimum investment in energy efficiency.

3. *Social and institutional barriers* – Blumstein *et al.* [24] has found that it is essential to consider not only the efficiency of strategies in achieving the goal of energy efficiency, but also their impact on the social and economic goals. The lack of institutional support and co-ordination at the community or national level is often a critical factor undermining the effectiveness of energy conservation strategies.

There are also other obstacles specific to Hong Kong. High land costs often work against energy conservation in Hong Kong as the percentage value of energy costs is small when compared with the building rental value. Blake [25] has found that because of the substantial land value element, building owners or users were not interested in the saving of energy costs. The developers are more concerned with making their development more attractive for sale or letting than with the investment associated with energy efficiency designs. Tenants of leased commercial buildings have little incentive to conserve energy since they are often charged a fixed sum on a superficial area basis for the landlord utilities. It has also been found that in Hong Kong electricity is perceived as a commodity rather than a non-renewable resource. People are generally wary of making investment in energy conservation measures because of the lack of understanding and the uncertainty of paybacks. Some people are even afraid that energy conservation may have an adverse effect on economic growth.

It is believed that successful BES, which are well received by the public and the building professions, can help break down the barriers and overcome the obstacles. Lim [26] pointed out that the success of BES depended on the will of the authorities to persist with the policy, the back-up of research and development, and the co-operation of the professions to accept any initial inconvenience. There are a number of issues to be addressed. Firstly, on the types of buildings that the BES will be applied. Classification by building type is important. Different buildings (e.g. offices, hotels and shops) cater for different functions with different operating hours and hence have varying energy consumption characteristics. The current Hong Kong OTTV standard only deals with the building envelope designs, classification of different commercial (non-residential) buildings, therefore, is not crucial at this stage. However, when the lighting and air-conditioning codes are considered, building types will need to be addressed to allow for the varying functional requirements and hours of operation of the buildings and the building services systems.

Secondly, compliance methodology should be tailor-made to suit the local situation as well as the different stages of BES development. BES usually contain some basic requirements which must be met at all times, such as the selection of design conditions and calculation procedures. Then, there are different alternative paths to demonstrate compliance, such as prescriptive path, system performance path and energy cost budget (or whole building performance). The common compliance methods of BES are shown in Fig. 4. The most common components of the building and building services designs addressed include the building envelope, HVAC systems and equipment, lighting, electric power, auxiliary systems, service water heating and energy management systems. Some BES makers may initially settle for prescriptive methods in some parts or the whole of the standard, but with an ultimate aim at a performance-based approach. For maximum flexibility to suit different users, the BES may include both prescriptive and performance options as well as an alternative compliance path.

Thirdly, the implementation and enforcement issues need to be tackled. It usually takes at least two years for the BES to have any impact on energy consumption. Any energy efficiency programme should consider the timing of the basic studies, consultation, implementation, impact assessment and feedbacks. The Hong Kong government will review the OTTV legislation two years after its implementation. If the BES are mandatory, then there must be well established and clearly defined procedure so that the BES can be checked and enforced. However, this may not be feasible because of the complexity involved with the building and building services designs and their operating characteristics. This raises the question of whether BES should be voluntary as guidelines or mandatory. There is no hard and fast rule about which one is more effective since the success of BES depends not only on how it is designed and coded but also on how it is implemented and publicized. Protagonists of mandatory approach argue that voluntary guidelines will not ensure high building energy efficiency. The market force which is found useful in domestic appliance standards (e.g. refrigerators and room air-conditioners) cannot be easily applied to buildings [27]. Statutory requirements will help level the playing field for developers and builders as energy-conscious designers and building professionals will not have to compete with others who achieve construction cost savings by eliminating or ignoring energy-efficient features. It is the government's responsibility to make sure that the efficient, not the easy path is followed.

Supporters of the voluntary approach, however, believe that mandatory standards are limiting design freedom and innovations if the BES are not comprehensive and flexible enough. Setting appropriate standards is difficult since what may be desirable in one building may be inappropriate in another, and various buildings show widely different energy use patterns which are difficult to explain and analyse. Mandatory codes, voluntary codes, and a mixture of both are now found in different parts of the world [2]. It is envisaged that Hong Kong will have a mixture of mandatory codes and voluntary guidelines to cater for certain aspects of the building and building services designs that cannot be well defined. No matter what approach is used, a crucial factor is the acceptance of the policy as a whole by the public and the professions.

Fourthly, although the principles in building energy efficiency established in other countries can be referred to when developing one's own BES, local information is required to formulate specific requirements and to justify the methods adopted. Deringer and Levine [28] have suggested two main processes for systematic BES development, namely policy and analysis. Figure 5 shows the key steps and components of the two processes. The actual procedure of BES development in a country will depend on the local circumstances, but the basic structure will be similar. There are three basic requirements to support the development of BES in the analysis process. These are the development and analysis of local weather data, analysis and establishment of typical buildings, and the development of building energy simulation techniques and analysis. The Building Energy Conservation Unit at the City University of Hong Kong has been conducting research and development work on these three areas as part of efforts to develop energy standards for both residential and commercial buildings.

Conclusions

There has been a marked increase in energy consumption in Hong Kong, particularly electricity use in commercial buildings. Overseas experience in energy efficiency activities indicates that building energy standards, codes or guidelines are becoming increasingly important in the formulation of energy efficiency policies. Compared with some of its Asian neighbours, Hong Kong is a newcomer in the development of building energy standards. The encouraging sign is that the Hong Kong government begins to recognize the energy and environmental issues. Apart from the Energy Efficiency Advisory Committee set up in 1991, an Energy Efficiency Office (EEO) was formed in 1994. The EEO is staffed with a number of building and engineering professionals to develop and carry out energy efficiency programmes in the territory. The EEO also represents the Hong Kong government on the Asia Pacific Economic Co-operation (APEC) Working Group on Regional Energy Co-operation. This will certainly enable Hong Kong to exchange ideas and information with other countries in the Asia Pacific region, and hopefully learn from their experience in energy efficiency issues. With the introduction of the prescriptive legislative controls of the building envelope designs in July 1995, it is hoped that a more comprehensive building energy code or standard covering all aspects of building and building services designs would be developed and introduced in the not too distant future. More research and development work is still needed though.

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