Building Energy Efficiency Standards in Hong Kong and Mainland China

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ABSTRACT

This paper investigates building energy efficiency standards in Hong Kong and mainland China. Building energy regulations are placed in the context of broad trends in energy supply and demand, and of energy policy. The paper offers an overview of the requirements of specific energy-efficiency laws and codes for buildings, and discusses how these requirements affect building design. While its fundamental economic policy approach emphasizes free markets and minimum government intervention, Hong Kong has developed building energy codes for commercial and other buildings largely in response to the energy and environmental concerns. Mandatory code for building envelope was enforced since 1995; energy codes for building services were developed and implemented on a voluntary basis in recent years. Performance-based compliance options and better integration of the codes are needed for future development.

As one of the world's most rapidly developing economies, China has a large impact on the world energy market and the global environment. Measures to improve energy efficiency in China's buildings are urgently needed since the number of new buildings is growing rapidly and people are requesting better living standards. Use of energy standards is likely to grow in China and programmes that complement and enhance the standards are expected to come in the future. Since As a major city of China, Hong Kong could play an important role in enhancing technology transfer and demonstration for energy-efficiency improvements. The result of these efforts will have long-term implications for the social and economic development of the Asian region and the world.

Introduction

Building energy efficiency standards and regulations are policy measures widely used to control energy consumption in buildings (Janda and Busch 1994). It can help overcome some of the significant market barriers and ensure that cost-effective energy-efficiency opportunities are incorporated into new buildings. This is especially important in developing countries where the number of new buildings is growing rapidly and the energy prices and market often do not encourage the use of efficient technologies. Research by Nadel (1997) showed that trends towards increased use of efficiency standards are likely to continue, along with periodic updates to standards and growth in programmes that complement them.

Development of building energy efficiency standards has been an important issue in Hong Kong and mainland China in the past two decades (Hui 1997a). As energy consumption in buildings accounts for a significant portion of total societal energy requirements and is growing very fast, the potential for energy saving in the building sector is tremendous. As one of the world's most rapidly developing economies, China has a large impact on world energy market and the global environment. As China is likely to maintain rapid rates of economic

growth in the 21st century, the strategy for providing energy services and ensuring efficient use of energy is very important for China and the world.

This paper investigates building energy efficiency standards in Hong Kong and mainland China. The paper places building energy regulations in the context of broad trends in energy supply and demand, and of energy policy in both Hong Kong andmainland China. It also offers an overview of the requirements of specific energy-efficiency laws and codes for buildings, and discusses how these requirements affect building design.

Situation in Hong Kong

Hong Kong is a highly developed city with extremely high building density. With growing concerns about energy and the environment, Hong Kong has been working hard in the past decade to develop energy-efficiency programmes and building energy codes (Hui 1999; Lam and Hui 1996).

Building Energy Consumption

Since the oil crises in the 1970s, Hong Kong has begun to study the issue of energy conservation in buildings by developing some basic concepts and guidelines. In the 1980s and early 1990s, as Hong Kong was undergoing an economic transformation from a manufacturing to a services center, energy use by the manufacturing sector was declining and building-related energy consumption in the residential sector and especially the commercial sector was increasing steadily. Figure 1 shows the sectoral breakdown of end-use energy in Hong Kong for 1984-96 (EMSD 1999).

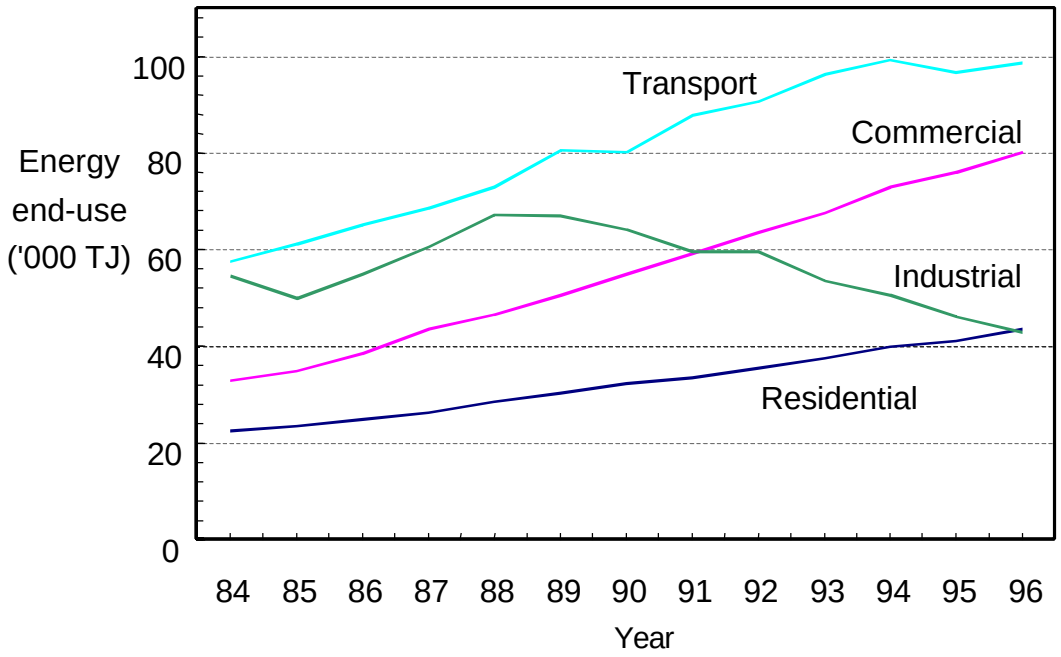

Figure 1. Sectoral breakdown of end-use energy in Hong Kong, 1984-96

Nowadays, energy use in buildings represents a major portion of the community's energy demand, especially for electricity. In 1998, the building sector (commercial and residential) accounts for 85% of electricity consumption and over 33% of final energy requirements (CSD 1999). Table 1 shows the final energy requirements in Hong Kong in 1998.

Table 1. Analysis of Final Energy Requirements in Hong Kong, 1998

Unit: Terajoule	**Commercial**	**Residential**	**Industrial**	**TOTAL**
Electricity	74 164 (59%)	32 793 (26%)	18 489 (15%)	125 447 (100%)
Gas	10 536 (44%)	12 519 (52%)	888 (4%)	23 943 (100%)
Electricity + gas	84 700	45 312	19 377	149 390
Percentage *	21.7%	11.6%	5.0%	38.2%

Note: * Percentage of (electricity + gas) in the final energy requirements.

Electricity and town gas are the major forms of energy supply in buildings and their consumption in the commercial and residential sectors represents almost the total energy use of the building sector. It can be seen from Table 1 that commercial buildings constitute 26.7% of the final energy requirements and residential buildings account for 14.1%. As the energy use in commercial buildings is the most significant sector in Hong Kong and is growing faster than other sectors, much of the energy-efficiency effort targeted at energy savings in commercial sector. This is different from many othercountries which usually focus first on the residential sector.

Overall Energy Policy

Hong Kong Government has a fundamental economic policy of minimum interference in the business sector. That means market forces determine the allocation of resources and the Government intervenes only when there are over-riding social considerations. Over the past decades, this policy has shaped the development of Hong Kong's energy sector, in that it is the private sector that supplies energy of all forms to meet market requirements; regulation of the energy sector is relatively light-handed.

In recent years, international concern over global warming and local concern over air quality have resulted in a greater focus on the environmental impact and efficiency of energy production and use. Considerable emphasis is now being placed on the development of strategies for sustainable development, involving the balance of economic, environmental and social considerations, and development of more environmentally friendly forms of energy production. The Government's general energy policy is to:

(a) ensure that the energy needs of the community are met reliably, efficiently, safely and at reasonable prices; and

(b) promote the efficient use and conservation of energy and the minimization of the environmental impact of energy production and use.

For energy-efficiency activities in Hong Kong, the 1990s were a period of fundamental change in policy instruments and agency responsibilities (Lam 1998). For example, the Energy Efficiency Advisory Committee was set up by the Government in April 1991 (it was later transformed into the Energy Advisory Committee in June 1996 to cover a wider scope of energy matters) and the Energy Efficiency Office, the government's technical agency, was established in August 1994. A number of tools and programmes have been implemented to encourage energy awareness (Hui 1999). All evidence indicates that government action is important for promoting efficient use of energy that will help optimize the energy resources and systems in the community.

Building Energy Codes and Regulations

Building (Energy Efficiency) Regulation (Hong Kong Government 1995), which came into operation on 21 July 1995, is the first set of legislation in Hong Kong to control energy-efficient design in buildings. It specifies statutory control on the design of building envelope of new commercial and hotel buildings by using the overall thermal transfer value (OTTV) method (Building Authority 1995). Lam and Hui (1996) have reviewed and analyzed the method, which is also being used in some Southeast Asian countries such as Singapore, Malaysia, Philippines and Thailand. It was found that the OTTV method emphasizes the control of solar heat gain and is applicable, in principle, to warmer climatic regions of the world which have large energy requirements for air-conditioning. As compared with some comprehensive building energy standards which adopt a whole-building energy budget approach, the OTTV method is easier to understand and simpler to implement. This is an important criterion for developing countries which do not have enough experience and proficiency to manage complicated energy codes.

Nevertheless, the OTTV method is prescriptive in nature and has been criticized for restricting design freedom and innovation in architecture (HKIA 1992). The OTTV method only deals with the building envelope and does not consider other aspects of building design (such as lighting and air-conditioning) and the coordination of building systems to optimize the combined performance. The use of OTTV as the only control parameter is inadequate and cannot ensure energy is used efficiently in the building (Hui 1997b). It is believed that 'real' energy savings arising directly from the Hong Kong OTTV standard were limited, although it did help to raise concern and awareness of energy-efficiency issues.

Apart from the building envelope standard, four sets of energy efficiency codes of practices for building services design have been prepared during the past two years (EMSD 1998a & b, 1999a & b). Table 2 shows the current status of the building energy codes. These energy codes were implemented initially on a voluntary basis, but they will be examined whether they should be put on a mandatory basis in the coming years. To gain the support of all concerned parties, seminars have been held to introduce the codes to building professionals. Supplementary guidelines for lighting and air-conditioning installations have also been published to explain the requirements of the codes and promote better energy efficiency in the operation and maintenance of existing buildings (EMSD 1998c & d).

Table 2. Building Energy Codes in Hong Kong

Area of concern	Date implemented	Status	Scope
Building envelope (OTTV)	July 1995	Mandatory	Commercial buildings and hotels
Lighting	July 1998	Voluntary	All buildings except domestic, industrial and medical ones
Air-conditioning	July 1998	Voluntary	All buildings except domestic, industrial and medical ones
Electrical services	February 1999	Voluntary	All buildings except for special industrial process
Lifts and escalators	mid-2000 (expected)	Voluntary	All buildings except for special industrial process

Note: Full text of the codes can be found at http://arch.hku.hk/research/BEER/.

To encourage wider acceptance of the building energy codes, a scheme of accreditation for energy efficient buildings has been introduced in late 1998. Under this scheme, any buildings (new and existing) that fully complies with the codes will be eligible for accreditation as an energy efficient building. A certificate of accreditation will be issued to the building's owner and its name entered into a register kept by the Government. The aim of the scheme is to arouse public awareness and stimulate greater interests in energy efficient buildings. An energy-efficiency building award, held in 1994 and 1997 in Hong Kong, also serves similar functions for drawing attentions from the public and the professionals.

Other Related Activities

An energy-efficiency labelling scheme for electrical appliances has been implemented in Hong Kong since 1995 to provide consumers and decision makers with information on opportunities for energy efficiency. The aim of the scheme is to promote classes of products that save energy, create differentiation among products, and allow consumers to make an educated purchase. At present, four types of electrical appliances were put under this scheme including household refrigerators, room coolers (unitary air-conditioners), washing machines, and compact fluorescent lamps. It is believed that the scheme has indirect impacts on the energy efficiency of residential buildings where these appliances are commonly used.

In association with an initiative for demand-side management (DSM) for electricity, the Government is considering programmes to promote high efficiency appliances and thermal storage air-conditioning systems, through rebates to the consumer from the power company which collects DSM incentive earnings from the Government. If this is implemented, financial incentives will be provided for improving energy efficiency of appliances and buildings. At the same time, the DSM measures will help reduce peak demand for electricity and longer term growth in demand, enabling the community to postpone or avoid construction of additional generating capacity.

To improve energy efficiency of existing buildings, energy audits have been conducted in government buildings since 1993 and measures have been implemented to achieve energy

savings in these buildings. Information on retrofitting existing buildings with energy-efficient equipment is being disseminated to the private sector. The Government is also examining the potential for wider use of water-cooled air-conditioning systems (which could produce electricity savings of 20-30%) for non-domestic developments, in order to raise the efficiency of air-conditioning plants.

To provide information and analytical tools for evaluating the costs, benefits and likely impacts of alternative policies, an energy end-use database has been developed in 1998 (EMSD 1999c). The database comprises a set of aggregate energy end-use statistics classified into the four energy sectors in Hong Kong, namely residential, commercial, industrial and transport. It provides essential information for formulating government policies and understanding the energy saving potential in different sub-sectors.

Situation in Mainland China

China has been experiencing a dramatic shortfall in energy and the scarcity of energy sources is a major issue in China's socio-economic development. In the 1980s, China actively promoted energy efficiency (primarily in heavy industry) to partially decouple energy and economic growth (Sinton, Levine & Wang 1998). As a result, the elasticity of energy consumption to gross domestic product (GDP) has declined significantly from 2.09 in 1953-1980 to 0.56 in 1981-1990. Although substantial success has been achieved in energy efficiency, it is believed that far greater improvements are critical to the country's economic and environmental future.

Energy Policy

The ideas for developing more and more efficient and environment-friendly energy sources have only recently begun taking root in China's energy policy planning. In the Ninth Five-Year Plan (1996-2000), for example, the primary role of China's energy sector has been highlighted as the driving engine for the country's overall economic growth and modernization. This is to be accomplished by implementing the following five objectives: (i) alleviating the energy industry's bottlenecks; (ii) building power plants (primarily coal-fired); (iii) strengthening oil and gas exploration and development; (iv) improving energy efficiency; and (v) developing rural energy (including small hydropower, solar, geothermal, and biogas).

The recent years have seen China 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* was passed on November 1, 1997 and it covers all forms of energy sources and provides an important mandate for energy-efficiency activities. A critical part of China's energy policy at present is to "put equal emphasis on both energy development and conservation, and higher priority on energy conservation in the short term". The need to improve the efficiency of energy use in all sectors, in parallel with the development of additional energy supplies, is a cornerstone of China's energy policy for the 21st century.

Energy Efficiency Laws

The energy legal system in China is quite complicated, with many different types and formats, including national energy laws, provincial codes and departmental regulations. They cover the exploration, development, production, supply and conservation of different energy resources including coal, oil, natural gas, electricity, nuclear power, rural energy and renewable energy. Many of the energy laws and regulations in China are administrative rules and regulatory documents issued by the State Council, and some of them are commands, directions and regulations issued by the departments and committees under the State Council. In general, the development of energy efficiency laws for buildings in China over the past two decades can be divided into four main stages as shown in Table 3.

Table 3. Four Development Stages of Energy Efficiency Standards for Buildings in China

Years	Major Activities
1982-88	Studies on technical standards and codes; development of the trial version of the residential energy code in 1986.
1988-94	Implementation of the technical standards; demonstration projects; development of the energy codes for tourist hotels in 1993.
1994-96	Strengthening of the organizations and improvement of policy documents and codes; setting up of a coordination group and research center by the Ministry of Construction; updating of the residential energy code; publishing of policy documents including: • *Ninth Five-year Plan and 2010 Strategy for Building Energy Efficiency in China* • *Technical Policy of Building Energy Efficiency (1996)*
1996 onwards	Holding of the National Conference on Building Energy Efficiency (9/96); moving towards market-based energy conservation • *Energy Conservation Law of the People's Republic of China* was passed on November 1, 1997; Article 37 on building design and construction

Building Energy and Related Codes

At present, there are two sets of building energy codes in mainland China, one for residential buildings and one for tourist hotels. Table 4 shows the contents of these two codes. The residential energy code (JGJ 26-95) emphasizes thermal insulation to reduce heating energy, and its trial version (first released in 1986) has been implemented in a few cities in China, including Beijing and Tianjin. Since the residential sector in China is the key consumer for energy and many buildings are still using poor envelope thermal insulation and low-efficiency heating method, much of the attention for energy efficiency is put on residential

buildings. The present target is to achieve 50% energy savings by 2010 (20% from thermal insulation and 30% from building systems and management).

Table 4. Contents of the Two Building Energy Codes in China

Energy conservation design standard for new heating residential buildings. JGJ 26-95	*Energy conservation design standard on building envelope and air conditioning for tourist hotels. GB 50189-93*
1. General information 2. Technical terms and symbols 3. Building thermal targets and heating coal consumption targets 4. Building thermal design 5. Heating design	1. General information 2. Technical terms 3. Basic requirements 4. Building envelope 5. Air-conditioning 6. Monitoring and measurement
Date implemented: July 1996	Date implemented: October 1993

Note: An English translation of the codes is available at http://arch.hku.hk/research/BEER/.

The energy code for tourist hotels (GB 50189-93) is a mandatory national standard and was developed primarily for tackling the rapid growth of hotel buildings in many cities of China. The energy consumption in tourist hotels, especially for electricity, is high because of the need for comfort air-conditioning and other hotel services. The code specifies prescriptive requirements for the design of building envelope and air conditioning systems, according to different classes and external climates of the tourist hotels.

There are also some other building design codes which might affect energy efficiency. A list of them is given in Table 5 and they include codes for thermal design and other building services systems.

Table 5. Related Building Codes in China

Related Building Codes	Date Implemented
Thermal design code for civil building. GB 50176-93	October 1993
Lighting design code for civil building. GBJ 133-90	March 1991
Heating, ventilating and air conditioning design code. GBJ 19-87	August 1988
Code for electrical design of civil buildings. JGJ/T 16-92	August 1993

Future Prospects

The energy consumed in buildings in China now accounts for 25-30% of the country's commercial energy use. But, the current levels of energy services and electricity consumption

per capita or per building are very low compared to international levels. The present efficiency level of building energy use in China is also low because of technological constraints, lack of effective management, and poor efficiency of the building materials and equipment. Historically, China has relied on central control for limiting energy consumption. With the on-going conversion of China's economic system to a market economy, the centrally planned system for promoting energy conservation must be transformed to operate more effectively in the new environment and to maximize the influence of market forces. This has presented challenges to the design and implementation of energy codes and legislation. The future role of the energy standards depends on the resolution of much larger political and economic questions facing China. Fundamental social forces and policies quite unconnected with energy use affect housing, industrial structure, urban design and transport infrastructure. These forces have profound impacts on energy consumption and should be studied carefully.

With the growing of economic development and people's living standards, heated building areas are expanding and air-conditioned buildings are proliferating very fast. The increasing demands for energy services will create substantial pressure on energy supply and economic development. The building energy consumption in China is expected to rise drastically and the potential for energy saving is large. This will offer a good opportunity for transforming the economy and promoting future development, but the establishment of building energy efficiency standards must be accelerated and enhanced.For example, a building energy code for commercial and office buildings is now being investigated by the Chinese Academy of Building Research; Shanghai, a key financial center in China, is studying the feasibility of a high-rise building energy code; the independent municipality of Chongqing is developing a new energy code which includes both heating and cooling requirements.

Discussion and Conclusion

Implementation will continue to be the most difficult and sensitive part for building energy codes in Hong Kong and mainland China (Hui 1999). For building energy codes to be effective, they must be accompanied by compliance and good building practices. The expected results cannot be obtained without a sound compliance system; there are several ways to ensure compliance. Mandatory inspection by local authorities, building energy certification and labelling and voluntary compliance are the most common. Effective implementation and enforcement of the standards requires careful consideration of technical, marketing, institutional and political factors. Without appropriate educational programmes and implementation mechanisms for the building industry, even a well-designed, mandatory standard will not save energy.

Design of standards requires considerable technical knowledge. They need to be flexible to adapt to dynamic conditions such as technological advances. They also should increase incentives for industry to invest in development of more energy-efficient technology. Building energy codes require minimum energy efficiency levels for new buildings by prescribing either particular materials and/or techniques or levels of performance. Prescriptive approaches tend to limit development of new technologies and techniques; minimum prescriptive standards will often become the maximum as there is little incentive to go beyond code compliance. In contrast, a performance-based approach could encourage innovation, but would be more complicated and require a higher level of skills from the designers or users.

For better flexibility and optimal efficiency, Hong Kong and mainland China should move towards performance-based codes and consider local characteristics in the design of energy standards.

Development of institutional, scientific, planning and management capacities is critical to the sustainable and effective use of energy standards. Since July 1997, Hong Kong has became a "Special Administrative Region" of the People's Republic of China. At present, the relationship between Hong Kong and mainland China is quite interesting; they have their own sets of building energy codes and regulations and they have also taken different approaches to energy-efficiency issues. As Hong Kong is an important window and a major city of China, there are opportunities for enhancing technology transfer and demonstration for energy-efficiency improvements through international cooperation. The result of these efforts will have long-term implications for the social and economic development of the Asian region and the world.

As the published information about energy standards in developing countries is limited (Janda and Busch 1994), it is hoped that the analysis presented here could provide information to partly fill the information gap. The experience in designing the building energy codes and promoting energy-efficiency activities might also be useful for other locations in the world with similar climate and societal structure.

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