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# Environmental Sustainability Assessment of Buildings Using Requirements in Building Energy Codes

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**SUMMARY**

To assess the environmental sustainability of buildings, a number of technological, ecological and socio-cultural factors are involved. Investigation on the existing building environmental assessment methods in the world shows that the building's energy performance is usually the key element in the evaluation process and will constitute a significant portion of the overall assessment results. With growing interest and importance of building energy codes in many worldwide locations, it is possible to make use of the requirements in the building energy codes to support the sustainability assessment of buildings. In order to do that effectively, the nature and characteristics of the codes must be understood and the trends of code development have to be considered.

This study investigates the environmental sustainability of buildings and how its assessment can be enhanced by using the requirements in the building energy codes. By examining the existing building environmental assessment schemes and the development of the building energy codes in the respective locations, it is hoped that better understanding of their interrelationship can be obtained and effective strategy to integrate them can be generated. The experience and prospects in Hong Kong in this area are discussed to illustrate the practical considerations in the design of the strategy.

To express the assessment criteria unambiguously, a comprehensive definition of sustainability and building energy performance to suit local needs is important. Proper coordination of the requirements in the building energy codes and the environmental assessment scheme is needed. At present, many of the existing building energy codes in the world are prescriptive in nature. To provide greater design flexibility and encourage innovative design, it is important to move towards performance-based approach and consider the integrated whole building performance in the design and evaluation. To obtain these advantages in the environmental sustainability assessment of buildings, further efforts are needed to integrate the requirements of building energy codes and the performance concept into the sustainability assessment process. This will help to strengthen the technical base of and confidence with the assessment method.

**Keywords**: Environmental sustainability, building environmental assessment, building energy codes, performance-based codes, Hong Kong.

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## 1. INTRODUCTION

In the past decade, building environmental assessment methods have emerged in many parts of the world as a legitimate means to evaluate the performance of buildings across a broad range of environmental issues (Cole, 1999). However, experience to date indicates that the worldwide application of the assessment methods in the building environmental field has met with only moderate success (Chau et al., 2000). There is a need to encourage more participation from building owners and designers and to establish objective assessment criteria for promoting sustainable building practices. These tasks are not only important to developed nations, but are also critical to developing countries striving to achieve sustainable development – which means protecting the environment while pursuing economic growth.

Another major challenge for building environmental assessment is to place building performance within a wider context of environmental sustainability (Cole, 2001). To assess the environmental sustainability of buildings, a number of technological, ecological and socio-cultural factors are involved. The building's energy performance is usually the key element in the evaluation process and will constitute a significant portion of the overall assessment results. With growing interest and importance of building energy codes in many worldwide locations (Janda and Busch, 1994; Hui, 2000), it is possible to make use of the requirements in the building energy codes to support the sustainability assessment of buildings. In order to do that effectively, the nature and characteristics of the codes must be understood and the trends of code development have to be considered.

This study investigates the environmental sustainability of buildings and how its assessment can be enhanced by using the requirements in the building energy codes. By examining some existing building environmental assessment schemes and the development of the building energy codes in the respective locations, it is hoped that better understanding of their interrelationship can be obtained and effective strategy to integrate them can be generated. The experience and prospects in Hong Kong in this area are discussed to illustrate the practical considerations in the design of the strategy.

## 2. ENVIRONMENTAL SUSTAINABILITY OF BUILDINGS

Sustainability is no longer a luxury to be considered when economic times are good. It is an imperative to be actively pursued with a sense of urgency. Although a large amount of work has been done to document the environmental, economic, and social impacts of the built environment, little has been done to study the effect of building energy codes and the regulatory system.

## 2.1 Sustainable Performance

In general, the process for assessing performance in achieving environmental sustainability is based on a number of components as shown below.

- Emissions to air
- Greenhouse gas production
- Releases to water
- Contamination of land
- Waste management
- Use of non-renewable resources
- Use of renewable natural resources

However, it is difficult to universally define and quantify the assessment criteria for these components since the local context, global impact and some qualitative factors have to be considered. Extensive research and discussion were being conducted to establish a set of consensus-based sustainability indicators, an objective weighting scale and a framework for the assessment scheme (Cole, 2001). The aim is to operationalise the terms enabling people to assess the environmental impact of their projects from a comprehensive perspective.

In practice, AboulNaga and Elsheshtawy (2001) have presented a case study for hot climates and discussed the importance of having a comprehensive definition of sustainability and clear guidelines for sustainable building practices. They have also illustrated the use of energy data for assessing sustainable building performance.

## 2.2 Importance of Energy Criteria

The building's energy performance is a key element in the evaluation process. Table 1 shows four examples of assessment methods and their credit points for energy criteria. The energy criteria can constitute 20% to 37% of the total credit points in these examples.

Table 1 Credit points for energy criteria in the assessment methods.

| Assessment Methods | Credit Points for Energy Criteria |
|---|---|
| Building Research Establishment Environmental Assessment Method (BREEAM) 98 for offices, UK (Baldwin et al., 1998) | Max. 120 for total net $CO_2$ emissions and 88 for other energy criteria. (Total 208 points out of 1,046 available) |
| BREEAM/Green Leaf for New Buildings, Canada (ECD Energy and Environment Canada, 2000) | 100 for meeting/exceeding energy codes and max. 270 for other energy criteria (Total 370 points out of 1,000 available) |
| Hong Kong Building Environmental Assessment Method (HK-BEAM) Version 1/96R (CET, 1999) | Max. 7 for air conditioning equipment electricity load and 12 for other energy criteria. (Total 19 points out of 59 available) |
| Leadership in Energy and Environmental Design (LEED) Version 2.0, June 2001 (USGBC, 2001) | Max. 10 for meeting energy consumption criteria, 3 for using renewable energy; 1 for green power. (Total 14 points out of 69 available) |

At present, the majority of existing building environmental assessment methods are voluntary in their application and have the primary objective of stimulating market demand for buildings with improved environmental performance (Cole, 1999). When specifying energy criteria, some of them consider and adopt the requirements in the local building energy codes. For example, HK-BEAM makes reference to the Hong Kong building energy codes (Lee, Yik and Burnett, 2001; Yik et al., 1998); LEED refers to ASHRAE 90.1-1999 (ASHRAE, 1999) or the state energy code; and the Canada's BREEAM/Green Leaf requires meeting or exceeding the requirements of ASHRAE 90.1-1999.

## 3. BUILDING ENERGY CODES

Common strategies for energy regulation and policy include incentive schemes, voluntary standards, mandatory standards and energy labelling (Langston and Ding, 2001). Building energy codes are instruments that guide and specify the direction for improving energy efficiency practices. Legislations can take the form of regulations, guidelines, standards, codes, and others. They may call for voluntary or mandatory actions.

### 3.1 Major Areas and Compliance Options

Figure 1 shows the major areas and compliance options of building energy codes. The major areas include building envelope, lighting, HVAC (heating, ventilating and air-conditioning), electrical power, lifts & escalators and service water heating. The basic/mandatory requirements are fundamental issues that must be satisfied. The prescriptive requirements, system/component performance and energy budget/cost are the options available for meeting the code's other criteria. For example, prescriptive requirements may be the insulation levels for building envelope components or equipment efficiencies for lighting and HVAC systems. The system/component performance requirements try to combine the consideration of several parameters and provide "trade-off" among them in the compliance process, such as the calculation of overall thermal transmission.

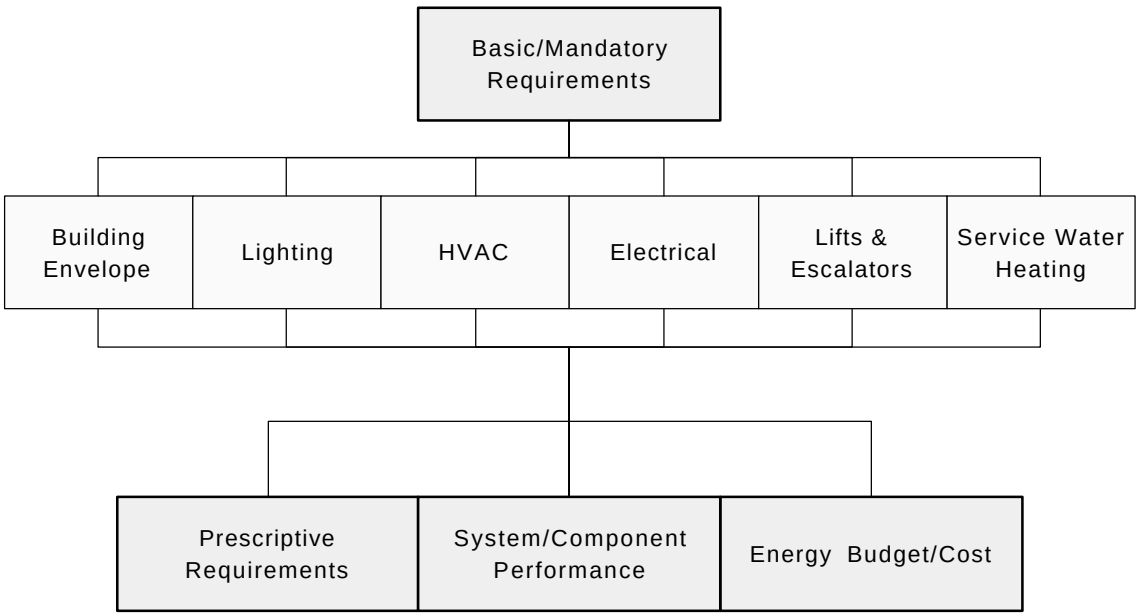


Figure 1 Major areas and compliance options for building energy codes.

The energy budget/cost method offers the greatest flexibility to manipulate the design parameters since it considers in its evaluation the total energy consumption for the building as

a whole. Compliance through the energy budget/cost option will need to study and estimate the likely consumption levels based on the integrated performance of the areas concerned. Since the energy budget/cost method is complicated and demanding, it is usually done by computer simulation and modelling.

### 3.2 Regulatory Framework

Regulation of energy-efficient building design requires control and guidance at the various stages of design, construction and development. Usually, building energy codes provide a minimum design standard of performance for all buildings to comply. As the procedures for determing compliance with the codes are well established and documented, they can serve as some kind of benchmark for measuring enhanced performance (Hui, 2000). In places where the building energy codes are comprehensive and widely implemented, they can gain wide acceptance as a building energy performance indicator, such as in USA and Canada.

Lee and Yik (2002) pointed out that if the local building energy codes are integrated with the building environmental assessment scheme, building owners will benefit from not having to prepare two detailed sets of information. They also suggested significant energy saving by combining the regulatory and voluntary approaches. However, if the requirements stipulated in the existing codes are mainly prescriptive and not stringent enough, then the design flexibility and actual saving cannot be ensured and optimised. A more holistic approach to the performance evaluation is needed to remove barriers to innovation and to encourage exceeding of marginal compliance. The goal is to influence building practices to become more energy efficient and sustainable.

## 4. EXPERIENCE AND PROSPECTS IN HONG KONG

As urban development continues to intensify in Hong Kong and as the awareness of sustainable development grows, there is an increasing local concern about the sustainability of the city (Barron and Steinbrecher, 1999). The study of greener and more energy-efficient buildings was also triggered by the quest for better performance and quality in the construction industry. In high density cities like Hong Kong, low energy design of urban environment and buildings requires considerations of a wide range of limiting factors such as land value and building density (Hui, 2001). Future development of building environmental assessment will depend on the establishment of more comprehensive building energy codes and the resolution of other political and economic issues.

### 4.1 Comprehensive Environmental Performance Assessment Scheme

Hong Kong Government is planning to set up a green building label system as a means of using market force to promote environmentally-friendly buildings. A consultancy study will soon be commissioned to develop this assessment scheme and it is believed the experience of the existing assessment methods will form a useful background. At the same time, review of the building regulations is being conducted with the aim to remove barriers to innovative and green building designs. These initiatives focus not only on new buildings but also on redevelopment of old and dilapidated buildings in the urban renewal process.

An objective and sufficiently demanding measure will be needed to design the new environmental assessment scheme in Hong Kong and to develop relevant performance indicators and benchmarks for charting environmental and sustainability progress. Although it is too early to describe the assessment scheme, it is believed that the following criteria are important for such a scheme.

- Understandable and acceptable by building professionals and general public.
- Practical and cost effective to implement.
- Technically sound and well supported by local research and analyses.
- Clear objectives and good considerations of local conditions.
- Efficient mechanism for implementation, capacity building and market stimulation.

As building environmental assessment is still in the early stages of development and implementation in Hong Kong, a systematic approach is needed to integrate environmental sustainability issues that are meaningful to the society. It is believed that a comprehensive building energy code is useful and important for achieving this purpose.

### 4.2 Performance-Based Building Energy Code

The existing building energy codes in Hong Kong are prescriptive in nature and they specify for each building component the minimum requirements to satisfy the code, including building envelope, lighting, air conditioning, electrical, and lift & escalator (Hui, 2000). Prescriptive requirements are simple to use, but their effect on the building's energy performance is indirect and this becomes a major barrier to performance optimisation, innovation and technological advancement. To encourage new techniques and greater design flexibility, a performance-based building energy code is now being developed in Hong Kong and a more comprehensive regulatory system will be set up to promote energy efficient designs of green buildings.

The performance approach to building codes emphasizes the practice of thinking and working in terms of ends rather than means (CIB, 1997). The performance-based building energy code will set a maximum allowable energy consumption level without specification of the methods, materials processes to be employed to achieve it. It can be used to allow trade-offs among different aspects of the assessment such that a combination of measures that would yield the best possible performance within the budget constraint can be adopted. Encouragement of innovation is a major reason for using the performance concept (Bröchner, Ang and Fredriksson, 1999). The complexity of the compliance process will need to be resolved through careful code design and suitable capacity building activities. It is believed the new code will form an essential base for designing the energy criteria in the new environmental assessment scheme mentioned before. It will also help to encourage more participation from building owners and designers.

## 5. CONCLUSION

Like many other urban cities, the buildings in Hong Kong play a significant role in determining the environmental sustainability of the society. Investigation on the existing building environmental assessment methods in the world shows that the energy criteria is a key factor in the evaluation process. To express the assessment criteria unambiguously, a comprehensive definition of sustainability and building energy performance to suit local needs is important. Proper coordination of the requirements in the building energy codes and the environmental assessment scheme is needed.

At present, many of the existing building energy codes in the world are prescriptive in nature. To provide greater design flexibility and encourage innovative design, it is important to move towards performance-based approach and consider the integrated whole building performance in the design and evaluation. To obtain these advantages in the environmental sustainability assessment of buildings, further efforts are needed to integrate the requirements of building

energy codes and the performance concept into the sustainability assessment process. This will help to strengthen the technical base of and confidence with the assessment method.

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