

Framework to Appraise the Building Control Systems in the face of Climate Change

Chi-kwong CHAN¹ and Edwin H W CHAN²

Abstract

The rising concerns about the adverse impacts of climate change demand for energy efficient buildings that timely calls for review of building control regulations. With reference to literatures relating to the regulatory control for energy efficient buildings, this paper identifies core areas that are essential for the reviews of which are common to building control regulations worldwide. The paper attempts to summarize these core areas and its associated information/considerations with a template which provide a solid ground for further research and data collection.

Keywords: building regulations, sustainability, energy efficiency, climate Change

1. Introduction

Building control regulations³ were once developed to provide protection to the public from safety and health hazards caused by the built environment. Since the oil crisis in 1970s, building control regulations of many countries have been extended or revised to look for energy conservation in buildings. Although there are a variety of regulations governing the energy efficiency of buildings nowadays, the expected saving potential of energy used in buildings are reported not yet realized and the growing pattern of energy used. With the rising concerns about the adverse impacts of climate change, and the need of greenhouse gas emissions reduction, coupling with the social and environmental demands, there are needs for sustainable/green buildings and its associated energy efficiency control regulations to be improved (Chan & Yung 2004). These necessitate timely review of the building control regulations. This paper identifies core areas of building control regulations that govern energy efficiency of buildings, and that are essential to timely review and improvement of these regulations.

2. Buildings, Climate Change and Building Control Regulations

Building development offers substantial social and economic benefits to society, like the provision of employment, housing, and workplace, and offering economic transactions.

¹ Building and Real Estate Department, Hong Kong Polytechnic University, Hung Hom, Kowloon, HKSAR; cckwong01@netvigator.com

² Building and Real Estate Department, Hong Kong Polytechnic University, Hung Hom, Kowloon, HKSAR; bsdchan@polyu.edu.hk

³ In this paper, building control regulations refer to those regulations enacted under national laws or acts, and include energy efficiency requirements of buildings as stipulated in mandatory standards or codes.

However, the development also poses negative impacts to the environment with regard to land use, material use, waste generation and natural resources during the life cycle of the buildings. Moreover, a great amount of energy is consumed during the life cycle of buildings. For instances, in countries of Organization for Economic Co-operation and Development (OECD), building sector as at 2000 accounts for 25 - 40% of final energy consumption by sector (OECD 2003) while in Asia, the building sector as at 2006 accounts for around 40-50% of final energy consumption (IEEJ, 2006). The energy consumption by the building sector is expected growing at a fast increasing rate and posing vast adverse impacts to the society in terms of economical, health and environmental aspects. The current technology of electricity generation is mainly by burning of fossil fuel. This technology generates in turn carbon dioxide gas which is one of the major greenhouse gases that bring the unwelcome climate change to earth. To mitigate the negative impacts of climate change, the Intergovernmental Panel on Climate Change (IPCC) urged in its 4th report in 2007 a global reduction of carbon dioxide emissions of at least 50% in 2050 from 2015 level.

Although most technologies are available, most of them are non-building control items. For example, high performance of insulation materials, active solar design for heating and cooling, and solar photovoltaic integration in buildings, and improvement to construction process and using prefabrication. Yet, they all have their difficulties and barriers (Chiang, Chan & Leung 2006; Levine et al, 2007). The following are some of the barriers preventing the promotion of energy efficiency of buildings (Chiang, Chan & Leung 2006; Levine et al., 2007):

- High cost of gathering reliable information on energy efficiency measures, the “stickiness” of the techniques practiced by the builders;
- Lack of incentives between landlords who would pay for efficiency and tenants who would realize the benefits;
- Limited access to finance, energy subsidies;
- Fragmentation of the construction industry; and
- Fragmentation of the design process into many professions, trades, work stages and industries

In many countries, there are also problems with a lack of coordination/integration among planning, environmental and building regulations to achieve sustainable buildings at affordable cost to the industry. It either hinders the impetus to deliver sustainable buildings or leads to non-compliance with planning/building regulations (Wong, Chan & Yu 2010; Visscher et al, 2010). With this background of building development, timely review and improvement of building control regulations are considered necessary. Traditionally, the source of authority, enforcement, compliance, and development trend of regulations constitute the core of the review of building control regulations (Garnharm Wright, 1983). In the context of climate change and sustainable development, non-regulatory or voluntary standards and codes, green specifications and non-regulatory incentive play an important role in promoting energy consumption reduction with the degree of success varies under different institutions

and incentive schemes (Lam et al 2009; Qian, Chan & Choy, 2013). With reference to this background, this paper discusses the following core areas:

- National Energy policies' Objectives
- Scope of regulations
- Types of regulations
- Enforcement Strategies of regulations
- Status of non-regulatory standards and codes
- The Use of mandatory labeling /reporting systems
- Planned Development of regulations
- Non-regulatory incentives

For the sake of discussion, the building control regulations and incentives of China (Cn), Hong Kong (HK), Japan (Jp), Singapore (Sg), United Kingdom (UK) and United States (US) are made reference to where appropriate.

3. National Building-related Energy Policies

National laws and acts confer source of authority to government or local government power to make, amend and enforce regulations. They provide framework for the control of energy efficiency of buildings. For instances, in China, the national laws⁴ stipulate that building proposals must be designed and constructed to comply with mandatory design standards⁵. The national energy policy emphasizes energy conservation along with other principles such as optimization of the energy consumption mix, promotion of environmental protection, and protection of energy security (ABC, 2007). In US, the Energy Independence and Security Act of 2007 mandates new buildings and major renovations to be designed such that fossil fuel-generated energy consumption is reduced by 100 percent by 2030. The bill also created the 'Zero Net Energy Commercial Buildings Initiative,' which sets forth a nationwide goal of carbon neutrality in all commercial buildings by 2050.

However, different countries may have different objectives emphasized in their national laws

⁴ Article 10 of National Energy Strategy of China, Article 4 of Construction Law of People's Republic of China, and Article 12 of Energy Conservation Law of People's Republic of China govern the design of energy efficiency of buildings.

⁵ These are: (a) Design Standard for Energy Efficiency Design of Civil Building Engineering (JGJ26-1995); (b) Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone (JGJ 134 – 2001); (c) Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Warm Winter Zone (JGJ 75-2003); and Design Standard for Energy Efficiency of Public Buildings (GB50189-2005).

or acts or energy policies. The formulation of national energy policy may also be affected by the international participation of the nation, for example, whether the nation is listed as Annex I or Annex B Parties to the Kyoto Protocol as Annex I Parties are subject to binding targets while Annex B Parties are not. This drives the countries to implement or elaborate policies and measures in accordance with the nation's circumstances. The European Union (EU) has adopted an EU-wide emission reduction commitment that corresponds to the total reduction commitment of individual member states. To support realization of the commitment the European Commission implements legislations to improve the energy efficiency of buildings. The Directive on the Energy Performance of Building (2002/91/EC) is an important instrument that affects most of the EU members (UNEP, 2007). For instance, Hong Kong being a member of Asia-Pacific Economic Co-operation (APEC) has committed to achieve a reduction in energy intensity of at least 25% from 2005 level by 2030 (China View, 2007), (EPD, 2008). Comparable quantities in relation to the national energy objectives include energy reduction targets, energy intensity, energy consumption per capita, energy consumption to gross domestic product, and etc.

4. Scope of Regulations

4.1. Types of buildings subject to regulations

Different building types usually have different requirements for the indoor climate and internal loads. In order to fulfill these requirements, different amount of energy are needed. In this regard, different countries, even local counties of the same countries, may interpret these energy requirements differently and place different degrees of emphasis on the building types. For examples, China, Japan, and Singapore have regulations to govern residential (new) and non-residential (new) buildings as well as major retrofitting of these existing buildings. However, in Hong Kong the residential (new) buildings are not subject to the energy regulation for the time being.

4.2. Elements subject to regulations

Many regulations are initially developed with thermal requirements for the building envelopes, and nearly all regulations for new buildings include these requirements nowadays. With the improvements made in the regulations, the HVAC systems are one of the main focuses of the regulations. There are also regulations and codes setting requirements on the energy consumption of equipments and appliances, lighting system is one of the examples. (IEA, 2008)

5. Types of Regulations

Energy efficiency requirements may be set in different approaches, namely prescriptive, trade-off, model building, energy frame and performance. Specific requirements can be set either on a building component (e.g. U-value of component) or as an overall maximum for a calculated value, for example, in Sweden the Building Code specifies that the maximum consumption is 110 kW/m²/year for residential buildings in South. As each type of regulation has its own merit, it is difficult to conclude which one is the best. (IEA, 2008) Other than this

kind of classification, regulations may be deterrent or non-deterrent in approach. For instances, some countries may develop regulations to encourage good building while some others may develop regulations to prevent bad buildings.

6. Enforcement Strategies

Enforcement and compliance of regulations are commonly through 3 stages of activities, namely approval of plans, inspection of compliance during the construction, and issuance of completion certificate for the occupation of the buildings. These activities may be carried out either by the public authority, or by privileged organizations or by private independent experts. In general, for instances in Singapore and in most common law countries, the public may rely on public authorities to set rules and enforce their compliance. Whilst, as in US rely on third party certifications (Shannon D Sentman, et, al, 2008). For instance,

- **Mandatory Requirements of Public Buildings:** In New York and Philadelphia, public projects of certain cost /or construction should achieve a Silver rating of Leadership in Energy and Environmental Design Green Building Rating System (LEED). In Houston, city-owned buildings greater than 10,000 sq. ft must adopt the LEED system “to the greatest extent practical and reasonable” and target for LEED Silver rating.
- **Mandate Requirements of Public and Private Buildings:** In Babylon of New York, buildings greater than 4,000 sq.ft are obliged to apply for LEED certification. All building projects must deposit \$0.03/sq.ft up to a total of \$15,000 into the Babylon Green Building Fund. Should the project earn a rating, the deposit will be refund. In San Francisco, commercial and residential projects greater than 25,000 sq.ft or taller than 75 feet are required to achieve LEED Certified rating by 2008. In 2009, the requirement for commercial buildings would be tightened up to LEED Silver and in 2010 to LEED Gold rating. Residential building would require a Silver rating by 2010.

There are penalties imposed in the regulations if compliance of the requirements of regulations is not meet. These penalties commonly include fiscal penalties, imprisonment and withholding of license.

7. Status of Energy Efficiency Standards and Codes

In the context of energy efficiency of buildings, building energy standards or codes are the foundation for building energy policies. They are important for they provide a minimum level of energy performance to ensure that buildings meet a reasonable level of energy efficiency. However, the status of standards or codes in different countries is different. Comparable descriptions are whether they are mandatory, voluntary, or proposed to be mandatory.

8. Climatic Conditions

When building codes or policy measures are to be appraised, evaluated or compared in a meaningfully, the climatic conditions of different countries should be taken into account. There are two systems namely the Köppen Climate Classification and the ASHRAE

standards classifications commonly used. However, the International Energy Agency (IEA) considered that these two methods appear to be too complicated for a general evaluation and comparison, thus recommends a simplified climate zones classification as below: (IEA, 2008)

- Cold climate ($2000 \leq \text{HDD } 18^\circ\text{C}$ and $\text{CDD } 18^\circ\text{C} < 500$)
- Heating based climate ($2000 \leq \text{HDD } 18^\circ\text{C}$ and $500 \leq \text{CDD } 18^\circ\text{C} < 500$)
- Combined climate ($2000 \leq \text{HDD } 18^\circ\text{C}$ and $1000 \leq \text{CDD } 18^\circ\text{C}$)
- Moderate climate ($\text{HDD } 18^\circ\text{C} < 2000$ and $1000 \leq \text{CDD } 18^\circ\text{C}$)
- Cooling based climate ($\text{HDD } 18^\circ\text{C} < 2000$ and $1000 \leq \text{CDD } 18^\circ\text{C}$)
- Hot climate ($\text{HDD } 18^\circ\text{C} < 1000$ and $1000 \leq \text{CDD } 18^\circ\text{C}$)

[N.B: HDD and CDD denote Heating Degree Days and Cooling Degree Days respectively]

The 'Cold Climate' is where winter is cold and summer temperature rarely higher than 22-25°C. Parts of Russia, Scandinavia and Canada are with the Cold climate. On the other hand, Hot climate is where summer is hot and winter warm and the winter temperature seldom lower than 16-18°C. Florida, northern Australia and Central Africa are examples of 'Hot Climate'. (IEA, 2008)

9. The Use of Mandatory Labeling /Reporting Systems

9.1. Energy Performance of Buildings Directive (EPBD)

The EPBD is an important European policy tool to improve energy performance of buildings. It aims to comply with the Kyoto Protocol to reduce greenhouse gas emissions, and has been implemented in 27 countries.

9.2. Mandatory Reporting System

Japan has implemented mandatory reporting approach such that a report on energy conservation measures must be submitted before commencement of building works. As revealed from (JEC Handbook, 2009), this requirement applies to:

- all new construction, and major renovations of commercial building since 2003;
- all new residential building of 2,000 m² or above since 2006;
- all ready-made residences of 150 m² or above, small and medium-sized residences and non-residential buildings of 300 m² or above since 2010.

9.3. Green Building Rating System

In UK, Building Research Establishment's Environmental Assessment Method (BREEAM) is a green building system, and has been said of being a widely adopted environmental performance rating system in the world. More than 818,943 homes and 22,972 buildings have been registered since its launching in 1990 (J. Cullen Howe, Michael B. Gerrard, 2010). Energy Efficiency is part of the rating system. Although BREEAM is not mandatory on national level, local authorities require a specific BREEAM rating to be achieved as part of planning requirements, and all new government buildings have to achieve an Excellent BREEAM rating. (Defra, 2010)

10. Planned Development

In China, the government has planned wider adoption of mandatory green labeling system, offering of fiscal incentives for energy-efficiency measures in new and existing buildings (N. Zhou et al, 2010). Japan determined in 2009 to accelerate Zero Energy Building (ZEB) development by 2030 (MOE, 2009). Measures for realization of ZEB include strengthening the current standard for the buildings in the Energy Efficiency Act, evaluate energy consumption of the entire building in a comprehensive manner in the regulation, and define milestone on to what extent and when the energy efficiency standards will be strengthened toward ZEB in the future. Japan, Singapore, UK and US have also planned to support voluntary building assessment scheme in which building energy efficiency has been incorporated with.

11. Incentives

The building sector is usually guided by regulations and standards as to the design, construction and operation, including what kinds of energy consumption systems to fit the building with, and how these systems are operated. Within the framework provided by regulations and standards, however, the behavior of the sector is very much depended on economic considerations. These considerations are usually short-term in nature and seldom take into account the long life-span of the building. Studies show that fiscal incentives are therefore recognized as very important for encouraging the building sector to adopt energy efficient approaches in design, construction and operation of buildings (Chan, Qian & Lam 2009). For examples, in Singapore, in order to encourage existing buildings to upgrade their building envelope, Building Construction Authority (BCA) has introduced grant to owners for the improvement of energy efficiency of the building. Also Under the Green Mark Scheme, there are three levels of financial incentives (gold, gold plus, and platinum), corresponding to increasing levels of green technologies and energy savings obtained. For energy performance, the gold level requires energy efficiency at the level required by the building standard. The gold plus level requires energy performance 25% better than standard, while the platinum level requires energy performance 30% better than the standard. The incentives range from SGD\$3/m² to SDG\$6 /m² of gross floor area for new buildings; retrofit of existing buildings is eligible for about 40% of the incentive for new buildings per square meter (Singapore's National Climate Strategy, 2008). In US, incentives are offered in a wide range of forms, including fast-track building permits, development bonuses, tax credits and fiscal incentives under Energy Policy Act 2005.

12. Core Areas Common to Building Control Systems

Having discussed the core areas salient to the review of different control regulations, it is possible to summarize the core areas common to building control regulations of energy efficiency of buildings in a template as appended in **Annex** of this paper. This template can be used to facilitate review, appraisal and comparison of building control systems to advance common understanding international regulatory systems, and to promote the exchange of information.

13. Conclusion

If building control systems are to be effectively improved, they have to be timely reviewed and appraised, and even compared with other similar groups of countries, so that appropriate actions could be initiated timely. In so doing, it may inevitably involve lots of information to be collected, and analyzed. To facilitate such kinds of review, key subject areas common to building control regulations across a number of countries have been identified and a template has been developed so that information can be gathered in a more coherently.

Acknowledgement

This paper is prepared with the support research grant of Hong Kong Polytechnic University.

Reference

ABC (2007) *Building Energy Efficiency Why Green Buildings Are Key to Asia's Future*, Asia Business Council, 2007

Chan E.H.W. and Yung E.H.K., (2004) Is the development control legal framework conducive to a sustainable dense urban development in Hong Kong? *Habitat International*, Vol. [28\(3\)](#), 409-426.

Chan EHW, Qian QK and Lam PTI (2009) The market for green building in developed Asian cities—the perspectives of building designers, *Energy Policy*, [Vol. 37\(8\)](#), 3061-3070

China View (2007) *APEC Leaders adopt Sydney Declaration on Climate Change* (http://news.xinhuanet.com/english/2007-09/09/content_6692153.htm [on 15.3.2013])

Defra (2010) *BREEAM, Sustainable Development in Government* (<http://sd.defra.gov.uk/progress/soge/performance-data-2010/target-areas/breeam/> [on 15.3.2013])

EPB (2008) *Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings (Commercial, Residential or Institutional Purposes) in Hong Kong*, EPD and the EMSD, 2008 Edition

Garnham Wright (1983) *Building control by legislation, the UK Experience*, John Wiley & Sons Ltd. 1983.

IEA (2008) *Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings*, IEA Information Paper, OECD/IEA, 2008

IEEJ (2006) *APEC Energy Handbook 2006*, Institute of Energy Economics, Japan (<http://www.ieej.or.jp/egeda/general/info/pdf/2006section3.pdf> [on 15.3.2013])

J. Cullen, Michael B. Gerrard (2010) *The Law of Green Buildings, Regulations and Legal Issues in Design, Construction, Operations, and Financing*, ELI Press, 2010

JEC Handbook (2009) *Japan Energy Conservation Handbook 2009* (<http://www.asiaeec-col.eccj.or.jp/databook/2009e/index.html> [on 15.3.2013])

Lam PTI, Chan EHW, Poon C.S., Chau CK, & Chun KP (2009) Factors affecting the implementation of green specifications in construction, *J. of Env. Mangt*, 91 (2010) 654–661.

Levine et al (2007): *Chapter 6 of Climate Change 2007: Mitigation of Climate Change*, Fourth Assessment Report of the Intergovernmental Panel on Climate Change

N. Zhou et al (2010) Overview of current energy-efficiency policies in China, *Energy Policy* 38(2010) 6439 - 6452

MOE (2009) *Announcement of a report by the Committee on the Development and Dissemination of Net-Zero Energy Buildings (ZEBs)*, Ministry of Economy, Trade and Industry of Japan (http://www.meti.go.jp/English/press/data/20091124_02html [on 17.3.2013])

OECD (2003) *Environmentally Sustainable Buildings Challenges and Policies*, Organization for Economic Co-operation and Development, 2003

Qian Q.K, Chan EHW & Choy, L.H.T., (2013), How transaction costs affect real estate developers entering into the Building Energy Efficiency (BEE) market? *Habitat International*, [Vol 37](#) (Jan 2013), 138–147

Shannon D Sentman, et al (2008) A Climate for Change: Green Building Policies, Programs, and Incentives, *Journal of Green Building*, 2008, Vol. 3(2), pp46-63

Singapore's National Climate Change Strategy (2008), (http://www.elaw.org/system/files/Singapore_Full_Version.pdf [on 12.3.2013])

UNEP (2007) *Buildings and Climate Change, Status, Challenges and Opportunities*, United Nations Environment Programme, 2007

Visscher et al (2010), Energy regulations require stricter enforcement as a response to climate change, First ICSU 2010, Hong Kong, 15-17 Dec. 2010

Wong F, Chan EHW & Yu A (2010) Property developers' major cost concerns arising from planning regulations under a high land-price policy, *J. of Urban Plan. & Dev.*, 137(2), 112-120.

Annex

Core Areas Common to Building Control Regulations of Energy Efficiency of Buildings

Core Areas	Countries (e.g.)					
	Cn	HK	Jp	Sg	UK	US
National Energy Policies' Objectives						
Energy reduction target						
Energy Intensity						
Energy consumption per capita						
Energy consumption per GDP						
International Participation						
Annex I Parties to Kyoto Protocol						
Annex B Parties to Kyoto Protocol						
EU member						
OECD member						
Others						
None						
Types of Buildings subject to Regulations						
Residential (New)						
Residential (retrofitting)						
Non-residential (New)						
Non-residential (retrofitting)						
Component /Elements Subject to Regulations						
Building envelop and its components						
HVAC systems ⁶						
Electrical equipments ⁷						
Appliances ⁸						
Renewable energy systems ⁹						
Types of Regulations						
prescriptive						
Trade-off						
Model building						
Energy frame						

⁶ HVAC systems stand for Heat, Ventilation, Air-conditioning and Cooling systems

⁷ This include lifts and escalators

⁸ These include televisions and computers, etc

⁹ These include passive solar devices

Performance based						
Approval of Plans						
By public authority						
By other authority						
By private, independent expert						
No approval of plans						
Construction Phase Inspection						
By public authority						
By other authority						
By private, independent expert						
No inspection						
Completion Certificate						
By public authority						
By other authority						
By private, independent expert						
No inspection						
Non-compliance Penalties						
Fiscal penalties						
Imprisonment						
Withholding licenses						
Status of Standards and Codes						
Mandatory						
Proposed mandatory						
Voluntary						
None						
Climate Zones						
Cold climate						
Heating based climate						
Combined climate						
Moderate climate						
Cooling based climate						
Hot climate						
Use of Mandatory Labeling /Reporting System						
EBDP Implemented						

Green building rating & certification implemented						
Report on energy conservation measures						
Green building rating & certificate to be mandatory						
Planned Developments						
Tightening of current standards						
Wider adoption of fiscal incentives						
Towards zero-carbon building development						
Wider adoption of voluntary schemes into regulations						
Non-regulatory Incentives						
Fiscal incentives						
Development bonus incentives						
Fast-track approval incentives						
Others						