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# The Role of Building Energy Codes in Climate Change Mitigation

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## ABSTRACT

Climate change is now a major concern in the world and global warming due to increased greenhouse gas emissions poses the most severe problem for governments today. To mitigate the adverse impacts of climate change, many countries are trying to reduce carbon dioxide emissions through energy conservation policies. As the building sector is a major consumer of energy in the society and can provide a significant saving potential, efforts have been made in the past decades to promote better energy efficiency in buildings. Among all the energy policy tools, building energy code is often considered one of the most important measures.

This research paper explains the role of building energy codes in achieving climate change mitigation and reducing greenhouse gas emissions. Firstly, the critical issues of climate change are described and their effects on energy policy and codes are evaluated. Secondly, the developments of building energy codes in Hong Kong and mainland China are examined so as to identify key factors for practical consideration and local assessment. Finally, the climate challenges and future prospects of the codes are discussed.

**Keywords**: Building energy codes, climate change mitigation, Hong Kong, mainland China.

# 建築節能規範在緩和氣候變化的角色

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## 摘要

氣候變化是目前全世界主要關心的議題，由於溫室氣體排放增加導致全球變暖，這成爲今天各國政府最頭痛的問題。 要緩和氣候變化的有害衝擊，許多國家都通過節能政策來設法減少二氧化碳排放。 建築是社會上主要能源消費者，而且能提供莫大的節能潛力，所以在過去數十年人們都努力促進建築節能工作。 在種種能源政策工具當中，建築節能規範往往被視爲最重要的措施之一。 這個研究論文解釋建築節能規範在緩和氣候變化和減少溫室氣體排放的角色。 首先，論文描述氣候變化的關鍵問題，並且評估它對能源政策和節能規範的影響。 其次，剖析香港和中國內地的建築節能規範發展情況，以便爲實用考慮和本地評估找出關鍵因素。 最後，討論氣候變化帶來的挑戰和建築節能規範的未來遠景。

**關鍵詞：** 建築節能規範，緩和氣候變化，香港，中國內地。

## 1. INTRODUCTION

Climate change has been a much-debated subject in the world and the built environment has significant impacts on energy use and carbon dioxide ($CO_2$) emissions which are the main roots of global climate change (Lowe, 2007). Nowadays, global warming due to increased greenhouse gas emissions is the most critical problem and potential risk for many countries (Chandler, *et al*., 2002; Steemers, 2003). For example, increased flooding, coastline vulnerability and more frequent severe weather events are forecasted by researchers and scientists. The seriousness of the damage depends on future global emission scenarios.

To mitigate the adverse impacts of climate change, many countries are trying to reduce $CO_2$ emissions through energy conservation programmes and policies. Since building sector is a major consumer of energy and can offer a significant saving potential, efforts have been made in the past to promote better building energy efficiency (Wiel, *et al*., 1998) and develop policy measures to control building energy consumption (Hui, 2000).

Among all the policy tools, building energy code (BEC) is often considered as one of the most important measures. The development and implementation of BEC is a complicated process affected by the social, environmental and economic factors in the society. This research paper explains the role of building energy codes in achieving climate change mitigation and reducing greenhouse gas emissions. Firstly, the critical issues of climate change are described and their effects on energy policy and codes are evaluated. Secondly, the developments of building energy codes in Hong Kong and mainland China are examined so as to identify key factors for practical consideration and local assessment. Finally, the climate challenges and future prospects of the codes are discussed. It is hoped that more discussions could be generated in order to develop a better understanding of the issues and enable prompt actions to be taken.

## 2. CLIMATE CHANGE ISSUES

The Intergovernmental Panel on Climate Change (IPCC), in its second assessment report, concluded that human-induced climate change represents an important stress on ecosystems and socioeconomic systems (Watson, *et al*., 2001). The Framework Convention on Climate Change (FCCC), signed by 155 nations at the United Nations Conference on Environment and Development (UNCED) in 1992, requires parties to promote and cooperate in the development, application, diffusion of technologies, practices, and processes that control, reduce, or prevent anthropogenic emissions of greenhouse gases.

Recently, the fourth assessment report of IPCC (IPCC, 2007) confirms the urgency of the climate change problem and indicates that if the global temperature were to rise by 1.9 - 4.6 ˚C and sustains for millennia, complete melting of the Greenland Ice Sheet could occur, leading to a sea level rise of 7 m. The threat of global climate change is a real problem and the awareness of the issue has been sharply rising (Tracy, Trumbull and Loh, 2006).

### 2.1 Global Warming and Climate Change

Lam (2005) pointed out that climate change tends to be taken to mean global warming, but in fact it is much more than that. The climate issue is concerned with the physical (temperature, rain, wind, etc.), chemical ($CO_2$, ozone, methane, etc.) and biological (plants, animals, bacteria, etc.) aspects of the Earth. The amount of $CO_2$ in the atmosphere is very delicately related to the dynamic balance among various living processes, e.g. photosynthesis, respiration and decay after death. Leung *et al*. (2004) discovered that the local climate change in Hong Kong is affected by the global trends as well as regional or local effects in particular urbanization and building developments. Figure 1 shows the trend analysis of air temperature in Hong Kong in the past 115 years.

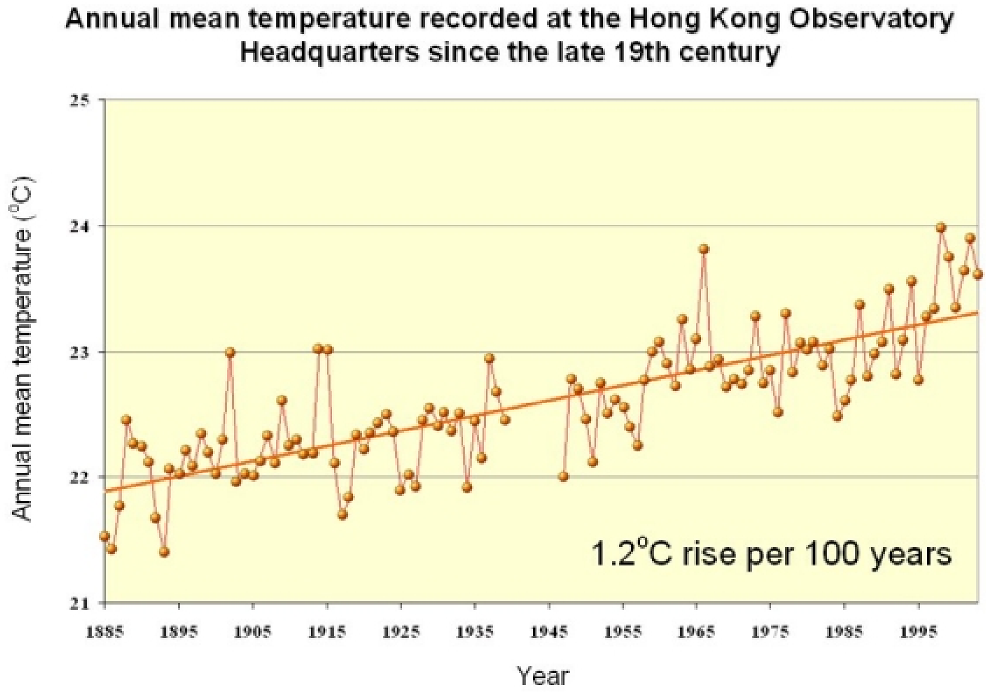


*Figure 1. Trend analysis of annual mean temperature at the Hong Kong Observatory (extracted from www.hko.gov.hk)*

## 2.2 Impacts of Energy Use

It is believed that energy use is responsible for 85% of anthropogenic $CO_2$ emissions and for one fourth of anthropogenic methane emissions (Martinot, Sinton and Haddad, 1997). Technologies for improving the efficiency of energy supply and consumption are very important for reducing $CO_2$ emissions associated with energy use and thus for mitigating global climate change.

When the weather is getting warmer, it will affect the energy consumption of buildings. In a research study to assess the effects of climate change on commercial building energy demand, Scout, Wrench and Hadley (1994) found that global warming would produce about a 2% decrease in heating requirements per 1 $^{o}$C and comparable increases in cooling requirements. The increase in cooling energy would be larger because of the effects of increased humidity with atmospheric warming. This humidity increase could be a significant factor in total building energy use, particularly in the hot and humid regions like Hong Kong. An unsustainable vicious circle would be formed if more and more heat is rejected to the atmosphere in the urban areas (also known as “urban heat islands”).

Santamouris *et al*. (2001) tried to assess the impact of urban climate on the energy consumption of buildings and they found that for the city of Athens, where the mean heat island intensity exceeds 10 °C, the cooling load of urban buildings may be doubled and the peak electricity load for cooling purposes may be tripled. Also, the minimum coefficient of performance (COP) of air conditioners may be decreased up to 25% due to the higher ambient temperatures. This illustrates clearly the adverse impacts of global warming in urban cities. Fortunately, some research studies indicate that climate warming may lead to energy savings in a colder regions but the outcome and savings depend on the nature of the building and its use (Matsuura, 1995).

## 3. ENERGY POLICY AND TOOLS

Building energy codes are policy measures to control energy consumption in buildings (Janda and Busch, 1994). It can help overcome the market barriers and ensure that cost-effective energy-saving measures are taken in the building sector. This is especially important for countries where the energy prices and free market do not encourage the use of energy efficient technologies (Lam and Hui, 1996).

### 3.1 Overall Energy Policy

Figure 2 shows the major factors in the overall energy policy and highlights the importance of the building sector. Considerations of energy supply and demand form the basis of the policy. As Wiel, *et al*. (1998) pointed out, buildings account for 25-30% of total energy-related $CO_2$ emissions and building energy use contributes 10-12% of the global warming. For developing countries which have tremendous growth of energy demand and building developments, significant opportunities exist to implement policies that will promote more rapid uptake of efficiency technologies and reduce $CO_2$ emissions in this sector.

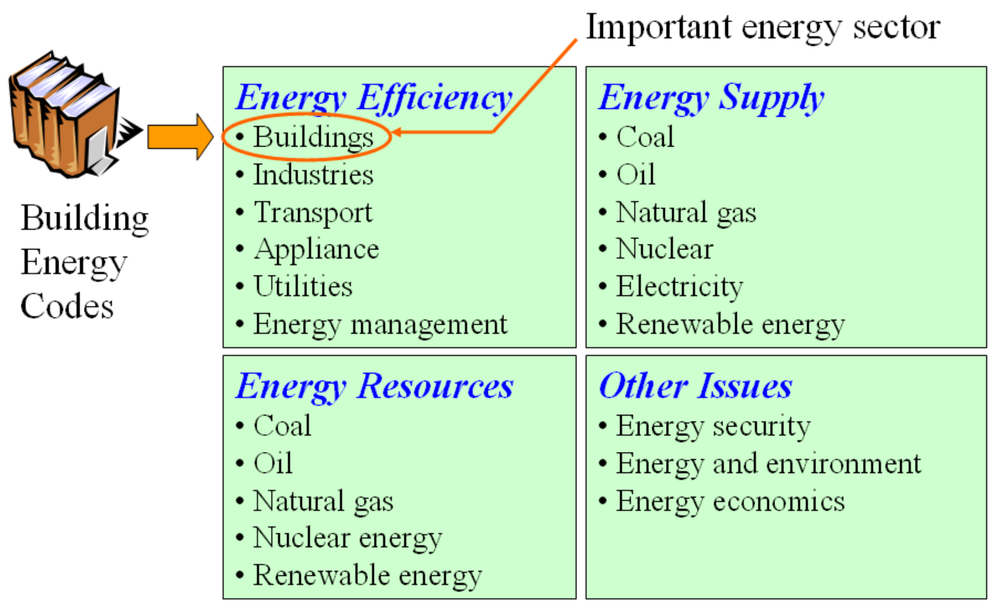


*Figure 2. Building sector in the overall energy policy*

For many countries, institutional development and capacity building are critical for ensuring successful energy policies. International technology transfer and assistance is also important for providing access to environmentally sound technologies and reducing the barriers in the local market (Martinot, Sinton and Haddad, 1997).

### 3.2 Policy Tools and Codes

Forsyth (1999) has examined the main barriers to private sector investment in energy technologies for developing countries and identified incentives and regulatory structures needed to accelerate investment without damaging local competitiveness. In order to enhance public-private synergy in the energy and climate change policy, the following policy tools are often considered by the governments.

- Codes and standards
- Financial and fiscal incentives
- Market pricing
- Environmental pricing (taxes)
- Information
- Research and development

Codes can act to regulate the consumer behaviours and stimulate the market development for energy efficient technologies. This is especially essential when the energy cost saving alone is not a sufficient incentive to attract investments for the energy conservation and enhancement measures. For example, when the energy cost is outweighed by the rental and salary costs, which is the case in Hong Kong and many other urban cities, the codes can ensure a certain minimum standard would be achieved.

## 4. DEVELOPMENTS IN HONG KONG AND MAINLAND CHINA

In the past two decades, development of BECs is an important issue in Hong Kong and mainland China (Hui, 2000). It is believed that the application of BECs can achieve a substantial reduction of energy consumption and an accompanied reduction of greenhouse gas emission in Hong Kong (Chan and Yeung, 2005). The energy policies and BECs in the mainland China have significant impacts for both China and the global environment (Yao, Li and Steemers, 2005).

### 4.1 Hong Kong Situation

Hong Kong Government has a fundamental economic policy of minimum intervention in the business sector. Over the past history, this policy has shaped the Hong Kong’s energy market and the regulation on the energy sector is relatively light-handed (Hui, 2000). However, with a growing concern about energy consumption and its implications to the environment, actions were taken by the Government in 1990s to promote energy conservation and a set of BECs was developed to control the total building energy consumption (Lam and Hui, 1996).

Table 1 indicates the current codes of practices in Hong Kong which cover various aspects of building design. The energy codes apply to building envelope, lighting systems, air-conditioning systems, electrical systems and lift and escalator installations, which are the most important design elements in our buildings. A performance-based BEC was also established to allow trade-offs and provide an alternative path for compliance for some innovative building projects (Hui, 2002b). Figure 3 shows the framework of the comprehensive BEC established in Hong Kong, which consists of two compliance paths (prescriptive approach and performance approach).

**Table 1**. Building energy codes in Hong Kong

| Area of concern | First implement | Current version | Status | Scope of application |
|---|---|---|---|---|
| Building envelope (OTTV) | 1995 | 2000 | Mandatory | Commercial buildings and hotels |
| Lighting | 1998 | 2007 | Voluntary | All buildings except domestic, industrial and medical ones |
| Air-conditioning | 1998 | 2007 | Voluntary | All buildings except domestic, industrial and medical ones |
| Electrical services | 1999 | 2007 | Voluntary | All buildings except for special industrial process |
| Lifts and escalators | 2000 | 2007 | Voluntary | All buildings except for special industrial process |
| Performance-based | 2004 | 2007 | Voluntary | All buildings except for special industrial process |

Note: 1. OTTV = overall thermal transfer value.
2. The OTTV code is put under the Building (Energy Efficiency) Regulations. The other codes are implemented through the Hong Kong Energy Efficiency Registration Scheme for Buildings.
3. The codes can be downloaded from the following websites: www.bd.gov.hk and www.emsd.gov.hk

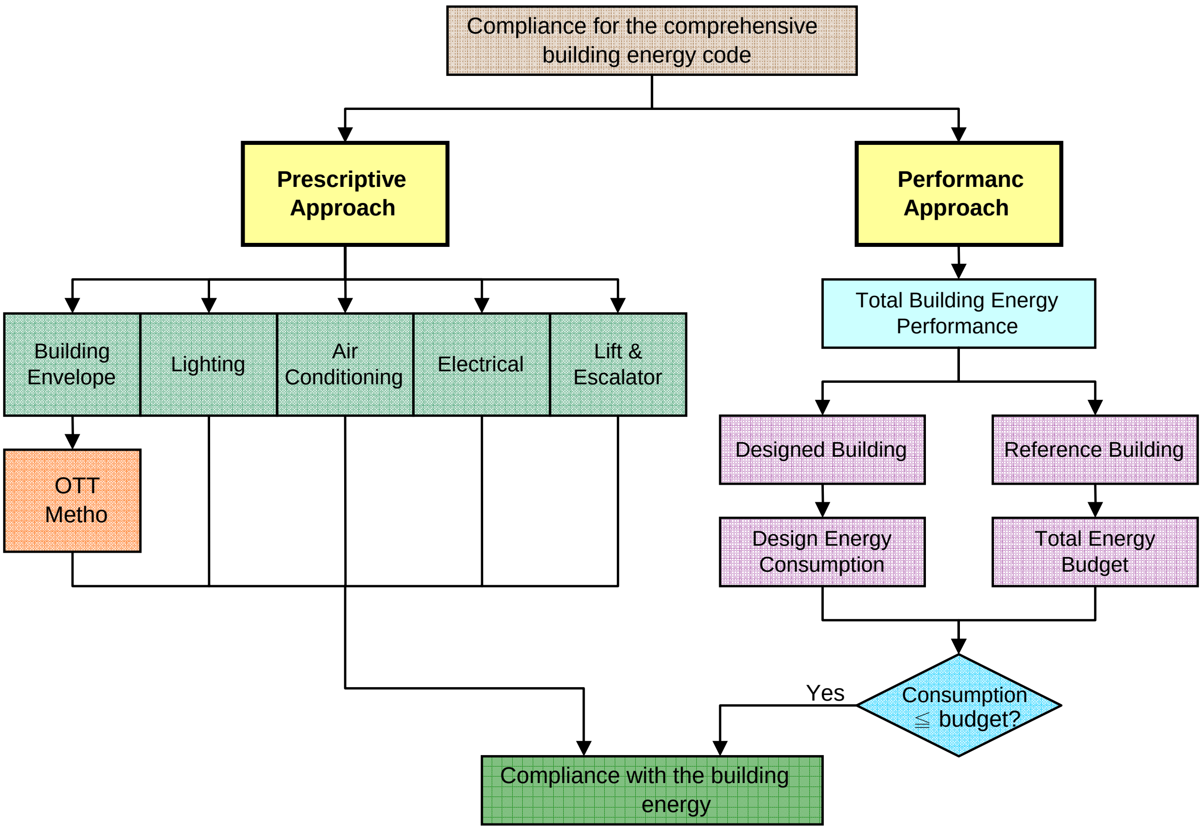


*Figure 3. Framework of a comprehensive building energy code*

At present, the building envelope (OTTV) code is linked with the Building (Energy Efficiency) Regulations, forming a mandatory requirement for new commercial and hotel buildings. The other five energy codes are implemented on a voluntary basis under the Hong Kong Energy Efficiency Registration Scheme for Buildings. In December 2005, the

Government has issued guidelines to require government projects and installations to adopt the energy codes as the baseline for building design.

## 4.2 Development in Mainland China

Under the central planning system, China's energy sector was highly centralized and oriented towards the supply side and the industrial sector. This orientation started to change in the past 30 years, when the central government realized that energy supplies and state-controlled investment capital would be insufficient to satisfy economic growth (Martinot, Sinton and Haddad, 1997). In recent years China has been stressing strongly on achieving optimum efficiency by implementing balanced development as well as conservation of existing resources. Energy consciousness amongst China's policy-makers has been rising. The *Energy Conservation Law of the People's Republic of China*, passed on 1 November 1997, covers all forms of energy sources and provides an important mandate for energy-efficiency activities.

The energy legal system in China includes national energy laws, provincial codes, departmental regulations, rules and orders (Yao, Li and Steemers, 2005). Many of the energy laws and regulations are administrative rules and orders issued by the State Council, and some of them are commands, directions and orders issued by the departments and committees under the State Council.

Table 2 shows five major BECs developed in China, one designed for public or commercial buildings (GB50189-2005) and the other four for residential buildings in different climatic regions. They have been taken up and implemented in some provinces and cities, with a target to achieve 50% energy savings by 2010. Generally speaking, China has developed a BEC system including design standards, testing standards, management standards, and building energy consumption standards (Wang, *et al.*, 2004).

**Table 2**. Major building energy codes in Mainland China

| **Building energy code** | **Date implemented** | **Scope of application** |
|---|---|---|
| GB50189-2005. Building energy code for public buildings (公共建建築節能設計標準) | Jul 2005 | Commercial buildings |
| JGJ75-2003: Design standard for energy efficiency of residential buildings in hot summer and warm winter zone (夏熱冬暖地區居住建築節能設計標準) | Oct 2003 | Residential buildings |
| JGJ134-2001. Design standard for energy efficiency of residential buildings in hot summer and cold winter zone (夏熱冬冷地區居住建築節能設計標準) | Oct 2001 | Residential buildings |
| JGJ26-95: Energy conservation design standard for new heating residential buildings (民用建築節能設計標準(採暖居住建築部分)) | Jul 1996 | Residential buildings |
| GB50176-93. Thermal design code for civil building (民用建築節能設計標準) | Oct 1993 | Residential buildings |

Lang (2004) pointed out that the energy efficiency laws and codes in China still need to be refined and there are insufficient economic incentives for energy-efficient design and construction in the industry. If the climate change concern continues to grow, the codes and related policies must be enhanced to achieve widespread adoption and effective regulations in the country.

## 5. DISCUSSIONS

Generally speaking, there are three approaches to deal with climate change problem: adapt, mitigate, or ignore. If our society is to develop policies to deal with climate change, then the BECs will certainly be an important element to consider and establish.

### 5.1 Climate Challenges

Chan (2006) pointed out that the occurrence of global warming is very unlikely be affected by Hong Kong's own mitigation policies. Therefore, while adopting mitigation policies, Hong Kong should also prepare adaptation policies to minimize the adverse effects of climate change. For example, the ability to cope with the impact of weather extremes should be considered carefully.

For building professions, Steemers (2003) has identified a number of questions and showed that adaptation to climate change presents one of the most pressing building research challenges. On the other hand, Roaf, Crichton and Nicol (2005) argued that in order to survive in a warming world and in the dark cities of the future, it is necessary to develop a new generation of resilient, regionally appropriate, low-impact buildings, powered by clean, renewable energy. To design for such sustainable buildings, it is important to develop a better understanding of the local climatic data (Hui and Tsang, 2005).

### 5.2 Future Prospects of BECs

In Hong Kong, although the BECs have been implemented for some years, their degree of acceptance in the private sector is still limited because the voluntary registration scheme cannot attract the attention of most business people. At present, review and studies are being conducted to consider how the codes could be better promoted or put into legislation. It is believed that some forms of mandatory control are needed to implement the codes effectively.

As building environmental assessment and green building labelling are becoming more and more important in the world, there is a possibility to make use of the requirements in the BECs to support the sustainability assessment of buildings (Hui, 2002a). This would enhance the popularity of the BECs and enable a better integration between building energy performance and environmental assessment. To achieve this goal, proper coordination of the requirements in the BECs and the environmental assessment scheme is needed. Establishment of a user-friendly system for building energy label or certificate is required.

Lowe (2007) believed that the key tasks for regulators is to move to performance-based regulation, to introduce more rigorous codes for existing buildings and to establish systems for training and certifying energy advisers. In Europe, for instance, the *EU Directive on the Energy Performance of Buildings* (EU, 2002), which came into force in January 2003, has set out an important policy framework for promotion of building energy performance in the European countries. The directive aims to improve the energy performance by setting out a methodology to calculate integrated energy performance of buildings, minimum energy requirements for new and renovated buildings, and an energy certification of buildings. This will enable better BECs to be created and contribute to reducing $CO_2$ emissions.

## 6. CONCLUSIONS

The threat of climate change has prompted people to study the scientific, economic, and ecological issues, and led them to focus on "sustainable development" of the built environment which is an important aspect of global climate change. It is clear that significant opportunities to help raise building energy efficiency will exist should countries begin to more fully commit to reducing the growth of $CO_2$ emissions.

The development of BECs in Hong Kong and mainland China has illustrated the role of energy policies and codes for promoting energy efficient technologies and awareness. It is expected that the BECs will be further refined and developed so as to form a sound basis for indicating the energy performance, establishing a system of building energy label and certificate, and assessing the environmental criteria of buildings. This eventually will contribute to reducing greenhouse gas emissions and lead to a more sustainable future.

As Mr. Al Gore pointed out in the film "An Inconvenient Truth", climate change is not a political issue; this is a moral issue. We must act quickly to prevent possibly grave consequences of global climate change for human societies.

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