

Building Energy Efficiency Policies in China

Status Report



June 2012

Authors

Shui Bin

Li Jun

Expert input

Junqiang Liang (CSTC)

Xiaoling Zhang (CSTC)

Siwei Lang (CABR)

Bo Song (CABR)

Xiu Yang (TU)

Da Yan (TU)

Xing Su (STU)

Jianguo Zhang (ERI)

Reviewers

Adam Hinge (Sustainable Energy Partnerships)

Anke Meyer (World Bank and ClimateWorks Foundation)

Jens Laustsen (GBPN)

Kevin Mo (China Sustainable Energy Program)

Peter Graham (GBPN)

Joe Huang (Whitebox Technologies)

Support During Development

Claire Brule (GBPN)

Alex Wang (GBPN)

Steve Nadel (ACEEE)

Jennifer Amann (ACEEE)

Glee Murry (ACEEE)

Patrick Kirk (ACEEE)

Graphic Design

Sophie Shnapp (GBPN)

Photo © GBPN



Published in May 2012 by Global Buildings Performance Network

Copyright 2012, American Council for an Energy-Efficient Economy (ACEEE) and Global Buildings Performance Network (GBPN). Any reproduction in full or in part of this publication must mention the full title and author and credit ACEEE and GBPN as the copyright owner. All rights reserved.

CONTENTS

FOREWORD.....	3
PREFACE.....	4
ACKNOWLEDGEMENTS	5
EXECUTIVE SUMMARY	7
CHAPTER 1- INTRODUCTION.....	14
1.1 Key Concepts in China’s Building Energy Use.....	14
1.1.1 Climate Zones.....	14
1.1.2 Building Classification:.....	14
1.1.3 Building Energy Consumption:.....	15
1.1.4 Building Energy Efficiency:	15
1.2 Administrative Structure of Building Energy Efficiency	16
1.3 Evolution of Building Energy Efficiency Policies in China.....	17
CHAPTER 2- Building Energy Performance in China	21
2.1 Building Energy Consumption Statistics	21
2.2 Total Building Energy Use	23
2.3 Energy Use in Urban Residential Buildings	26
2.3.1 Energy Consumption of Residential Air Conditioning	26
2.3.2 Other Urban Residential Energy Use.....	27
2.4 Energy Use in Public Buildings Except for Space Heating	28
2.5 Greenhouse Gas Emissions Related to Building Energy Use	29
CHAPTER 3- Efficiency Policies for New Buildings.....	32
3.1 Overview	32
3.2 Building Energy Codes.....	33
3.2.1 The System of Building Energy Codes	33
3.2.2 The System of Inspection and Supervision.....	35
3.2.3 Economic Incentive Measures	37
3.2.4 Implementation Results	38
3.3 Building Energy Efficiency Labelling and Evaluation	39
3.3.1 Key Concepts	39
3.3.2 Development Review	39
3.3.3 Building Energy Efficiency Labeling and Evaluation	40
3.3.4 Implementation Results	40
3.4 Green Buildings	41
3.4.1 Key Concepts	41
3.4.2 Development Review	41
3.4.3 Green Building Labeling and Evaluation.....	43

3.4.4	Implementation Results	44
CHAPTER 4-	Building Energy Efficiency Policies for Existing Buildings.....	46
4.1	Overview	46
4.1.1	Development Review	47
4.1.2	Heat Reform.....	49
4.2	Residential Buildings.....	51
4.2.1	Development Review	51
4.2.2	Implementation Results	52
4.3	Public Buildings	53
4.3.1	Development Review	53
4.3.2	Implementation Results	55
CHAPTER 5-	Application of Renewable Energy in Buildings	56
5.1	Overview	56
5.2	Development Review	58
5.3	Implementation Status	60
CHAPTER 6-	Rural Building Energy Consumption	62
6.1	Overview	62
6.2	Development Review	64
6.3	Implementation Status	65
CHAPTER 7-	Assessment and Future Prospects.....	67
7.1	Making Great Strides	67
7.1.1	Development Strategies for Building Energy Efficiency	67
7.1.1	Strong Support from Central Government	68
7.1.2	Defining Stakeholders' Responsibilities with Oversight	69
7.2	Outstanding Challenges.....	69
7.3	The Next Steps	71
CHAPTER 8-	Conclusions.....	74
CHAPTER 9-	References.....	76
APPENDICES		

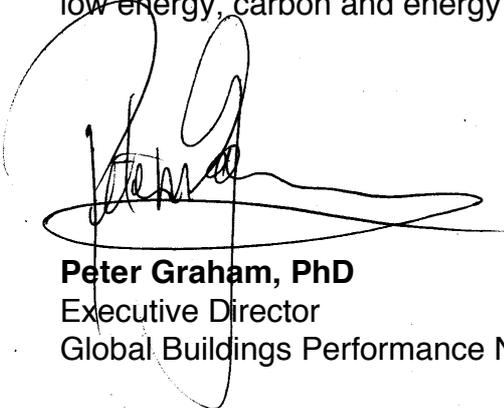
FOREWORD

It is well known that the scale of building development in China is unprecedented. It is also evident that the expansion of the built environment coupled with the impact of energy consumed by China's buildings will have a significant influence on global greenhouse gas emissions. Much of the information available in English about the Chinese building sector elaborates on these well-known themes. However, there are less well-documented insights about the efforts made by China in addressing the challenge of building energy-efficiently on a massive scale. As this report shows, there is much the global community can learn from Chinese best practices.

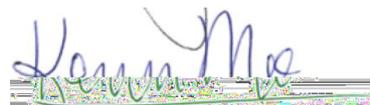
The rationale for this report was to address the current lack of data on Chinese building energy performance and the effectiveness of building energy policies that is produced and available widely in English. This lack of Chinese data is undermining global attempts to determine the GHG abatement potential of the building sector. The situation also hinders Chinese experts from participating and influencing the discourse on achieving the global abatement potential of the building sector.

Supported by China Sustainable Energy Program (CSEP), a number of key publications have been produced in Chinese, which quantitatively and qualitatively describe the energy performance of buildings in China, present analysis of the effectiveness of building energy codes and complimentary policies, and describe best practices. These publications therefore contain key data and insight that is in demand internationally and can contribute to filling an important knowledge gap.

This study has drawn on these Chinese publications and in consultation with the authors of the status of building energy performance, GHG abatement potential, policy scope and effectiveness, and exemplary policies and buildings that are considered best practice in China. In so doing this work contributes to facilitating one of the shared missions of GBPN and CSEP's Buildings Program - the international exchange of knowledge and expertise on best-practice policies for low energy, carbon and energy efficient buildings in China.



Peter Graham, PhD
Executive Director
Global Buildings Performance Network



Kevin Mo, PhD
Director, Buildings & Appliances
Program
China Sustainable Energy Program

PREFACE

China has been actively promoting building energy efficiency since the early 1980s, with an increasing concern for sustainable development, national energy security and a growing interest in pursuing a low-carbon economy. Over the course of nearly thirty-years of effort, China has made impressive progress developing and deploying an array of policies, regulations and projects related to building energy efficiency.

In order to help international building energy efficiency experts and energy policy researchers obtain a comprehensive and an objective understanding of China's building energy efficiency policies, Global Building Performance Network (GBPN, <http://www.globalbuildings.org/>) provided financial support for the development of this report and organized the peer review of the English version. The China Sustainable Energy Program (CSEP, <http://www.efchina.org/CSEPCN/FHome.do>) provided non-financial support for the development of this report, such as recommending a list of reading materials, introducing relevant building energy efficiency experts in China.

The structure of this report came about as the product of discussions between invited Chinese building energy efficiency experts and the project team. The content of this report comprises key aspects of a series of Chinese government policies and directives related to building energy efficiency, and also incorporates and analyzes the findings of a number of recent Chinese publications (e.g., *Report on Building Energy Efficiency Development in China (2010)* by the Center of Science and Technology of Construction at the Ministry of Housing and Urban-Rural Development (or cited as CSTC (2011) in this report); *Research Report on Annual Development of Building Energy Efficiency in China* by the Building Energy Efficiency Research Center at Tsinghua University (or cited as BEERC (2011) in this report)). Additional information was obtained and summarized from relevant Chinese web pages and through discussions with various Chinese building energy efficiency experts.

The report was first written in Chinese, and was then subjected to two rounds of peer review kindly provided by the invited Chinese building energy efficiency experts. It was then translated into English. Following input from international building energy efficiency experts, the English version was revised; this input is also reflected in the updated Chinese version. The authors of the report are Shui Bin (Chapters 1, 3, 4, 7 and 8) and Li Jun (Chapters 2, 5 and 6, Section 4.1.2, Appendixes A and B). As the report was prepared with some haste and is limited in length, some deficiencies may be present; therefore the authors would be grateful for any feedback readers should wish to provide.

Authors, June 25, 2012

ACKNOWLEDGEMENTS

This report was initially conceived by Peter Graham, Executive Director of Global Building Performance Network (GBPN), and Kevin Mo, building program manager of China Sustainable Energy Program (CSEP).

Both believed that a comprehensive and objective understanding of China's building energy efficiency policies and related activities by international practitioners will serve as a critical step in the pursuance of joint efforts between China and other countries to promote building energy efficiency at national and global levels. Peter and Kevin defined the research scope and established the project team. Kevin narrowed a list of must-read publications for the project team's reference, while also generously providing his time for the guidance of the project team's work.

The very existence of this report can be attributed to the strong support of both Peter and Kevin, as well as ongoing support from GBPN and CSEP.

Two Chinese reports helped us greatly in the preparation of this report: *Report on Building Energy Efficiency Development in China 2010* by the Center of Science and Technology of Construction at the Ministry of Housing and Urban-Rural Development (or cited as CSTC (2011) in this report), and *Research Report on Annual Development of Building Energy Efficiency in China* by the Building Energy Efficiency Research Center at Tsinghua University (or cited as BEERC (2011) in this report).

The report benefited from the valuable input of a group of invited Chinese building energy experts. They are Junqiang Liang and Xiaoling Zhang from the Center of Science and Technology of Construction at the Ministry of Housing and Urban-Rural Development, Siwei Lang and Bo Song from the China Academy of Building Research, Xiu Yang and Da Yan from Tsinghua University, Xing Su from Shanghai Tongji University, and Jianguo Zhang from the Energy Research Institute of the National Development and Reform Commission.

GBPN not only provided financial support for the development of the report, but also organized a list of renowned international building energy efficiency experts to review the reports: Jens Laustsen at GBPN, Joe Huang at Whitebox Technologies, Adam Hinge at Sustainable Energy Partnerships and Anke S. Meyer (senior consultant to the World Bank and ClimateWorks Foundation). We would like to express our sincere appreciation to them for their valuable input: their insightful comments significantly improved the quality of the report.

Last but not least, we would like to thank the teams at GBPN, CSEP, and at the American Council for an Energy-Efficient Economy (ACEEE) for their support

during the development of the report. They are Claire Brule and Alex Wang at GBPN, Kevin Mo at CSEP, and Steve Nadel, Jennifer Amann, Glee Murry and Patrick Kirk at ACEEE.

EXECUTIVE SUMMARY

The construction industry has been a significant mainstay in China's rapid economic development for a number of years, accounting for some 6.6% of gross domestic product in 2009. In recent years China has been adding about 1.7 billion square meters of new floor space on an annual basis (including both urban and rural areas). In 2010, the total area of existing buildings in China was approximately 48.6 billion square meters.

How to improve the building energy efficiency of the soaring number of new buildings and accelerate the retrofit of the huge stock of existing building are two daunting challenges currently facing China.

The report begins with an introduction (Chapter 1) of key concepts and an overview of the administrative structures that play a role in China's building energy use, along with a brief history of building energy efficiency policies in China (Section 1.3). The body of the report is structured as a review of five aspects of China's building energy efficiency: building energy performance (Chapter 2), building energy efficiency policies for new buildings (Chapter 3), building energy efficiency policies for existing buildings (Chapter 4), application of renewable energy to buildings (Chapter 5) and rural building energy use (Chapter 6). The report also provides an assessment of the future prospects and directions for building energy efficiency policy development in China (Chapter 7).

Evolution of Building Energy Efficiency Policies in China

China has pursued the development of its building energy efficiency policies since the early 1980s; this period can be broken down into four development phases (Section 1.3):

- Research preparation (early 1980s to 1986). China began to study building energy use in residential and public¹ buildings, and conducted research on such issues as building energy efficiency technologies and building energy codes.
- Pilot projects (1987-1993). China commenced implementation of demonstration projects at a small scale, examining the implications of these pilots and adapting suitable methodologies for the drafting of policies, regulations and technical standards, with an aim to scaling up and a broader promotion of selected policies.

¹ The definition of public buildings is similar to what is typically referred to as *commercial buildings* in many other countries.

- System formation (1994-2005). China began to put in place the regulatory, administrative, and technological support systems to promote building energy efficiency. During this period China issued building energy codes covering both residential and public buildings for application in each of the climate zones.
- System improvement and policy implementation (2006 to the present). In recent years China has focused on the improvement of the existing regulatory, administrative and technical support systems, promoting the enforcement of building energy codes, residential retrofit, green buildings, and the application of renewable energy in building energy efficiency.

Building Energy Performance in China

Buildings account for nearly one fifth of China's total primary energy consumption and carbon emissions. In 2008, the primary energy consumption of buildings in China was nearly 380 million tons of oil equivalent (excluding biomass energy), or a 1.5 fold increase relative to 1996(Section 2.2).

Energy intensity in buildings differs significantly across different climate zones, which is mainly a consequence of the long winter heating period in the northern regions. In recent years, residential heating energy use has been steadily increasing in the Hot Summer Cold Winter (HSCW) zone, while cooling energy use has skyrocketed in both the HSCW zone and the Hot Summer Warm Winter (HSWW) zone (Section 2.2).

Energy intensity in buildings also differs significantly by building type. For example, electricity intensity in large public buildings (>20,000 square meters) is often 2-3 times higher than that in smaller public buildings (Section 2.4).

Carbon emissions associated with building energy use reached 1,260 million tons in 2008. Both Chinese and foreign experts estimate that there exists huge potential for curtailing the increase in energy demand and greenhouse gas (GHG) emissions reduction by improving energy efficiency in China's building sector (Section 2.5).

Building Energy Efficiency Policies for New Buildings

In addition to the massive level of construction that has taken place over the past decade, it is estimated that China will add a further 10 to 15 billion square meters of residential buildings in urban areas, with an additional 10 billion square meters of public buildings to be built between 2010 and 2020. With this scale of development in mind, the Chinese government has been actively engaged in the formulation and deployment of a series of policy instruments to improve building energy efficiency for new buildings (Section 3.1).

Building Energy Codes.

China has established a relatively comprehensive system of building energy codes for new buildings. This system includes design standards and acceptance codes covering residential buildings in the three major climate zones and public buildings throughout China, along with the main construction processes, which include design, construction, and acceptance. Most noteworthy, the Acceptance Codes makes compliance with building energy efficiency requirements mandatory for the final acceptance of a construction project (Section 3.2.1).

Inspection and supervision are critical components in the enforcement of building energy codes. China's current system of inspection and supervision benefits from strong regulatory support, employment of third parties, and is reinforced by an annual national governmental inspection (Section 3.2.2). According to national inspection data, the compliance rate with building energy codes has improved significantly in the past five years (Section 3.2.4).

Building Energy Efficiency Labelling and Evaluation.

China began to establish its system of building energy efficiency labeling and evaluation in 2006 (Section 3.3.2). There are two types of building energy efficiency labels in place: a building energy efficiency label that relies on theoretical values of building energy efficiency evaluated during the acceptance stage, and a building energy efficiency label that relies on actual values of building energy efficiency evaluated during normal operation (Section 3.3.3).

Since 2009, the Ministry of Housing and Urban-Rural Development (MOHURD) has promoted building energy efficiency labeling in newly built government office buildings and large-sized public buildings through pilot projects in selected provinces and cities. As of 2010, forty-five building projects had been approved and granted star ratings (Section 3.3.4).

Green Buildings.

The year 2004 represented a turning point in the development of green building in China. Within only six years China has managed to develop its technical and management system for green building (Section 3.4.2).

Green building labeling falls under two categories: green building design evaluation labeling and green building evaluation labeling. The two are focused on the design and operation stages, respectively (Section 3.4.3).

From the debut of green building evaluation and labeling in China in 2008 to the end of 2011, a total of 271 buildings were awarded with green building evaluation labels (Section 3.4.4).

Building Energy Efficiency Policies for Existing Buildings

By the end of 2010, the total area of existing buildings in China equaled 48.6 billion square meters, 38.7% of which was located in urban areas. Since the 1990s, the Chinese government has launched a series of policies and provided various types of financial support to promote heat reform and retrofit in existing buildings (Section 4.1.1).

Heat Reform.

Heat reform is an important part of China's drive to improve building energy efficiency. The aim of heat reform in China is to reduce the amount of energy wasted by end users through the reform of the heating pricing system and by establishing market mechanisms and to stimulate heat suppliers' efforts to improve the energy efficiency of their heat supply networks.

By the end of 2010, eighty cities at prefectural level and above in northern heating areas had established consumption-based pricing and billing systems, representing a total of 317 million square meters of building space (Section 4.1.2).

Residential Buildings.

The building energy use of China's northern heating regions accounts for more than 40% of the country's total urban building energy consumption. Most of the residents in the old buildings in this region are low and middle income families living in cities. The residential retrofit in northern heating regions has not only played a very important role in enhancing building energy efficiency, but has also been a significant means by which to improve the quality of housing conditions for urban populations of low and middle income living in this part of the country (Section 4.2.1).

From 2006 to 2010, China completed residential retrofit of 182 million square meters in northern China, while in 2010 alone a floor area of 86 million square meters was retrofitted (Section 4.2.2).

Public Buildings.

The Chinese government has selected government office buildings, large-scale public buildings, and college and university buildings as the targets of its public building energy efficiency improvement initiatives (Section 4.3.1).

By the end of 2010, a wide range of the policies and projects had been implemented relating to government office buildings and large-scale public buildings, including energy consumption data collection (33,000 building units), energy audits (4,850 building units), and public disclosure of energy consumption information (6,000 building units). In the same year, 72 universities carried out energy-saving pilot projects (Section 4.3.2).

Financial Support.

One significant challenge to retrofit is financing. In order to address this issue, the Chinese government has been helping to establish multi-source financing mechanisms for residential retrofit projects in the northern heating regions (Section 4.1.1), and for improving building energy efficiency in government office buildings and large-scale public buildings (Section 4.3.1).

Application of Renewable Energy in Buildings.

China has huge potential for the application of renewable energy resources in buildings. During the 11th Five-Year Period (FYP), the Chinese government introduced a series of incentives and supporting policies to promote renewable energy. MOHURD and the Ministry of Finance issued fiscal policies to promote renewable energy's application in the building sector through pilot projects in designated cities, thereby achieving significant progress.

At present, many provinces and cities have issued local policy regulations for the purpose of promoting renewable energy in buildings. Such policy regulations mainly focus on the promotion and application of renewable energy technologies including photovoltaic power generation, building integrated photovoltaic, solar water heating, and geothermal heat pumps, among others. At the same time, local Departments of Finance have also issued financial support plans and relevant policies. Several local authorities have begun to implement policies making the use of renewable energy in buildings mandatory, while a number of new policies are expected to be implemented during the 12th FYP. However, so far the scope of application of renewable energy in buildings has been quite limited with fairly slow progress due to inadequate financial support.

Rural Building Energy Consumption.

At present total building floor space in China's rural areas is close to 24 billion square meters, accounting for approximately 60% of China's total building area. As there is a huge difference in the economic conditions and standard of living between rural and urban residents, commercial energy consumption and energy intensity in rural buildings have historically been far lower than those in urban areas.

So far, buildings in rural areas in China are built by farmers themselves and are thus exempt from the monitoring and regulatory systems of the central and local governments, while no design standards for energy efficiency of rural buildings have been issued by the relevant government institutions, and building energy performance in rural areas is generally poor (Section 6.1).

An increasing number of rural households have begun to use commercially available fossil fuels while the proportion of biomass in total rural energy use continues to decline. Moreover, the inefficient use of biomass also wastes large amounts of energy and generates significant environmental pollution.

Improvement in building energy performance and promotion of high efficiency household durables via the “household appliances going to countryside” policy campaign constitute two effective ways of reducing building energy use while improving the living environments of households in rural areas across China (Section 6.2).

Assessment and Future Prospects

Making Great Strides.

China has achieved significant progress in improving building energy efficiency over the last two decades, much of which can be attributed to carefully planned development strategies, and strong and consistent support from the central government.

For example, The Chinese government has applied the following general strategy to the promotion of building energy efficiency across the country: (1) prioritization of tasks in a clear-cut manner, (2) beginning first with the more straightforward undertakings before tackling more complex tasks, (3) commencing initiatives from single “points” and expanding to wider “areas.” These sound development strategies have helped China to better utilize limited government resources (such as financial and regulatory support), and effectively promote building energy efficiency policies and projects at both national and regional levels (Section 7.1).

Outstanding Challenges.

Chinese officials and building energy experts are clearly aware of the outstanding challenges still to be tackled, including (1) rising building energy consumption, (2) the need for an institutionalized process for the updating of building energy codes, (3) difficulties securing financing for retrofit projects, (4) slow progress in heat reform, (5) scarcity of technologies and management needed for promoting the application of renewable energy in building energy efficiency, (6) inadequate capacity building of relevant stakeholders in building energy efficiency, and (7) the enormous task of promoting building energy efficiency in rural areas (Section 7.2).

The Next Steps.

By 2015, China aims to complete the residential retrofit of another 400 million square meters in the northern heating regions, and will continue to promote heat reform in this region. In addition, government targets call for the complete residential retrofit of 50 million square meters in the HSCW, the thermal retrofit of 60 million square meters of public buildings and the development of 2,000 building energy-efficiency pilot projects to be implemented by public organizations.

What Conclusions Can Be Drawn From This Report?

While it is clear that building energy efficiency policies in China have been developed within the country’s unique political, economic and cultural context, and

are therefore not necessarily applicable to other nations, it is nonetheless equally evident that the success of energy efficiency policies in China is critical not only to the energy security and sustainable development of China itself, but indeed of the entire world.

There can be no doubt that the acquisition of a solid understanding of China's building energy efficiency policies and related activities by international practitioners would be conducive to increased exchange of ideas and experiences between China and other countries, thereby directly contributing to the promotion of building energy efficiency in China and elsewhere around the globe.

CHAPTER 1- INTRODUCTION

1.1 Key Concepts in China's Building Energy Use

1.1.1 Climate Zones

Climate conditions are among the most important factors influencing building energy consumption. China has five climate zones²: Severe Cold, Cold, Hot Summer Cold Winter (HSCW), Hot Summer Warm Winter (HSWW) and Temperate (Figure 1-1).³

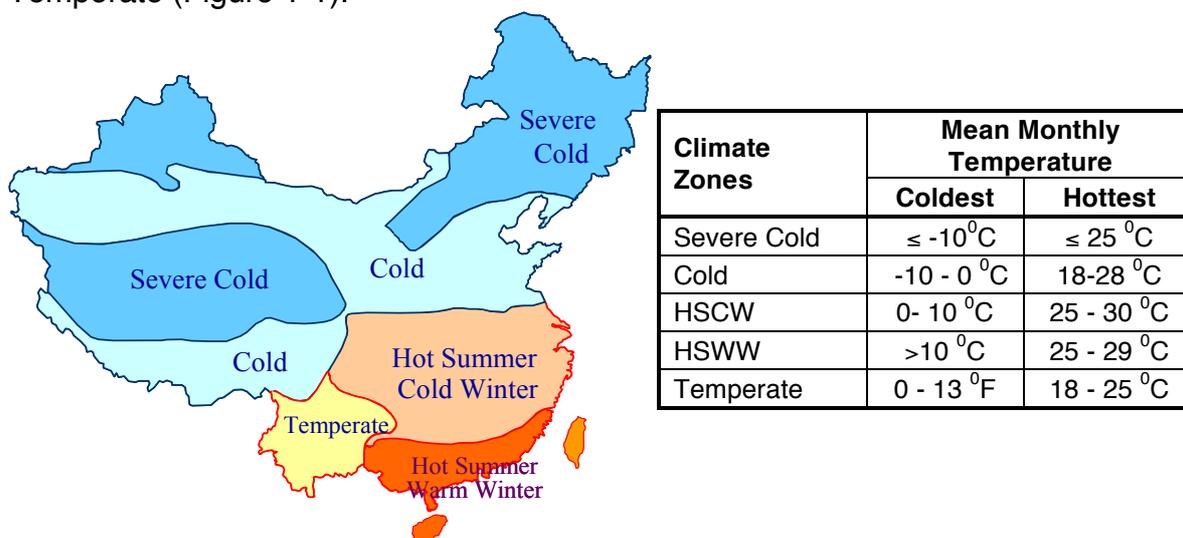


Figure 1-1 China's Climate Zones

Source: Map from Huang and Deringer (2007); Table translated from MOHURD (1993)

1.1.2 Building Classification

In terms of building function, buildings in China can be categorized into civil and industrial buildings. Civil buildings include both residential and public buildings. Major types of public buildings include government office buildings, commercial buildings, buildings used in the service industries, buildings used for educational purposes, and hospitals (Figure 1-2).

According to the number of floors above the ground, residential buildings can be grouped into low-rise buildings (1-3 floors), multi-floor buildings (4-6), middle-high buildings (7-9) and high-rise buildings (more than 10)⁴.

² See *Codes for Building Thermal Design of Civil Buildings* (1993)

³ See details from Section 2.2 of this report.

⁴ See *Code for Design of Civil Buildings* GB50352-2005.

Public buildings are categorized according to their total floor space as “general public buildings” (smaller than 20,000 square meters) and “large-sized public buildings” (larger than 20,000 square meters).

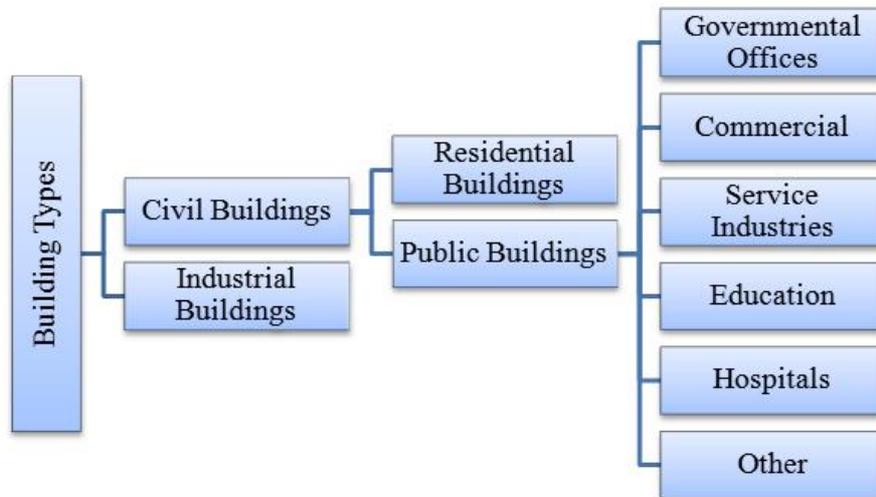


Figure 1-2 Building Types in China

Source: *Regulations on Energy Conservation in Civil Buildings* (2008)

1.1.3 Building Energy Consumption

Building energy use has two definitions. One refers to the energy used during the operational stage, including energy consumed for space heating, air conditioning, water heating, lighting and cooking. The other definition refers to the total energy used during a building’s life cycle, including energy used for the production of building materials, construction, building operation, and decommissioning.

Both concepts of building energy consumption have been employed in Chinese research reports and in government documents. In this report, *building energy consumption* refers to the first definition.

1.1.4 Building Energy Efficiency

Building energy efficiency is the means by which building energy consumption is reduced through the implementation of building energy codes, the adoption of energy efficient technologies and techniques, the use of equipment, appliances, materials and products, and through the implementation of operational and management practices and other relevant approaches during the planning, design, new construction (including redevelopment and expansion), retrofit, and operational phases of the building’s life cycle.

This report focuses on building-related energy efficiency issues (e.g., policies, regulations, data, and projects). While the energy efficiency of end uses is an important issue in building energy efficiency, it is not however the focus of this report (a brief review of this topic has been included in Appendix 1).

1.2 Administrative Structure of Building Energy Efficiency

The Ministry of Housing and Urban-Rural Development (MOHURD, <http://www.mohurd.gov.cn/>) is a national governing entity responsible for construction related issues under the State Council. Formerly known as the Ministry of Construction (MOC), the ministry was renamed MOHURD in 2008. One of MOHURD's functions is to be responsible for the development, supervision and management of building energy efficiency policies and projects at the national level.

MOHURD's provincial and local branches, or known as the construction departments of provincial and local governments, are responsible for developing, supervising and managing building energy efficiency policies and projects within their administrative regions, and are charged with assisting in the implementation of national building energy efficiency policies and projects at provincial, city and county levels (Figure 1-3).

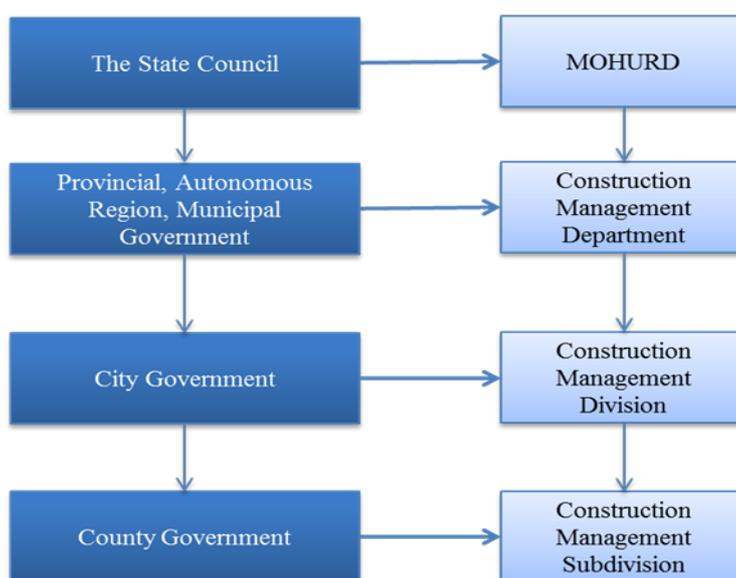


Figure 1-3 Administrative Structure for Building Energy Efficiency Promotion in China

Two of MOHURD's departments are responsible for the development and deployment of policies and projects related to building energy efficiency:

- The Department of Building Energy Efficiency and Science and Technology is responsible for developing building energy efficiency policies, organizing and implementing major building energy efficiency projects and international scientific and technological cooperation projects; and
- The Department of Standard Rating is responsible for managing the development of building energy codes, national construction standards, appraisal methods for construction projects, and for guiding and supervising the implementation of building codes and standards.

MOHURD also has two governmental research entities under its direct management:

- The Research Institute for Standards and Norms, founded in 1983, focuses on the development of codes and standards related to construction projects, including those for building energy efficiency.
- The Center of Science and Technology of Construction (CSTC)⁵, founded in 1994, conducts research and provides technical, research and administrative support to building energy efficiency policies and projects, evaluates and promotes scientific and technological projects and products, and handles the management of pilot projects.

1.3 Evolution of Building Energy Efficiency Policies in China⁶

In order to reduce building energy use and improve building energy efficiency, China has been developing and deploying an array of relevant policies and projects since the 1980s. China's efforts can be broken down into four development phases (Table 1-1):

- Research preparation (early 1980s to 1986). China began to study building energy use in civil buildings, and conducted research on such issues as building energy efficiency technologies and building energy codes.
- Pilot projects (1987-1993). In 1988, China used the method of "letting pilots (two pilot cities) to bring along (eight provincial cities)" to promote new wall materials and energy-saving buildings.
- System formation (1994-2005). China began to put in place the regulatory, administrative, and technological support systems to promote building energy efficiency. During this period China issued building energy codes covering both residential and public buildings for application in each of the climate zones.
- System improvement and policy implementation (2006 to the present). China's most recent efforts have focused on the improvement of the existing regulatory, administrative and technical support systems, the implementation of building energy codes, expansion of the program for residential retrofit, the promotion of green building, and the application of renewable energy in building energy efficiency.

⁵ Please see CSTC's website at <http://www.cstcmoc.org.cn/>.

⁶ Section 1.2 of CSTC (2011) describes the development of China's building energy efficiency in four stages: "(1) theoretical exploration (~ 1986), (2) pilot demonstration and popularization (1987 to 2000), (3) transition stage (2001 to 2005), and (4) implementation in an all-round way." Section 1.3 of this report was partly based on the contents of Section 1.2 of CSTC (2011).

Table 1-1 A Brief Review of Building Energy Efficiency Policy Development in China

Development Stages		Years	Selected Policy Activities	Chapters/Sections
1	Research Preparation (1980s to 1986)	Early 1980s	China began to conduct research on civil building energy use, building energy efficiency technologies and building energy codes.	3.2.1
		1986	<i>Energy Conservation Design Standard for Civil Building (Heating of Residential Building)</i> (1986) was the first design standard for residential buildings in China, which proposed the target of a 30% energy saving ⁷ .	3.2.1
2	Pilot Projects (1987 to 1992)	1988-1992	China issued the <i>Opinions on Speeding up the Innovation of Wall Materials and Promotion of Energy-Efficient Buildings (1988)</i> , and carried out pilot projects in two Chinese cities. In 1992, the experiments in two cities were scaled up to incorporate eight provinces and cities.	
3	System Formation (1994 - 2005)	1993	China issued the <i>Energy Conservation Design Standard for Thermal Engineering and Air Adjustment in Tourist Hotel Buildings (1993)</i> , the first design standard for public (including commercial) buildings.	3.2.1
		1993-1996	The former MOC established the Building Energy Efficiency Office and the Building Energy Efficiency Center, and began to develop and implement building energy efficiency policies in an organized manner, including development of the <i>9th Five-Year Plan and 2010 Planning for Building Energy Efficiency, Technology Policy for Building Energy Efficiency</i> , etc.	
		1995	China updated the <i>Energy Conservation Design Standard for Civil Building (Heating of Residential Building) (1995)</i> , increasing the energy-saving target up to 50%.	3.2.1
		1997	China issued its first <i>Energy Conservation Law (1997)</i> .	
		1999	China issued <i>Provisions on the Administration of Energy Conservation for Civil Buildings (1999)</i> , with regulations for the first time detailing the responsibilities of relevant stakeholders involved in the approval, design, construction, inspection, final acceptance and property management of construction projects. Penalties for violations of the regulations were also included in these Provisions.	3.2.2

⁷ See the explanation of this energy conservation target in Section 3.2.1 of this report.

Development Stages		Years	Selected Policy Activities	Chapters/ Sections
3	System Formation (1994 - 2005)	2001	China issued the <i>Design Standards for Energy Efficiency of Residential Buildings in the Hot Summer Cold Winter Region (2001)</i> .	3.2.1
		2003	China issued the <i>Design Standards for Energy Efficiency of Residential Buildings in the Hot Summer Warm Winter Region (2003)</i> , proposing the energy-saving target of 50% for newly-built residential buildings in this zone.	3.2.1
			The issuance of <i>Opinions on the Guide for the Pilot Reform Work of Heat Supply Systems in Cities and Towns (2003)</i> marked the beginning of heating reform. The regulations also stated the requirement of “implementation of consumption-based tariffs and billing systems, and promotion of energy saving in terms of both heating supply and demand.”	4.1.2
		2005	The first <i>Design Standard for Energy Efficiency of Public Buildings (2005)</i> was issued in China, proposing the target of 50% energy saving for new public buildings.	3.2.1
			The issuance of the <i>Renewable Energy Law of the People’s Republic of China</i> provided the legal and political support for the application of renewable energy in building energy efficiency.	5.2
			The former MOC conducted its first national building energy efficiency inspection.	3.2.2
4	System Improvement and Policy Implementation (2006 to the present)	2006	China issued revised <i>Provisions on the Administration of Energy Conservation for Civil Buildings</i> .	
			China issued the <i>Evaluation Standard for Green Buildings</i> , first national standard for green buildings.	3.4
		2007	China issued the <i>Code for Acceptance of Energy Efficient Building Construction</i> , the first building energy code dealing with standards for the acceptance of construction quality to meet building energy efficiency design requirements ⁸ .	3.2.1
			China revised and issued the <i>Energy Conservation Law of the People’s Republic of China</i> .	
		2007	The State Council issued its <i>Notice on Distribution of Comprehensive Working Scheme of Energy Conservation and Emission Reduction</i> , which established the residential retrofit of 150 million square meters as a task under the 11 th FYP.	4.2

⁸ The *Code for Acceptance of Energy Efficient Building Construction* may be world’s first code dealing with acceptance of construction quality in building energy efficiency design requirements.

Development Stages		Years	Selected Policy Activities	Chapter/Sections
4	System Improvement and Policy Implementation (2006 to the present)	2007	The <i>System of Statistical Reporting on the Energy Consumption of Civil Buildings</i> required 23 cities to engage in statistics gathering work related to civil buildings' energy use.	2.1
		2008	The issuance of the <i>Regulations of Energy Conservation in Civil Buildings</i> and <i>Regulation of Energy Conservation of Public Organizations</i> provided specific guidance for articles related to building energy efficiency under the <i>Energy Conservation Law of the People's Republic of China</i> .	4.2.1, 4.3
		2009	China issued the <i>Standards for Energy Efficiency Inspection of Public Buildings</i> and the <i>Standards for Energy Efficiency Inspection of Residential Buildings</i> .	
		2010	China revised two important design standards for building energy efficiency: the <i>Design Standards for Energy Efficiency of Residential Buildings in Severe Cold and Cold Regions</i> ⁹ and the <i>Design Standards for Energy Efficiency of Residential Buildings in the Hot Summer Cold Winter Region</i> . The energy-saving target was increased to 65% in the former, but there was no clear specification in the case of the latter ¹⁰ .	3.2.1
		2011	The State Council issued the <i>Comprehensive Working Scheme for Energy Conservation and Emissions Reduction</i> in the 12 th Five-Year Plan, stating that China will conduct residential retrofit of 400 million square meters in the northern heating zone, and 50 million square meters in the hot-summer and cold-winter zone.	7.3

⁹ Namely the *Energy Conservation Design Standard for Civil Building (Heating of Residential Building) (1995 Revision)*.

¹⁰ Yang et al. (2011) pointed out that there was no clear energy saving target in the general principles of the standard, but the quantification of the specific target cited in some texts was still 50%.

CHAPTER 2- BUILDING ENERGY PERFORMANCE IN CHINA

2.1 Building Energy Consumption Statistics

The *China Energy Statistic Yearbook* is an authoritative statistical reference that contains comprehensive data describing national energy infrastructure development, energy production and consumption, and the balance of energy supply and demand. The Yearbook provides statistics relating to energy consumption in agriculture, industrial sectors, construction, wholesale and retail sectors, transportation, and in other major economic sectors. It has been compiled by the National Bureau of Statistics of China (NBSC) since 1986. Formerly the Yearbook was published once every two years; since 2004 it has been published on an annual basis. As it essentially serves as a general resource containing macro statistics, the Yearbook does not contain specific data relating to building energy consumption.

From 2007, MOHURD began to gather civil building energy consumption statistics, publishing the *Statistical Report System on the Civil Public Building Energy Consumption* in the same year (on the basis of examination and approval by the National Bureau of Statistics of China), specifying that the statistics gathering work for the *Statistical Report System* should thereafter be carried out on a trial basis in 23 pilot cities throughout China. This work is carried out annually and is coordinated by MOHURD in order to survey public and residential buildings in large and medium cities throughout China. The unit of survey is an individual building unit. Table 2-1 lists the statistics collected and methods used.

Basic information gathered in the survey consists of nine statistical indicators: building name, building area, number of floors, building type, building function, completion time, types of energy consumed (e.g. electricity, coal and natural gas, plus various other information concerning building energy consumption), and types of heating and cooling systems.

Table 2-1 Building Energy Consumption Survey

Buildings surveyed	Survey method	Survey progress		
		Year	Number of surveyed buildings (units)	Floor space (million m ²)
Government and large-scale commercial buildings	Complete survey	2007	61,960	361
Residential and small-scale commercial buildings	Sampling survey	2008	51,988	342
		2009	90,571	609
		2010	33,000*	Na

*Among which 4850 blocks of buildings have completed energy auditing and more than 1500 have been subjected to dynamic energy consumption monitoring (China Construction Newspaper 2011¹¹)

Data source: Newsletter on the Information Statistics of Energy Consumption and Energy Efficiency of Civil Buildings (Issue 3, 2011), and CSTC (2011) (p.74).

In 2010, MOHURD published and distributed the *System of Statistical Reporting for Energy Consumption and Energy Efficiency of Civil Buildings*, launching the nationwide campaign to gather building energy consumption statistics throughout China¹² and further specifying the main parties responsible for reporting the relevant statistical content (as shown in Table 2-2). Following the implementation of the *System of Statistical Reporting*, the reporting frequency was changed from a biannual plus annual submission schedule to a single annual report submission. The system is currently only implemented in designated cities and regions and the organization of building energy consumption surveys in rural areas is not a mandatory requirement.

Table 2-2 Surveyed Buildings and Reporting Bodies

Surveyed buildings	Reporting parties
Government buildings	Institutional administrations of government bodies or energy-consuming units
Large-scale public buildings	Building owners, parties legally entitled to use buildings or energy suppliers
Small and medium-sized public buildings	
Residential buildings	Housing administrations or energy suppliers

¹¹See <http://www.gbeca.org/cms/GBECA/zhengcefagui/guojiazhengce/15ubr50khphpa.xhtml>

¹² Statistical gathering for residential buildings and small and medium public buildings has been expanded from 23 cities to 79 cities nationwide.

2.2 Total Building Energy Use¹³

In 2008 the total building area in China was 43 billion square meters, among which roughly 12.3 billion square meters are residential buildings in urban areas, 7.1 billion square meters are public buildings and 23.6 billion square meters are buildings in rural areas.

The primary energy consumption of buildings throughout China (excluding biomass energy) is nearly 380 million tons of oil equivalent (Mtoe), accounting for nearly one fifth of China's total primary energy consumption (BEERC 2011; CSSB 2012), where the main types of energy consumed are electricity (44%), coal (40%), natural gas (13%) and oil products (3%). Figure 2-1 illustrates the change in building energy consumption in China between 1996 and 2008.

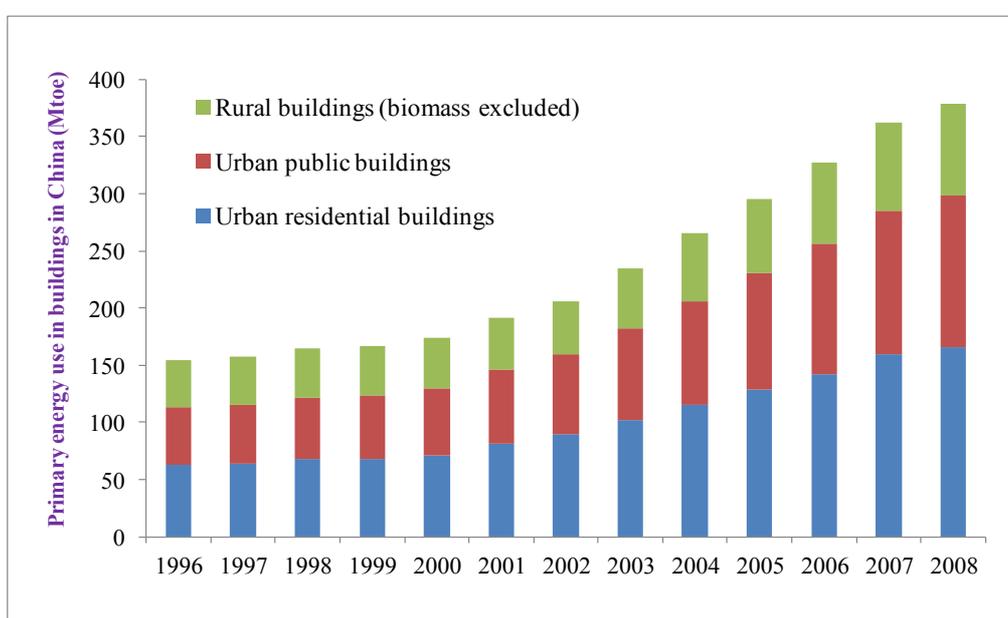


Figure 2-1 Building Energy Use in China 1996-2008

Source: Qi (2010); BEERC (2011)

Note: data in Qi (2010) and BEERC (2011) has been rearranged to reallocate heating consumption to residential and public buildings in northern areas proportional to floor space.

¹³ The unit of energy consumption in this report refers to the international unit, namely toe, KWh, MWh or TWh. Chinese academic research literature related to the energy tends to refer to the ton of coal equivalent (tce), which is generally taken as the unit of reference (because coal is the main energy source in China). In this report, the conversion coefficient 1toe equals 1.43 tce is used. Electric power is converted by using the approach for calculating corresponding coal consumption for power generation, saying 1 MWh electricity is equivalent to 0.327 tce (nearly 80% of electricity in China is generated by coal-fired power plants. This conversion coefficient takes the average efficiency of the power plant and electricity transmission and distribution loss into account). Coal and other primary sources of energy are converted by means of the electro-thermal equivalent method, with 1 tce= 29.3 GJ=8140 KWh. The energy consumption described throughout this report refers to the primary energy consumption unless otherwise specified.

Geographically speaking, China is very large with different regions that are characterized by enormous differences in climate, levels of economic development and building functions. In addition, the various types of buildings each feature different characteristics in terms of their energy consumption. One example of this difference is widespread use of biomass energy in buildings in rural areas, which is comparatively rare in urban areas. Other examples include the energy-consuming modes and rates of energy consumption per unit area, which feature relatively large differences between residential, public and commercial buildings, in this case in exclusively urban areas.

According to international conventions, building energy consumption is often divided into two categories, residential and public. At present, as experts in the Chinese building industry take the urban-rural differences into account, along with differences in regional climate, characteristics of energy use and other factors specific to the national context, building energy consumption is generally classified into four categories: (1) Space heating in northern urban buildings; (2) non-heating energy consumption of urban residential buildings; (3) non-heating energy consumption in public buildings; and (4) energy consumption of rural residential buildings (Qi 2010).

At present, as the heating energy consumption of northern urban buildings accounts for a large proportion of the total building energy consumption in China, it is often researched on a separate basis and non-heating energy consumption is considered as a separate category in the literature related to building energy consumption in China. This classification approach is distinct from the *whole building energy consumption*¹⁴ analysis method that is generally adopted in the international building research literature.

The Severe Cold and Cold regions are Heating Zone (the zone in which buildings are required to have heating) includes 14 northern provinces, municipalities and autonomous regions. This region accounts for 33% and 40% of the national population and GDP, respectively (CSSB 2012). Winter heating energy consumption in northern urban buildings represents an important proportion of total national building energy consumption, roughly one fourth of building commercial energy consumption in 2008. The average primary energy consumption per square meter in this zone fell from 197.8 KWh/m²/year in 1996 to 141.6 KWh/m²/year in 2009 (BEERC 2011), which is attributed to the implementation of building energy efficiency standards.

The HSCW Zone refers to the Yangtze River basin and its peripheral regions, covering 16 provinces, autonomous regions and municipalities. The zone

¹⁴ Include space and household water heating, lighting, household appliances, cooking, and all other building energy consumption.

occupies about 1.8 million km² and accounts for 42% and 48% of the national population and GDP, respectively. As climate in the zone is relatively different from that of other countries and regions at the same latitudes, Chinese building energy research experts often take this zone as a separate subject of research. This zone is characterized by a sultry summer, damp and chilly winters, small diurnal temperature swings, large annual precipitation, and rather limited sunshine. In the past, buildings in this zone had neither heating nor cooling, due mainly to economic and social reasons. Moreover, little emphasis was made on thermal insulation or heat protection in the design of residential buildings, and thus the thermal performance of the building envelope was generally poor.

As a result, the indoor thermal environment and housing conditions of buildings in winter and summer were uncomfortable. With the economic development of this zone and rapidly rising standard of living, the demand for heating and air conditioning by local residents has increased, with residents often independently installing heating and air conditioning equipment. On average, space heating and air conditioning energy consumption in the HSCW zone increased by nearly 70% per year from 1996 to 2008. Although the average heating energy consumption of this zone is still low at only 16.2 KWh/m²/year (BEERC 2011), it is quite foreseeable that in keeping with the continuous improvement in living standards and residents' demand for a more comfortable living environment, that energy consumption would also increase.

The primary energy intensity in terms of energy consumption per square meter for different types of buildings across various regions was derived after reprocessing the statistical data in the existing research literature related to building energy consumption in China, as shown in Figure 2-2.

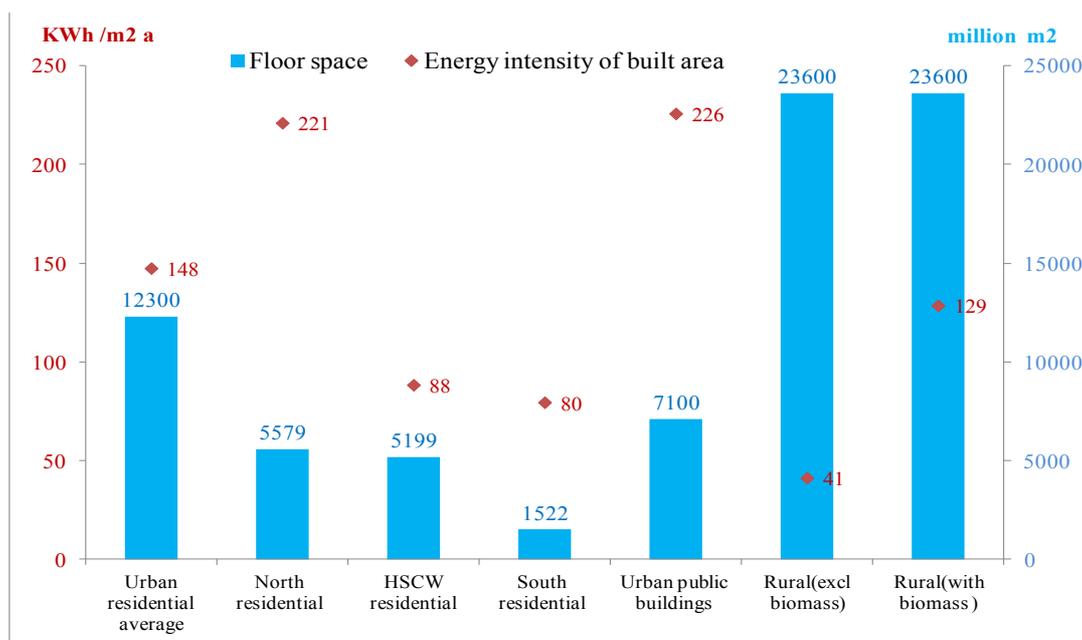


Figure 2-2 Building Area and Primary Energy Intensity by Region in 2008

Data sources: BEERC (2011); CSTC (2011); CSSB(2010)

Note: Owing to the arrangement of data in the BEERC (2011) some statistical data are unavailable. It is assumed that the unit area of non-heating energy consumption of the urban residential buildings in each climate region in China is identical.

2.3 Energy Use in Urban Residential Buildings

Urban residential energy use includes the energy consumption involved in heating, air conditioning, cooking, water heating, lighting and that use by other household appliances (Figure 2-3). The main sources of energy are electricity, coal, natural gas, LPG and coal gas.

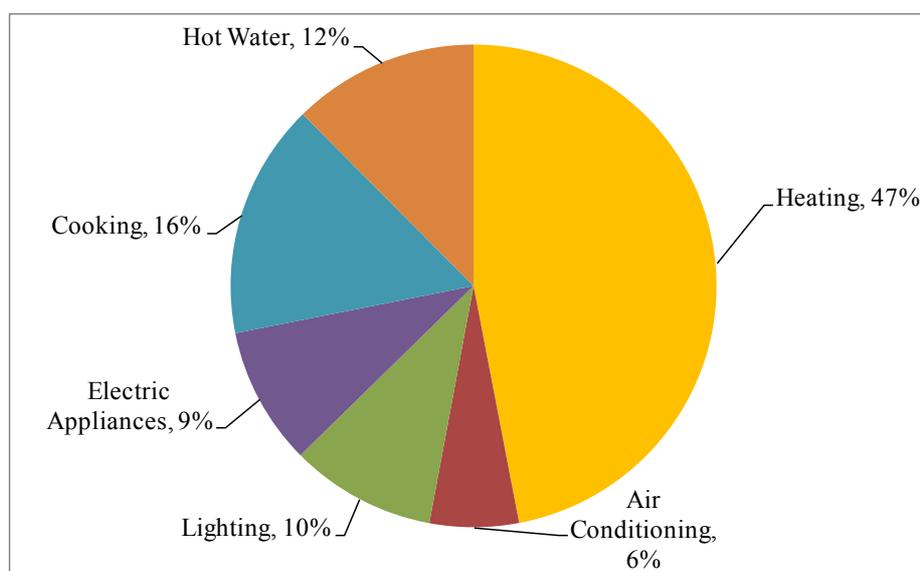


Figure 2-3 Breakdown of Energy Consumption in Urban Residential Buildings in 2008

Source: BEERC (2011)

2.3.1 Energy Consumption of Residential Air Conditioning

With the growing popularity of air conditioning in buildings, China has become the world's third largest air conditioning market, third only to the United States and Japan and accounting for 12% of global air conditioning market demand¹⁵. In recent years, energy consumption by air conditioning in summer has skyrocketed in the HSCW zone and southern provinces, with significant consequences. Periods of high temperatures each summer have led to increased demand for power from the electrical grid, and thus power shortages have been known to occur in a number of provinces, obliging electricity suppliers to enact brownout measures to cope with the peak periods of excessive demand¹⁶.

¹⁵<http://www.carrier.com.cn>, air conditioner production in China accounts for 80% of total global output.

¹⁶CSTC (2011).

Since the 1990s, with rising incomes and changes in lifestyles among urban residents in China, air conditioning has become increasingly prevalent in urban homes, where most households have adopted air conditioning. At present, the ownership rate of air conditioning in large and medium cities is over 80%, and even exceeds 100% in some provinces and cities¹⁷. Energy consumption by air conditioning in urban residential buildings throughout China in 2008 was 41 billion KWh, or 9.37 Mtoe in terms of primary energy demand, accounting for 6% of total residential energy consumption (Figure 6; BEERC 2011).

2.3.2 Other Urban Residential Energy Use

In 2008 other urban residential energy consumption (energy use excluding heating and air conditioning) in China reached 74.8 Mtoe, accounting for 16% of total building energy consumption, representing an increase of 250% from that of its 1996 level, while electricity consumption grew faster still, from 31 TWh in 1996 to 267 TWh in 2008, an increase of nearly 600% during the same period (BEERC 2011).

Dividing by 190 million urban households in China¹⁸, the average lighting electricity consumption of each urban household in China is about 352 KWh, which is significantly lower than that in the developed European and American countries¹⁹. At the same time, the energy consumption level of heating, air conditioning, domestic water heating and household apparatus in the urban families in China is also significantly lower than that of developed countries. Generally, the average energy consumption level per unit area by urban residents in China (except residential buildings in the northern areas) is lower than that in America, Western Europe, Japan and other developed countries (e.g., in 2006, the average household heating energy consumption in the EU-27 countries exceeded 150 KWh/m²/year²⁰, equivalent to the average energy consumption of residential buildings in China, while the average primary energy consumption of residential buildings in the US in 2005 was 245KWh/m²/year²¹).

¹⁷China Encyclopedia web: <http://www.chinabaike.com/z/zl/323048.html>

¹⁸ Takungbao website: <http://gb.takungpao.com/tw/comment/2010-06-24/285546.html>

¹⁹ The average annual lighting consumption of American families is nearly 2000KWh per household, 3 times higher than that of Chinese families. The average energy consumption is 560 KWh in European families and 939 KWh in Japanese families respectively. Refer to the IEA Guidebook on Energy Efficient Electric Lighting for Buildings http://www.lightinglab.fi/IEAAnnex45/guidebook/2_lighting%20energy%20in%20buildings.pdf.

Figures from different years are cited, the year-on-year changes in developed countries are small.

²⁰ European Union MURE-ODYSSEE Energy Statistical Database. Primary energy consumption of heating should be even higher.

²¹ According to the statistics of United States Department of Energy, the total residential building area in America was 22.4 billion m² in 2005, and the average final energy consumption was 137 KWh/m²/year (data source: Energy Information Administration 2005 Residential Energy Consumption Survey: Energy Consumption and Expenditures Tables).

<http://205.254.135.7/consumption/residential/data/2005/c&e/summary/pdf/alltables1-15.pdf>

2.4 Energy Use in Public Buildings Except for Space Heating

Public buildings account for about one third of the total urban building area in China (BEERC 2011, and Energy Conservation Service Special Committee of China Energy Conservation Association 2011). The energy use in public buildings mainly includes the energy used in heating, lighting, air conditioning and ventilation, domestic hot water supply, office equipment, elevators, water drainage and other facilities, as well as the energy used for other special functions. From 1996 to 2008, the total energy consumption of public buildings increased by nearly two and a half times and was as high as 135 Mtoe in 2008, when electricity consumption increased nearly fourfold, from 78 TWh to 379.3 TWh (BEERC 2011).

BEERC (2011) pointed out that public buildings' energy consumption could be divided into two categories. The first category comprised the majority of common public buildings with floor space less than 20,000 square meters, unit area electricity consumption²² (except heating) generally in the range of 50-70kWh/m²a (which is much lower than that of the large-sized public buildings), and for which the electricity consumption for elevators is almost zero.

The second category is made up of the minority of large-sized public buildings with floor space greater than 20,000 square meters, with electricity consumption including lighting, office electrical equipment, electric water heating, elevators, air conditioning systems, and other special functional equipment facilities such as kitchens, information centers, etc. This latter category's electricity consumption is for the most part distributed in a higher range of 120-150 kWh/ m² a, equivalent to 1.8-2.6 times that of common public buildings. The comparison in the energy consumption of the two categories of buildings is shown in Table 2-3:

Table 2-3 Characteristics of Energy Consumption of Two Categories of Public Buildings

Building type	Floor area of single building	Total area (million m ²)	Energy intensity except for heating (kWh/(m ² a))*	Total energy use * (TWh/year)
Large-sized public buildings	>20,000 m ²	Approx. 400	90~200	50
Common public buildings	< 20,000 m ²	4900	30~70*	202

*The values include energy use by air conditioning and exclude heating.

Source: BEERC (2011)

²² Note: electricity is the main energy used in the public buildings.

2.5 Greenhouse Gas Emissions Related to Building Energy Use

In 2008, CO₂ emissions associated with energy consumption in the Chinese building sector was 1,260 million tons, accounting for nearly one fifth of the total CO₂ emission in China that year (Qi 2010).

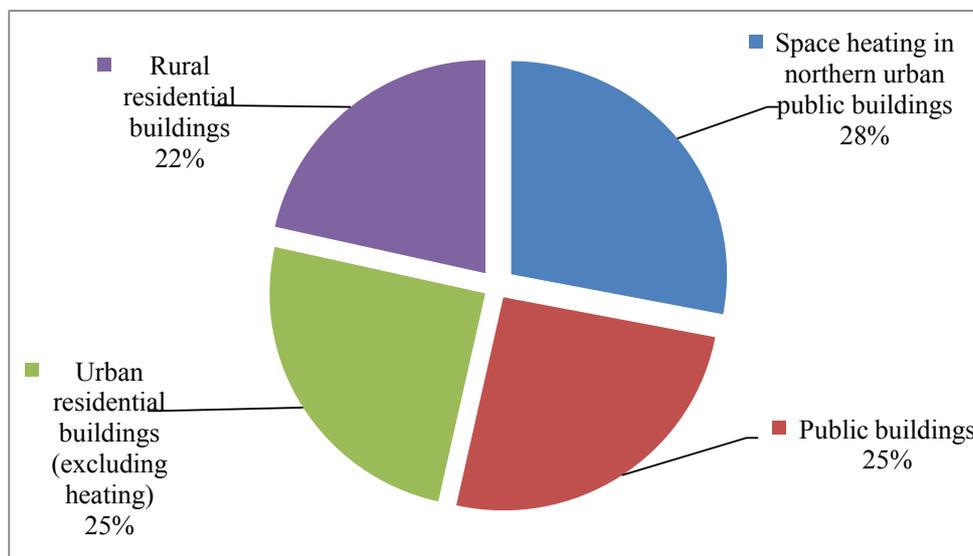


Figure 2-4 Carbon Emissions of China's Building Sector by Building Type

Source: Qi (2010)

Chinese and foreign organizations alike have conducted evaluations of the projections for energy consumption and greenhouse gas emissions by the Chinese building sector. These organizations include the Energy Research Institute, the National Development and Reform Commission (NDRC), Tsinghua University, the China Academy of Building Research, the Energy Foundation²³, the China Energy Team of the Lawrence Berkeley National Laboratory and the International Energy Agency (IEA). Significant variation exists in regards to the structure of the models used, the hypotheses articulated concerning baselines, parameters and development assumptions (including those related to technological progress, energy prices, etc.), the methods of analysis and the accuracy of model simulation, so not surprisingly the results of each institute's analysis differ significantly. Under the business as usual (BAU) scenario, it is projected by these research institutes that building energy consumption related CO₂ emission in China will reach 1,800-2,800 Mt by 2020 and in the range of 2,500-4,000 Mt by 2030.

By adopting the life cycle analysis method and considering energy consumption and emissions occurring during building installation, construction, demolition and

²³ As estimated by Kevin Mo from the Energy Foundation.

recovery processes, Xu, Huang and Yin (2010) estimated that the emissions from Chinese buildings would be 4,500-5,000 million tons by 2020. At the same time, Fridley et al (2008) also adopted the life cycle analysis method and projected that the under the BAU scenario CO₂ emissions from commercial buildings in China would reach 1,220 Mt by 2020, whereas under the policy scenario 25 Mt CO₂ emission could be reduced.

The models used by the Energy Research Institute (ERI 2009) and International Energy Agency (IEA 2007) include an energy market with income and price elasticity of final energy demand and other economic analysis methods. The BAU scenario assumed by IEA (2007) and ERI (2009) assumes that energy performance would not improve significantly during the period of analysis, that current mainstream technology would be used in future development, and that the scope for renewable energy as well as for technological change (and adoption) of emissions reduction technologies would also be limited.

By contrast, under the policy scenario (or low-carbon scenario), it is assumed that the final energy performance (including the end use energy-consuming products used in buildings) will be significantly improved, that low energy-consuming or zero energy-consuming buildings will become the mainstream in new building construction in the future, and that renewable and energy-efficient lifestyle and other emissions reduction technologies will be rapidly deployed and promoted under the influence of effective climate policies (e.g. carbon taxes, green energy subsidies and other incentive mechanisms).

Analyses by Tsinghua University, the Central European University (CEU), the Energy Foundation and the China Academy of Building Research emphasize the improvement and advancement of building technology, but did not describe the mechanism of end users' response to energy prices. Tsinghua University and the China Academy of Building Research's studies were conducted mainly from the perspective of engineering by considering the energy conservation standards for buildings to be built in the future, renovation of existing buildings, and various energy performance advancements for end use energy-consuming products.

The CEU's modeling framework for global building energy use (thermal comfort and water heating) across different regions around the world includes building stock modeling (by vintage and building type) and takes different equipment/appliance technologies into account. In addition, the research by Fridley et al (2008) was carried out from the life cycle analysis perspective so as to assess the contribution of improvements in the energy performance of Chinese commercial buildings and the impact of end use energy-consuming products on the reduction of building energy consumption and associated CO₂ emissions.

IEA (2007) estimated that the CO₂ emissions associated with building energy consumption in China under the policy scenario would be 15% and 25% lower than under the BAU scenario by 2020 and 2030 respectively. In comparison, the research by the Energy Research Institute (2009) estimated that the CO₂

emissions of buildings under the low-carbon economy (LCE) development scenario would be 20% lower than the BAU case both by 2020 and 2030 alike, and that the CO₂ emissions of buildings under the enhanced LCE scenario would be 22% and 30% lower than under the BAU by 2020 and 2030 respectively.

The research findings by the Energy Foundation and China Academy of Building Research showed that, under conditions where green building practices were implemented and building energy conservation standards were strengthened and promoted, the greenhouse gas emissions of the building sector in China would witness an inflection point around 2020 and its potential for emission reductions would equal approximately one third of total building sector emissions by 2030 (Mo 2010). In addition, according to research by the China National Institute of Standardization et al (2011), with the promotion of energy-efficient lighting and household appliances in China, 78.4 Mt and 159 Mt of CO₂ emissions could be eliminated by 2015 and 2030 respectively.

Although there exists great differences between different models in terms of projections of energy consumption demand and of buildings' carbon emissions, all of the analyses clearly demonstrate that China's building sector possesses huge potential for energy conservation and GHG emissions reduction.

CHAPTER 3- EFFICIENCY POLICIES FOR NEW BUILDINGS

3.1 Overview

The construction industry has been a pillar industry in China's rapid economic development, accounting for 6.6% of China's gross domestic product in 2009(CSSB 2012). Between 2000 and 2010, China added some 1.7 billion square meters of new floor space on an annual basis (including both urban and rural areas). In 2010, China completed the construction of 2.8 billion square meters of new buildings, which was roughly 3.44 times the total area built in 2000 (Figure 3-1). It is estimated that China will add another 10 to 15 billion square meters of residential buildings in urban areas, and an additional 10 billion square meters of public buildings by 2020 (CSTC 2011).

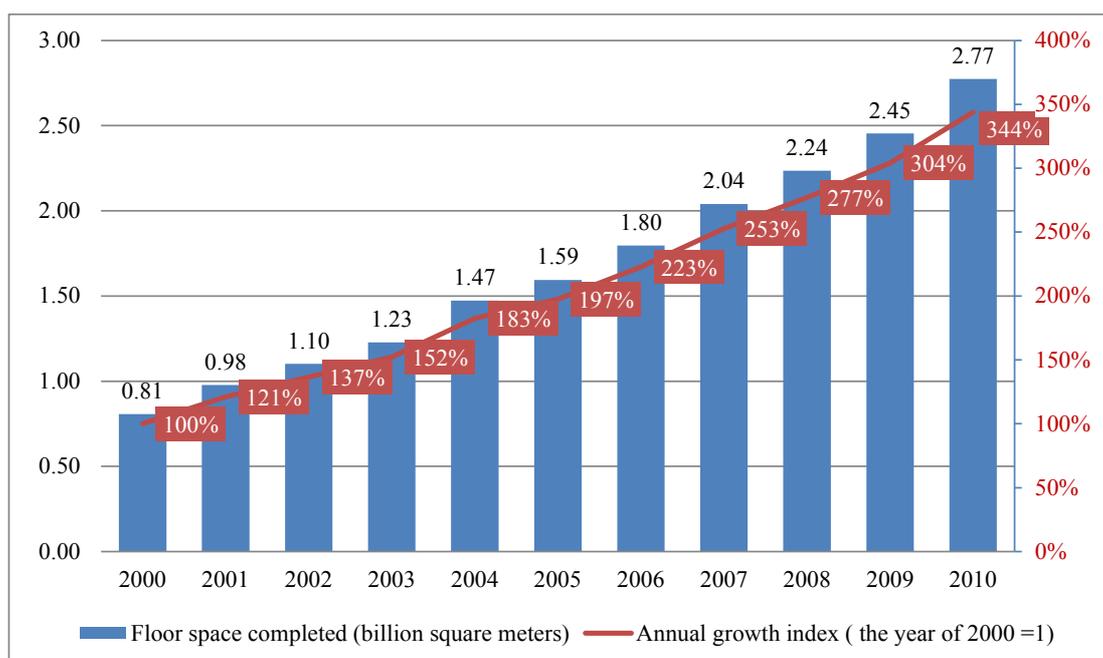


Figure 3-1 New Floor Space Constructed in China, 2000-2010

Source: CSSB (2012)

In order to promote the energy efficiency of new buildings, the Chinese government has been actively engaged in the development and deployment of a series of policy instruments, including the formulation of a building energy code system and a related system of supervision and enforcement, the establishment of a framework for building energy efficiency performance labeling and associated evaluations, as well as the rolling out of a nationwide promotion of green building.

3.2 Building Energy Codes

3.2.1 The System of Building Energy Codes

Since the 1986 issuance of *The Energy Conservation Design Standards for Civil Buildings (Heating of Residential Buildings)*, China has established a relatively comprehensive building energy codes system for new buildings. This system includes design standards and acceptance codes, covering residential and public buildings, all major climate zones, and the main construction processes, which include design, construction, acceptance, operation and retrofit (Table 3-1).

Table 3-1 Building Energy Codes System

Building Energy Codes		Contents
Design Standard	<i>Design Standards for Energy Efficiency of Residential Buildings in Severe Cold and Cold Zones</i> (1986, 1995 ²⁴ and 2010)	Building energy efficiency requirements for building envelope, thermal insulation, heating and ventilation.
	<i>Design Standards for Energy Efficiency of Residential Buildings in the Hot Summer and Cold Winter Zone</i> (2001 and 2010)	Building envelope and thermal insulation, and energy efficiency for heating, air conditioning and ventilation systems (HVAC).
	<i>Design Standards for Energy Efficiency of Residential Buildings in the Hot Summer and Warm Winter Zone</i> (2003)	Thermal engineering for walls and roofs, shading, and energy efficiency for HVAC.
	<i>Design Standards for the Energy Efficiency of Public Buildings</i> (2005)	Building energy efficiency indexes and requirements by climate zone, building envelope, thermal insulation, HVAC.
Acceptance Standard	<i>Code for Acceptance of Energy Efficient Building Construction</i> (2007)	Provisions for building energy efficiency construction works for walls, curtain walls, doors and windows, roofs, floors, HVAC, piping networks for space heating and air conditioning systems, power distribution and lighting, monitoring and control, and on-site inspections, among others.

Source: CSTC (2011)

A comparison of China's design standards with its American commercial and residential counterparts is listed in Table 3-2.

The energy saving targets, or 30%, 50% and 65%, mentioned in the design standards are based on building energy use of a typical building (building envelope and equipment) in the 1980s (Yang et al. 2011), see Table 3-3.

²⁴ The 1986 and 1995 versions of this code are entitled *The Energy Conservation Design Standards for Civil Buildings (Heating of Residential Buildings)*.

Table 3-2 Comparison of China's Design Standards with ASHRAE 90.1 and IECC

	China				U.S.	
	Commercial	Residential			Commercial	Residential
	Public and Commercial Buildings (2005)	Heating (2010)	HSCW (2010)	HSWW (2003)	ASHRAE 90.1 2007	IECC 2009
Envelope	√	√	√	√	√	√
HVAC	√	√	√	√	√	√
Service hot water and pumping	X	X	X	X	√	√
Lighting	*	X	X	X	√	√
Electrical power	X	X	X	X	√	X
Trade-offs and building component performance approach	√	√	√	√	√	√
Renewable energy	X	√	√	X	√	√

Note that “*” indicates that energy efficient lighting is not covered by the existing Chinese design standards but by a separate lighting standard. The presence of a “√” or an “X” in the above cells respectively indicates that the specific subjects (e.g., the envelope) are covered or not covered by the relevant building energy code.

Source: Evans et al. (2009); Shui et al. (2011)

Table 3-3 Energy-Saving Targets for New Buildings

Building Energy Codes		Residential Building			Public Building (2005)
		Heating Zone (2010)	HSCW Zone (2010)	HSWW Zone (2003)	
Targeted Subjects		District heating	Heating and air conditioning	Heating and air conditioning	Heating, air conditioning and lighting
Energy-Saving Targets		65%	50% ²⁵	50%	50%
Baseline	Data Sources	Building energy use data surveyed in 1980 and 1981	Calculated building energy use based on assumptions		
	Building Envelope	Typical building envelope in the 1980s			
	Equipment	Typical equipment used in the 1980s			

Source: The table is based on information provided in tables produced by Yang et al. (2011).

²⁵ Yang et al. (2011) pointed out that there was no clear energy saving target in the general principles of the standard, but the quantification of the specific target cited in some texts was 50%.

In 2007, China issued the Code for Acceptance of Energy Efficient Building Construction, also known as the “Acceptance Codes.” The Acceptance Codes address compliance with building energy codes at the construction stage and include specific provisions for construction practices to comply with building energy codes related to walls, curtain walls, doors and windows, roofing, flooring, HVAC, power distribution, lighting, monitoring and quality control.

The Acceptance Code makes compliance with building energy efficiency requirements mandatory for the final acceptance of a construction project, lifting energy efficiency standards and codes to equal importance with safety-related building codes (such as fire-proofing codes and construction structure codes related to earthquake resistance).

3.2.2 The System of Inspection and Supervision²⁶

Inspection and supervision are critical components in the enforcement of building energy codes. China’s current system of inspection and supervision benefits from strong regulatory support, and is reinforced by an annual national inspection conducted by MOHURD.

Note that not every new building undergoes a comprehensive inspection and supervision process. Any new residential community of 50,000 square meters or more is required to undergo construction inspection. Local MOHURD officials at the provincial and municipal level will determine if construction inspection will take place for residential projects under 50,000 square meters. Construction inspection is required for construction projects involving public and commercial buildings with a total investment over RMB 30 million. In addition to schools, cinemas and stadium buildings, any buildings supported by foreign aid and loans are also subject to construction inspection (MOHURD 2001).

Regulatory Support

Provisions on the Administration of Energy Conservation for Civil Buildings (1999) is China’s first government-issued regulation that specifies the responsibilities of stakeholders in the process of construction project approval, design, construction, engineering quality inspection, final acceptance and property management. The Provisions also stipulate penalties for any violations of regulations.

In 2005, MOHURD issued the *Notice on the Strict Implementation of Energy Efficiency Design Standards for New Residential Buildings (2005)*, which added mandatory compliance with building energy codes to the existing construction management system.

²⁶ Please refer to Shui et al. (2009), Evans et al. (2010), Shui et al. (2011), and Shui (2012) for related information.

The revised *Energy Conservation Law* (2007) also contained provisions outlining the responsibilities of key stakeholders in regard to compliance with building energy codes, and with respect to public disclosure of building energy use information to consumers.

The *Regulations on Energy Conservation in Civil Buildings* (2008) provided further details on the responsibilities of stakeholders in construction project processes and relevant penalties for violations (Box 3-1).

Box 3-1 Management Provisions for Building Energy Efficiency (Construction)

Construction

A construction company shall inspect wall materials, thermal insulation materials, doors and windows, heating and cooling systems, and lighting equipment. If the above elements do not comply with building drawing documents, they shall not be used.

If a construction inspection company discovers that the work of the construction company does not comply with building energy codes, the construction inspection company shall ask the construction company to correct any shortcomings identified.

If the construction company refuses to follow this request, the construction inspection company shall inform the developer and report its findings to relevant governmental entities. Without the approval signature of construction inspector(s), the construction company shall not be allowed to proceed to the next phase of the construction procedures.

Penalty for Violation

If the construction company fails to comply with mandatory provisions of the building energy codes, the company is required to correct its wrongdoing and pay penalty of between 2% and 4% of the contract cost.

Source: *Regulation on Energy Conservation in Civil Buildings* (2008)

National Inspection of Building Energy Efficiency and Emissions Mitigation²⁷

Since 2005, MOHURD has conducted an annual nationwide inspection of building energy efficiency and emissions mitigation to evaluate the level of compliance with building energy codes in various cities.

The inspection typically takes place in December, requiring roughly two or three weeks to complete. Each inspection covers the majority of 31 provincial territories (22 provinces, 4 municipalities, and 5 autonomous regions). By default the capital city of each provincial division is selected for annual inspection. In addition, two cities (or districts for municipalities) in each provincial territory are randomly selected for inclusion in the annual inspection.

²⁷ This section is based on Section 5.6 of Shui (2012).

MOHURD usually sends approximately ten survey teams to conduct the annual inspection. Each team consists of officials from MOHURD, building energy codes experts from various research institutes and centers, as well as local code management and enforcement officials (who do not carry out inspections in their own provinces, cities and counties).

The inspection criteria include the implementation of relevant national and local building energy efficiency policies and regulations, as well as compliance with mandatory items in design standards and the Acceptance Codes.

An inspection team will randomly select the documentation and reports of a construction project for evaluation and conduct an on-site inspection of a randomly-selected construction site. Inspection checklists are used during the inspection process. The checklists are varied by drawing inspection and construction inspection activities, respectively. If a building is found to be non-compliant with any of the mandatory code requirements, the building is counted as non-compliant in the inspection statistics, regardless of whether the identified instance of non-compliance is immediately rectified.

After each inspection, MOHURD announces the inspection results on its website, listing both those provincial divisions that have done an excellent job, as well as those which require improvement. In order to better prepare for the annual national inspection of building energy efficiency and to promote the implementation of building energy codes, local governments also conduct their own scheduled and random inspections.

3.2.3 Economic Incentive Measures

Building energy efficiency in China has been promoted mainly through government intervention. Since the 1990s, the Chinese government has promulgated a series of tax-based incentive policies for promoting building energy efficiency in new buildings. These economic incentive measures have focused on the adjustment tax for fixed asset investment, corporate income tax and value added tax. In addition, these measures cover not only new energy-efficient buildings, but also the production and use of new wall materials (Table 3-4).

Table 3-4 Selected Economic Incentives for Building Energy Efficiency in New Buildings

	Selected Economic Incentive Policies
Adjustment Tax for Fixed Asset Investment	The <i>Provisional Rules on Adjustment Tax for Fixed Asset Investment (1991)</i> directed investment towards building energy efficiency through favorable tax policies; for example, the <i>Rules</i> stipulated a tax rate of zero for fixed asset investments in energy-efficient residential buildings in the northern areas.
Income Tax	The <i>Notification on Various Preferential Policies for Corporate Income Tax (1994)</i> specified that no corporate income tax would be collected for five years from the date of manufacture of the goods sold if this company obtained income through the selling of building materials (for walls) made of coal slack, furnace cinder and fly ash.
Value Added Tax	In order to encourage the production and use of new wall materials, the government issued a series of policies elaborating tax exemptions or adjustments in relation to value added taxes in 1992, 1995, 2001 and 2004. By the end of 2005, any enterprise could take advantage of preferential policies that reduced the value added tax by half on production of new wall materials, regardless of the scale of manufacture.

Source: BECon (2009)

3.2.4 Implementation Results

The 2010 national inspection of building energy efficiency included inspection of areas in 26 provinces (municipalities and autonomous regions) and of the Production and Construction Corps of the Chinese People's Liberation Army in Xinjiang. According to the inspection results provided by MOHURD, the compliance rate with building energy codes has improved from 53% (design stage) and 21% (construction stage) in 2005 to 99.5% and 95.4%, respectively, in 2010 (MOHURD 2006, 2007, 2008, 2009, 2010, 2011 2008, 2009, 2010, 2011).

While the dramatic improvement of the compliance rate may suggest a significant improvement in enforcement, some international building experts have expressed concerns with respect to possible limitations resulting from the design of the national inspections and from the definition of the compliance rate. Evans et al. (2010) argued that the lack of protocols for software testing and the lack of protocols for building simulation would affect the compliance rate at the design stage. It is also worth noting that the annual inspection of building energy efficiency and emissions mitigation focuses mainly on compliance with mandatory items in the design standards and in the Acceptance Codes in the cities selected for inspection. The announced compliance rate does not reflect the surveyed areas' compliance with *non-mandatory* items or compliance rates in small towns and rural areas (Shui 2012).

3.3 Building Energy Efficiency Labelling and Evaluation

3.3.1 Key Concepts

Building energy efficiency labeling mainly targets newly-built residential and public buildings. It is a means by which information can be disclosed related to building energy use and the energy efficiency of relevant energy-consuming systems.

Building energy efficiency evaluation focuses on the testing, measurement and calculation of building energy use and the energy efficiency of associated energy-using equipment (e.g. heating and air conditioning systems in residential buildings; heating and air conditioning systems and lighting in public buildings) and other performance indexes, thus providing information about the level of energy use of the subjects under study.

Any building that applies for building energy efficiency labeling must comply with national mandatory standards, including building energy codes (design standards and the Acceptance Codes), before applying for building energy efficiency labels.

3.3.2 Development Review

China began to establish its system of building energy efficiency labeling and evaluation in 2006, with the release of *Decisions on Enhancing Energy Conservation* (2006), which stressed that “the mandatory energy efficiency labeling system shall be implemented as soon as possible, and this energy efficiency labeling should extend its coverage to household appliances, electric motors, automobiles, and buildings...”

The Notice on Disseminating “A Comprehensive Working Scheme for Energy Saving and Emissions Reductions” (2007) and *The Regulations on Civil Building Energy Efficiency* (2008) required “the enhancement of full-cycle monitoring and management for the implementation of building energy consumption limit requirements for new buildings, the implementation of measurement and evaluation of building energy efficiency, and the prohibition of construction projects to commence, accept and make sales if their projects do not comply with building energy codes.” *The Regulations on Civil Building Energy Efficiency* (2008) also required government offices and large-scale public buildings to conduct building energy efficiency evaluations, and to publicly disclose evaluation results.

In addition, *Tentative Methods for Managing Civil Building Energy Performance Labels* (2007) specifies the definitions, organization, management and other aspects of testing, evaluating and labeling building energy performance. *The Technical Guide for Labeling, Testing and Evaluating Civil Building Energy Performance* (2007) provides specific methods for testing and evaluating the grades of building energy performance labels.

At present each province has established a provincial agency for building energy efficiency measurement and evaluation. Most provinces and cities have also developed their own enforcement regulations for promoting building energy efficiency measurement and evaluation (CSTC 2011).

3.3.3 Building Energy Efficiency Labeling and Evaluation

There are two types of building energy efficiency labels in place: (1) a building energy efficiency label that relies on *theoretical values* of building energy efficiency evaluated after the building is completed and accepted, which is valid for a one-year period; and (2) a building energy efficiency label that relies on actual values of building energy efficiency evaluated from on-site actual building energy performance that has been continuously measured for at least one year, which is valid for five years.

In late 2011, MOHURD organized a group of Chinese building experts to review *The Energy Performance Certification Standards of Building*, which is the revised version of *Technical Guide for Labeling, Testing and Evaluating Civil Building Energy Performance (2007)*. This coming standard rates building energy efficiency labels on a scale of one to three stars (Table 3-5), rather than based on a five star scale as was the case in the previous version.

Table 3-5 Theoretical Values of Building Energy Efficiency Label Grades

Grade	Relative Energy Saving Rate η for General Items
☆	$0 < \eta < 15\%$
☆☆	$15\% \leq \eta < 30\%$
☆☆☆	$\eta \geq 30\%$

Note: The relative energy saving rate for general items η is the energy-saving rate relative to the current design standards for building energy efficiency.

For example, if a building obtains a one-star rating, it indicates that this building is between 0 and 15% more energy efficient relative to a reference building (as described in the current design standards for building energy efficiency).

3.3.4 Implementation Results

Since 2009, MOHURD has promoted building energy efficiency labeling in newly-built government office buildings and large-sized public buildings through pilot projects in selected provinces and cities. By 2010, 45 of the 71 applications were approved and granted star ratings: including 5 three-star projects, 21 two-star projects and 19 one-star projects. The deployment of building energy efficiency labeling and evaluation is still in its initial stage.

3.4 Green Buildings

3.4.1 Key Concepts

Green buildings in China mainly refer to newly-built residential buildings, office buildings, department stores, hotel buildings and other public buildings. The concept of green buildings addresses the desire to maximize saving of resources (i.e. saving energy, land, water and materials), protect the environment, reduce pollution, and improve living conditions such that they are comfortable, healthy and safe throughout a building's life cycle (i.e. planning, design, construction, operation and decommissioning).

3.4.2 Development Review

The year 2004 represented a turning point for the development of green building in China. Before 2004, the main activities undertaken included exploration, study and application of the concepts of green building. At a workshop in 2004, President Hu Jintao specifically proposed the development of land-saving and energy efficient housing, the establishment and rigorous implementation of stricter standards for the conservation of energy, water and materials. Mr. Hu's proposals greatly boosted the acceleration of development of green building in China: in only six years China has managed to develop a relatively comprehensive technical and management system for green building (see "technical system" and "management system" in Figure 3-2).

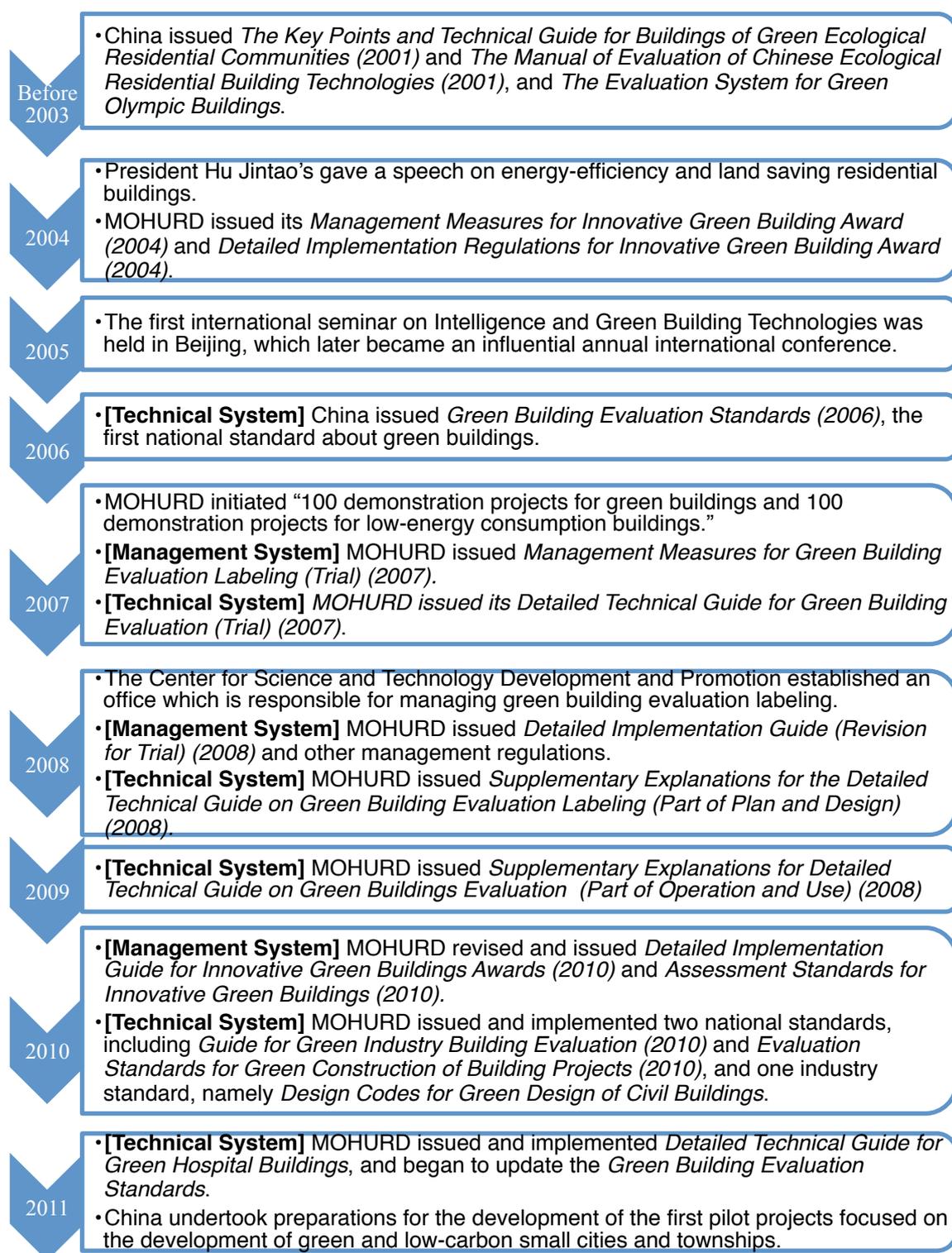


Figure 3-2 Development History of Green Building in China

3.4.3 Green Building Labeling and Evaluation

The green building evaluation system consists of six indexes, including (1) land use and outdoor environment, (2) energy efficiency and utilization, (3) water efficiency and utilization, (4) materials saving and utilization, (5) indoor environmental quality and (6) operation management (for residential buildings) or comprehensive performance of the building life cycle (for public buildings).

Each index includes control (or mandatory) items, general items and preferred items. Control items contain essential criteria specified in the Green Building Evaluation Standards that must be met by a green residential or public building. According to the extent to which a green building is able to meet the criteria contained in the general items and optimized items, they can be graded into one of three levels in a three-star ranking system (see Tables 3-6 and 3-7).

Table 3-6 Grade Criteria for Green Building (Residential Buildings)

Grade		Total	☆	☆☆	☆☆☆
General Items (40 Items)	Land Use and Outdoor Environment	9	4	6	7
	Energy Efficiency and Utilization	5	2	3	4
	Water Efficiency and Utilization	7	3	4	6
	Materials Saving and Utilization	6	3	4	5
	Indoor Environment Quality	5	2	3	4
	Operation Management	8	5	6	7
Preferred Items		6	N.A.	2	4

Source: Green Building Evaluation Standards, 2006

Table 3-7 Grade Criteria for Green Building (Public Buildings)

Grade		Total	☆	☆☆	☆☆☆
General Items (40 Items)	Land Use and Outdoor Environment	8	3	5	7
	Energy Efficiency and Utilization	10	5	6	8
	Water Efficiency and Utilization	6	2	3	4
	Materials Saving and Utilization	5	2	3	4
	Indoor Environment Quality	7	2	4	6
	Operation Management	7	3	4	6
Preferred Items		21	N.A.	6	13

Source: Green Building Evaluation Standards, 2006

Green building labels fall under two categories: green building design evaluation labels and green building evaluation labels. Both are based on the *Green Building Evaluation Standards* (2006) and the *Detailed Technical Guide for Green Building Evaluation* (2007). The two are evaluations focused on the design and operation stages, respectively (Table 3-8).

Table 3-8 Green Building Labeling

	Green Building Design Evaluation Labeling	Green Building Evaluation Labeling
Target	Residential and public buildings that are undergoing planning, design and construction.	Residential and public buildings that have been completed and have been put into use.
Technical basis	<i>Green Building Evaluation Standards (2006)</i>	
	<i>Detailed Technical Guide for Green Building Evaluation (2007)</i>	
	<i>Supplementary Explanation on Detailed Technical Guide (Operation and Use) for Green Buildings Evaluation (2008)</i>	<i>Supplementary Explanation on Detailed Technical Guide ((Plan and Design) for Green Buildings Evaluation (2009)</i>
Period of Validity	One year	Three years

3.4.4 Implementation Results

At the end of 2007, MOHURD initiated a program entitled “100 demonstration projects of green buildings and 100 demonstration projects of low-energy consumption buildings.” The initiative required applicant projects to be residential or commercial buildings at the planning stage of construction, buildings still under construction, or buildings that had already been completed within the previous year. Furthermore, an applicant project involving a residential or public building should be larger than 20,000 square meters, while a residential community or a group of residential communities should be larger than 100,000 square meters.

From the debut of green building evaluation and labeling in China in 2008 to the conclusion of this initiative at the end of 2011, a total of 271 buildings were awarded with green building evaluation labels (see Figure 3-3).

Many cities have been actively promoting green buildings. For example, Beijing intends to develop the “Future Science City” and “Lize Financial Business City” as green and low-carbon demonstration parks. China is cooperating with Singapore to build an ecological city in Tianjin to demonstrate the application of green and low-energy consumption technologies in accordance with local conditions. Aiming at becoming ‘the capital of green buildings,’ the city of Shenzhen was elected as a national demonstration city for the application of renewable energy in building energy efficiency in 2009. Since that time Shenzhen has been promoting the

concept of green buildings in every aspect of the government's construction management (China Urban Studies Society 2011).

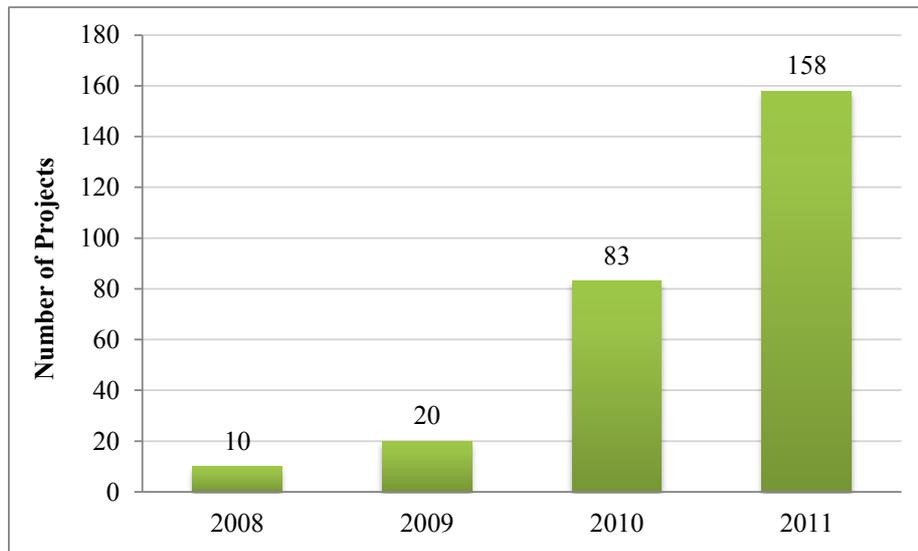


Figure 3-3 Number of Green Building Evaluation and Labeling Projects, 2008 -2011

Data Source: Data from 2008 to 2010 is from China Urban Studies Society (2011) *Green Buildings 2011*; 2011 data was obtained from the MOHURD website.

CHAPTER 4- BUILDING ENERGY EFFICIENCY POLICIES FOR EXISTING BUILDINGS

4.1 Overview

China has a huge stock of existing buildings. The total area of buildings in China increased from 27.8 billion square meters in 2000 to 48.6 billion square meters in 2010; i.e. nearly 1.75 times the total area in 2000 (Figure 4-1). Retrofitting of existing buildings has been one of two foremost challenges to promoting building energy efficiency in China.

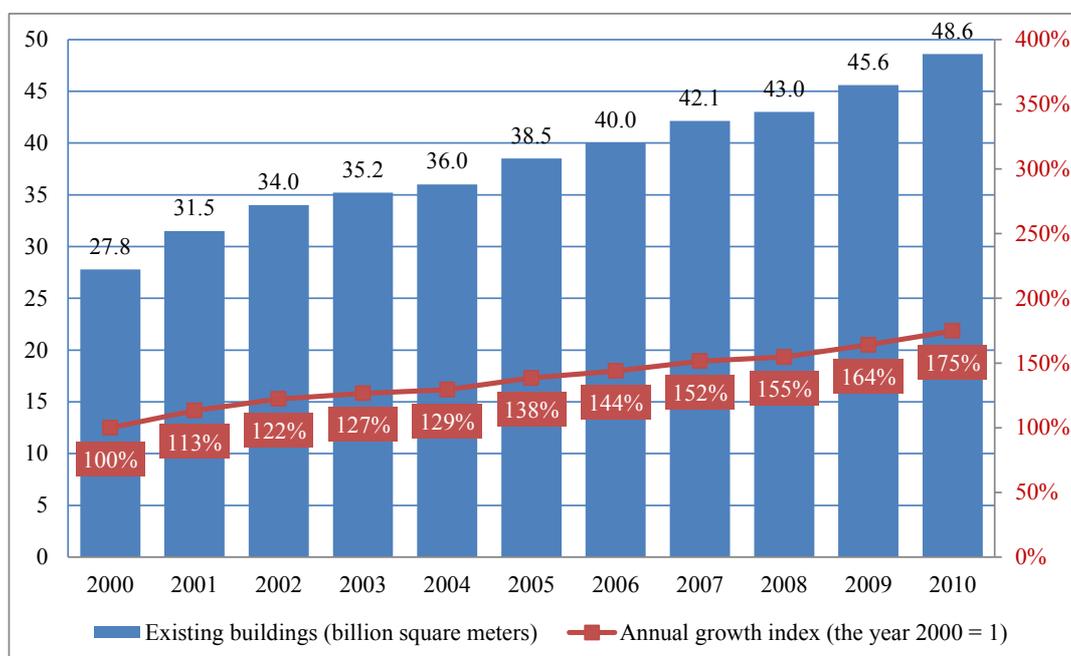


Figure 4-1 Total Areas of Existing Buildings and Annual Growth Index, 2000 -2010

Source: CSSB (2012)

Energy efficiency retrofit refers to activities related to the upgrading, renovation, or modification of the building envelope, heat supply system, heating and cooling systems, lighting equipment, or hot-water supply facilities that do not comply with mandatory building energy efficiency standards.

The technical methods for retrofitting in China focus on the building envelope, external windows, heat reform (housing unit-based measurement and

consumption-based billing), lighting equipment and other electrical facilities, and the use of renewable energy.²⁸ Residential retrofit in China includes nine types:

- Comprehensive retrofit, including the retrofit of the building envelope, indoor heating metering, and outdoor heating system;
- Building envelope only;
- Windows only;
- Outdoor heating system only;
- Indoor heating system and metering;
- Building envelope, indoor heating system and metering;
- Building envelope and outdoor heating system;
- Indoor heating system and metering and outdoor heating system, and
- Building envelope and geothermal pump.

During the 11th FYP period (2006-2010), China completed residential retrofit of 183 million square meters, 18% higher than the expected 150 million square meters.

4.1.1 Development Review

Regulatory Support

During the 1990s, China promoted energy efficiency retrofit by launching a series of policies, regulations and technical standards. The MOC (the predecessor to MOHURD) issued the *Ninth Five-Year Plan and 2010 Planning on Building Energy Efficiency (1995)*, which laid out such goals as promoting retrofit in the northern heating regions and in the HSCW zone, as well as heat reform during the Ninth FYP (2001 to 2005) and in the lead up to 2010.

The *MOC Outline of the “Tenth Five-Year Plan” for Building Energy Efficiency (2002)* further identified retrofit as a focus for the Tenth FYP (2006 to 2010), including the improvement of thermal insulation of the building envelope and heat reform.

The *Energy Conservation Law of the People’s Republic of China* issued in 2007 specifically stated that “building energy efficiency plans shall include retrofit,” and “as for retrofit, heat meters – the devices for controlling indoor room temperature and the devices for controlling heat supply systems – should be installed according to applicable requirements.”

The State Council issued the *Notice on Distributing a Comprehensive Working Scheme for Energy Saving and Emissions Reduction (2007)* and brought specific working objectives: retrofitting 150 million square meters of residential buildings in

²⁸<http://www.qhcin.gov.cn/Sites/RootSite/JZKJYJN-SNGDGZDT/2010/6/28/8.html>

the northern heating regions, and promoting operation management and retrofit pilots in large-scale public buildings during the 10th FYP (2006 to 2010).

In 2008, the government issued *Regulations on Civil Building Energy Efficiency (2008)* to explain and supplement the *Energy Conservation Law of the People's Republic of China* with detailed provisions related to building energy efficiency. The *Regulations on Civil Building Energy Efficiency (2008)* contains specific chapters clarifying the energy efficiency of existing buildings, including the definition of retrofit, technology options, and fee collection for residential and public buildings, respectively.

The *Regulations on Energy Efficiency of Public Organizations (2008)* issued in the same year required public organizations to enhance supervision, management, planning and other energy measures for improving the building energy efficiency of their own buildings.

During the last decade, the government has issued technical standards associated with retrofit, such as *Technical Specifications for Energy Conservation Renovation of Existing Heating in Residential Buildings (2000)* (the updated version was reviewed by experts in November 2011 and has been submitted for approval), *Testing and Measurement of Building Energy Efficiency in Public Buildings (2009)*, and *Testing and Measurement of Building Energy Efficiency in Residential Buildings (2009)*.

Financial Support

One significant challenge to the retrofit is financing. In order to address this issue, the Chinese government has been helping to establish a multi-source financing mechanism for residential retrofit projects in the northern heating regions.

During the 11th FYP period (2006 to 2010), the central government arranged RMB 24.4 billion of financial support, of which 18.9% came from the central government, 36.9% from the local government, and 44.2% from other non-governmental financial sources²⁹.

In the 12th FYP period (2011-2015), the central government will further assist in increasing available financial support. For example, the central government will provide subsidies of RMB 55 and RMB 45 per square meter for residential retrofit projects in the Severe Cold and Cold regions, respectively.

The central government has also encouraged local governments to provide local financial support for retrofit. Recently the Beijing government announced that the municipal government would subsidize energy efficiency retrofit of buildings, offering RMB 100 per square meter in addition to the subsidy from the central government, and would furthermore subsidize the retrofit associated with

²⁹http://jjs.mof.gov.cn/zhengwuxinxi/lingdaojianghua/201107/t20110714_576304.html

installation of solar water heating systems to the tune of RMB 200 per square meter³⁰.

4.1.2 Heat Reform

Heat reform is an important part of China's drive to improve building energy efficiency. Over the years the government has subsidized the cost of residential heating in northern cities and towns, with heat expenses calculated by heating area rather than actual heat consumption. Such a heat supply system did not encourage building energy efficiency and a considerable amount of heat was wasted in northern heating areas.

The aim of heat reform in China is to reduce the amount of energy wasted by end users through the reform of the heating pricing system and by establishing market mechanisms, to increase heat suppliers' efforts to improve the energy efficiency of their heat supply networks, to share the retrofit costs of energy efficiency renovation, and also to promote retrofit (Qi 2010). Figure 4-2 presents selected heat reform activities promoted by the Chinese government.

³⁰<http://www.bj.chinanews.com/news/2011/1221/20780.html>

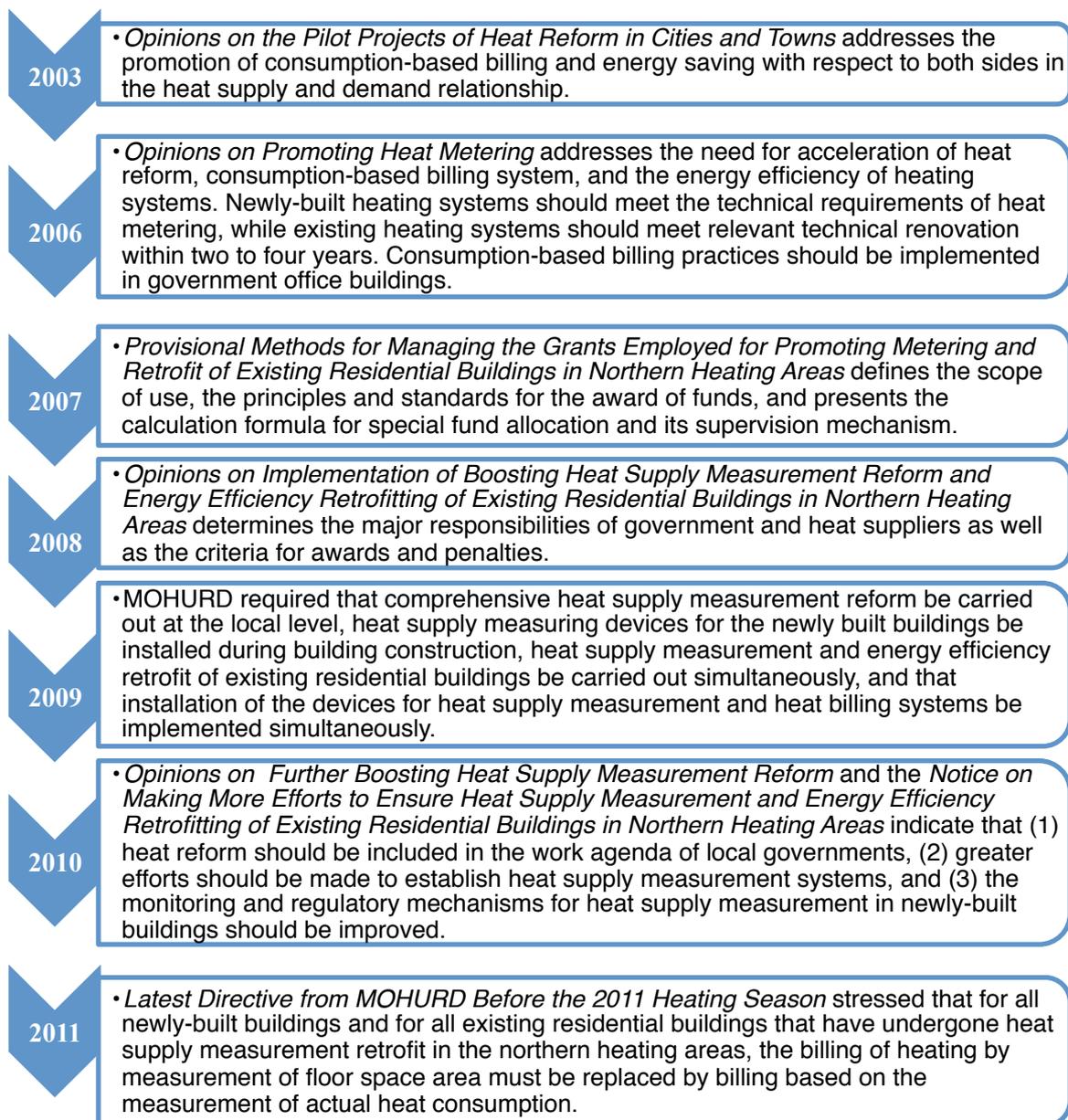


Figure 4-2 Progress of Promotion of Heat Supply Reform Policies

Source: BEERC (2011); website of MOHURD³¹

At the beginning of the 1990s, the state required public utilities to change the mechanisms by which they operated. As a consequence various cities carried out pilot reforms of their heat supply systems (Li and Dong, 2010). On July 21, 2003, the MOC and other ministries and commissions jointly published and distributed

³¹See http://www.mohurd.gov.cn/zcfg/jswj/jskj/201104/t20110421_203196.htm

their *Opinions on the Guide for the Pilot Work of Heat Reform in Cities and Towns (2003)*, proposing the requirement of a “steady introduction of a system of consumption-based billing that would promote energy efficiency in the heat supply and consumption”.

Since 2006, MOHURD has issued a series of documents to accelerate the implementation progress of heat metering and consumption-based billing systems. This was facilitated by a clearly established series of special financing vehicles (supported by national fiscal revenues) designed specifically to reward the adoption of heat metering and consumption-based billing systems.

By the end of 2010, 80 cities at prefectural level and above in northern heating areas had established consumption-based pricing and billing systems, representing a total of 317 million square meters of building space (Qiu 2011)³².

4.2 Residential Buildings

4.2.1 Development Review

The building energy use of China’s northern heating regions accounts for more than 40% of the country’s total urban building energy consumption. Most of the residents in the old buildings in this region are low and middle-income families living in cities. As most old buildings do not feature building envelopes that are equipped with thermal insulation measures, the indoor temperature in winter is low and the level of housing comfort is likewise relatively poor; therefore, the residential retrofit that has taken place in northern China has not only played a very important role in building energy efficiency, but has also been a significant means by which to improve the quality of housing conditions for urban populations of low and middle income.

In addition, the government believes that the encouragement of retrofit would stimulate the development of related industries such as new building materials, instruments manufacturing, and building construction, and is thus another useful strategy that can be used to increase domestic demand and promote employment.

China began its residential retrofit activities with international cooperation. Table 4-1 lists a number of government-to-government (bilateral) international cooperative projects. Non-governmental projects have also been implemented by the World Bank in Tianjin, and by Owens-Corning in Urumqi³³.

³²MOHURD: http://www.mohurd.gov.cn/bldjgzyhd/201109/t20110930_206469.html

³³ Joe Huang is a GBPN Expert Review Panel Member, President of White Box Technologies, Inc..

Table 4-1 List of International Cooperative Projects for Energy-Saving Retrofit of Existing Residential Buildings

Year	International Collaborator	Location
1997	Canada	City of Harbin; approx. 2442 square meters of existing residential buildings;
2002	France	City of Harbin; approx. 19,000 square meters of existing residential buildings
2005	Germany	City of Tangshan, City of Beijing, City of Urumqi

Source: BEERC (2011) (p.146)

Based on the accumulated experience of pilot retrofit projects, China has conducted assessments of technologies suitable for retrofit, and has established associated standards (For example, the *Technical Guide for Energy-Saving Reconstruction and Heat Supply Measurement of Existing Residential Buildings in Northern Heating Areas (Trial)* (2008) and has issued various policies related to retrofit.

During the 11th FYP period (2006 to 2010), the government increased the scale of residential retrofit. The *Bulletin of Issuing a Comprehensive Working Schemes for Energy-Saving and Emissions Reduction by the State Council* (2007) confirmed the goals of the 11th FYP, including residential retrofit of 150 million m² in the northern heating areas.

In January 2011, the Chinese government issued guidelines to emphasize the promotion of heat reform and residential retrofit. By the end of the 12th Five-Year Plan, each province, Autonomous Region and Municipality, must complete the implementation of heat metering, consumption-based billing and retrofit of at least 35% of all old residential buildings. MOHURD and the Ministry of Finance (MOF) are to assist allocate the tasks, evaluate the annual performance of each province, Autonomous Region and Municipality, and report to the State Council³⁴.

4.2.2 Implementation Results

During the 11th FYP (2006 to 2010), China completed residential retrofit of 182 million square meters in northern China, while in 2010 alone a floor area of 86 million square meters was retrofitted. It is estimated that the completed retrofit projects could save China 1.4 million tons of toe annually and result in an annual reduction of 5.2 million tons of CO₂ emissions and 0.4 million tons of SO₂ emissions³⁵. Meanwhile, the accompanying consumption-based billing could

³⁴http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/201101/t20110128_202232.html

³⁵http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/201104/t20110421_203196.html

reduce heating costs by more than 10%, and improve the living standards of 2 million urban households³⁶.

In June 2011, MOHURD announced that China plans to complete residential retrofit of 400 million square meters in the northern heating regions, which will help more than 7 million urban households improve their heating and housing conditions³⁷.

4.3 Public Buildings

The Chinese government has elected to focus on government office buildings, large-scale public buildings, and buildings in colleges and universities as the principal types of public buildings for building energy efficiency improvement.

4.3.1 Development Review

National Government and Large-Scale Public Buildings

The annual electricity consumption of government office buildings and large-scale public buildings accounts for about 22% of China's total urban electricity consumption. The annual electricity consumption per square meter is ten to twenty times higher than that of ordinary residential buildings³⁸.

In 2007, the central government issued the Implementation Guidelines of Improving Building Energy Efficiency in Governmental Office Buildings and Large-Scale Public Buildings (2007). It mandates that

- New buildings should strictly follow mandatory items in building energy codes. For example, building design should follow the requirements for conservation of energy, land, water, and materials, and for environmental protection.
- Upon the completion of a construction project, energy efficiency performance should be evaluated. If the new building cannot meet building energy codes, relevant government agencies should not issue the acceptance approval.
- In provinces and cities with high concentration of governmental office buildings and large-scale public buildings, the relevant energy conservation supervision system should be established, providing energy statistics, energy audits, and public information exposure of building energy use³⁹.

³⁶http://jjs.mof.gov.cn/zhengwuxinxi/lingdaojianghua/201107/t20110714_576304.html

³⁷<http://news.dichan.sina.com.cn/bj/2011/06/10/331188.html>

³⁸http://www.gov.cn/zwgk/2007-10/29/content_788896.htm

³⁹http://www.gov.cn/zwgk/2007-10/29/content_788896.htm

In the same year, the Central Government provided 24 provinces and cities with a total of RMB 99.05 million in financial support for the establishment of building energy efficiency inspection systems, including energy data collection, energy audits, public disclosure of building energy consumption information, and for the creation of a dynamic monitoring system⁴⁰ in three pilot cities, Beijing, Tianjin and Shenzhen⁴¹.

In order to promote building energy efficiency in public institutions (notably for central, provincial and local governments and institutions operating with full or partial governmental financial support) and to set a good example for other entities, the State Council issued the *Regulations on Energy-Efficiency for Public Institutions (2008)*. Under these new *Regulations*, public institutions are required to improve their energy efficiency through supervision, management, planning and promotion of relevant measures related to energy efficiency.

In the publication “*Guidance for Further Promoting Building Energy Efficiency in Public Buildings*”⁴² (2011), MOHURD highlighted that during the period of 12th Five-Year Plan (2011 to 2015) energy consumption per square meter in public buildings should be reduced by 10%, and by 20% in the case of such buildings in selected cities, and by 30% for large-scale public buildings in these cities. In the case of key cities implementing retrofit, the central government is to provide financial support, which is calculated at roughly RMB 20 per square meter.

Colleges and Universities

Colleges and universities are another target for building energy efficiency. By the end of 2005, there were 2,273 colleges and universities with 23 million students⁴³. A research study shows that “In 2005, the energy use per capita in 45 colleges and universities was 1.6 times that of average urban household in Beijing, while its water use per capita was 1.9 times the country’s average rate.” Conserving energy and reducing water usage is evidently an urgent and necessary task for China’s colleges and universities.

In order to promote the development of “Saving-oriented Campuses,” MOHURD and the Ministry of Education jointly published a series of documents⁴⁴, including:

- *Technical Guidelines for Energy-saving Supervision Systems for Campus Buildings in Colleges and Universities (2009)*,

⁴⁰ Dynamic monitoring systems refer to on-line energy management systems that allow key energy consuming units to submit their energy use data on-line, and which support a series of energy management analyses at unit and local level.

⁴¹ <http://60.247.103.213/qikanshow.asp?articleid=2336&cataid=3>

⁴² http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/201105/t20110510_203337.html

⁴³ http://www.mohurd.gov.cn/zxydt/200805/t20080520_168966.html

⁴⁴ http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/200911/t20091110_196722.html

- *Technical Guidelines for Operation and Management of Energy-saving Supervision Systems for Campus Buildings in Colleges and Universities (2009)*,
- *Guidance for Energy Statistics, Energy Audits, and Public Information Disclosure of Building Energy Consumption for Campus Buildings in Colleges and Universities (2009)*,
- *Guidance for Energy-saving Operation and Management of Campus Facilities in Colleges and Universities*, and
- *Guidance for Rating Systems and Evaluation for “Saving-oriented” Campuses in Colleges and Universities*.

The *Notice for Further Promotion of Building Energy-Efficiency in Public Buildings (2011)* noted that promoting retrofit in colleges and universities should continue, with no less than an additional 0.2 million square meters to be retrofitted, and at least a 20% reduction in building energy use per square meter.

4.3.2 Implementation Results

By the end of 2010, government office buildings and large-scale public buildings had been the site for the implementation of a wide range of policies and projects, including energy consumption data collection (33,000 building units), energy audits (4,850 building units), public disclosure of energy consumption information (6,000 building units), and dynamic monitoring (1,500 building units)⁴⁵. In the same year, 72 universities carried out energy-saving pilot projects; however there is currently no information available concerning the implementation results of these projects.

⁴⁵http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/201104/t20110421_203196.html

CHAPTER 5- APPLICATION OF RENEWABLE ENERGY IN BUILDINGS

5.1 Overview

The increased use of renewable energy holds great promise for China. Not only can it play an important role in relieving the increasingly serious imbalance between energy supply and energy demand faced by the country (thereby contributing to increased security of energy supply), but further application of renewable energy can also serve as the basis for low-carbon economic development. Moreover, it can help in the achievement of the industrial structure adjustment sought in the context of China's 12th Five-Year Plan, which seeks to facilitate the transformation of the current economic growth pattern, increase employment, and promote the development of a renewable energy industry while improving people's standard of living and protecting the natural environment.

Renewable energy sources like solar energy and shallow geothermal energy can be used to satisfy building energy requirements such as heating, air conditioning, hot water supplies and lighting, each of which represents an important area of application for renewable energy. The application of these renewable resources can play an important role in substituting for conventional fossil fuels and in enhancing the energy efficiency of buildings.

China has huge potential for the development of solar energy resources as areas where the annual amount of solar radiation exceeds $4200\text{MJ}/\text{m}^2$ (the level of solar radiation intensity that can be effectively utilized) account for 72% of China's territory (Box 5-1). In addition, there are abundant low temperature heat resources that can be collected from surface water, shallow ground water and soil. Therefore, there is an enormous potential for China's renewable energy resources to be exploited. Over the past ten years, China has witnessed high-speed development in the field of renewable energy.

As for the promotion and application of renewable energy in the building sector, at present China mainly focuses on solar energy and geothermal heat pump technologies. The application of solar energy includes solar-thermal and photovoltaic power generation techniques.

The solar-thermal technique mainly includes: (1) passive solar application in building design, (2) solar water heating systems (which can be divided into domestic solar water heating systems and solar hot water engineering projects for different purposes), and (3) solar heating systems. The application techniques for solar photovoltaic in building are commonly known as "Integrated Building PV."

Box 5-1 Renewable Energy Supply in China

Most of China's solar potential is located in Tibet and Qinghai where there is a relatively small population and few buildings.

Both solar energy and shallow geothermal energy are considered low-grade energies and are of low heat value, but they can nevertheless satisfy the basic requirements for household energy consumption in buildings. Therefore, it is quite reasonable to expect that the vigorous development and large-scale promotion and application of these types of energy in buildings can make a major contribution to achieving the objectives of energy conservation and greenhouse gas emission reduction in the building sector.

The total installed capacity of wind-power generation grew to nearly 42GW in 2010 from 225MW in 1998, an increase by a factor of roughly 190 times, with generating capacity doubling every two years since 2005. In recent years, the photovoltaic industry in China has also been developing at quite a fast pace. China's current solar cell module production capacity is amongst the largest in the world, trailing only those of Europe and Japan. According to the analysis of Liang and Chen (2011), the production capacity of solar cells was projected to increase by 81% in 2011 to reach 35GWp, accounting for 2/3 of global capacity and exceeding the worldwide total demand.

Solar-thermal technology has been widely used in the China's building sector. China is the largest producer of solar water heaters with an annual production capacity exceeding 20 million square meters.

According to statistics from MOHURD, as of 2010, the total nationwide heat collection area of solar water heaters had reached 150 million square meters (which is still modest compared to the total building stock), thus replacing more than 21 Mtoe of fossil fuels annually. It is projected that by 2020 the current heat collection area will double.

Some provinces and cities have begun to impose regulations concerning the mandatory use of solar-thermal in the building sector. For example, regulations in Hebei Province require solar water heaters to be installed for newly built residential buildings with more than twelve floors, and likewise in Shanghai for newly built residential buildings with more than six floors.

At the same time, the technical application of geothermal heat pump technology is developing rapidly, with an annual growth rate of 20%. The application area of geothermal heat pump technology in some northern cities accounts for one third of the total local heating area (one example is the city of Shenyang⁴⁶). In 2008, projects applying renewable energy permitted the country to reduce CO₂ emissions by nearly 20 million tons.

⁴⁶Please refer to the Baidu Encyclopedia website <http://baike.baidu.com/view/21641.htm>.

It is predicted that total area making use of heating and cooling by geothermal heat pumps will reach 200 million square meters in 2020, 400 million square meters in 2030 and 1,000 million square meters in 2050, respectively (Sun et al, 2010).

A current major challenge faced by China is the relatively low proportion of total energy use that is accounted for by the application of renewable energy in residential, commercial and industrial buildings. Simultaneously, as a result of residents' rising incomes and their demand for greater comfort, many towns that did not originally belong to a heating zone have begun to install their own heating equipment.

It is also worth noting that in the country's vast rural areas, use of commercially available energy resources such as coal, natural gas and electricity is increasing and is likely to continue to increase in the future, while the share of biomass in many rural residential buildings' energy use continues to decline, the present use of traditional biomass energy in these same rural areas is also relatively inefficient.⁴⁷

5.2 Development Review

The fundamental legal basis related to the use and management of renewable energy in China is *Renewable Energy Law of the People's Republic of China* promulgated in 2005. This law constitutes a relatively complete series of regulations and policy measures, thus establishing the basic legal system and policy framework for promoting the development and utilization of renewable energy.

Under this framework, in order to coordinate national energy and economic policy for energy conservation and emissions reduction, since the Eleventh Five-Year Plan (2006-2010), the National Development and Reform Commission, MOHURD, Ministry of Finance, Electricity Regulatory Commission, National Standards Commission and relevant departments have successively issued a series of relevant supporting policies to promote the application of renewable energy in the building sector, such as *Implementation Opinions on Promoting the Application of Renewable Energy in Buildings* and *Notification on Accelerating the Application and Scale-up of Solar Water Heating Systems*. MOHURD also plans to organize demonstration projects for renewable energy application in buildings across the country during the Twelfth FYP (2011-2015)⁴⁸, and thus, jointly with Ministry of

⁴⁷ At present, the utilization of methane, fuel wood, straw and other biomass energy in rural area is relatively inefficient and causes serious environmental pollution.

⁴⁸ Encourage implementation of centralized contiguous demonstration, financial and policy support for key demonstration projects and major application, and promote technology R&D and

Finance (MOF), issued the "Notice on the Organization of the Annual Program of Integrated PV Buildings Demonstration Projects in 2012" at the end of 2011. The Notice required local governments to encourage the establishment of green cities and promote contiguous and large-scale photovoltaic power generation in residential and commercial buildings in green and eco cities.

Since 2006, when MOHURD and Ministry of Finance began to develop demonstration projects for the countrywide application of renewable energy in the building sector, a variety of central and local policies and regulations have been issued that aim to support the application of renewable energy in buildings. With the continuous improvement of the level of technical application of renewable energy in buildings and the ongoing reduction of development costs for renewable energy technology, the prospects are very good for the application of renewable energy in urban, rural, residential and public buildings in China. The system of promotion for the application of renewable energy in buildings in China is shown in the Figure 5-1.

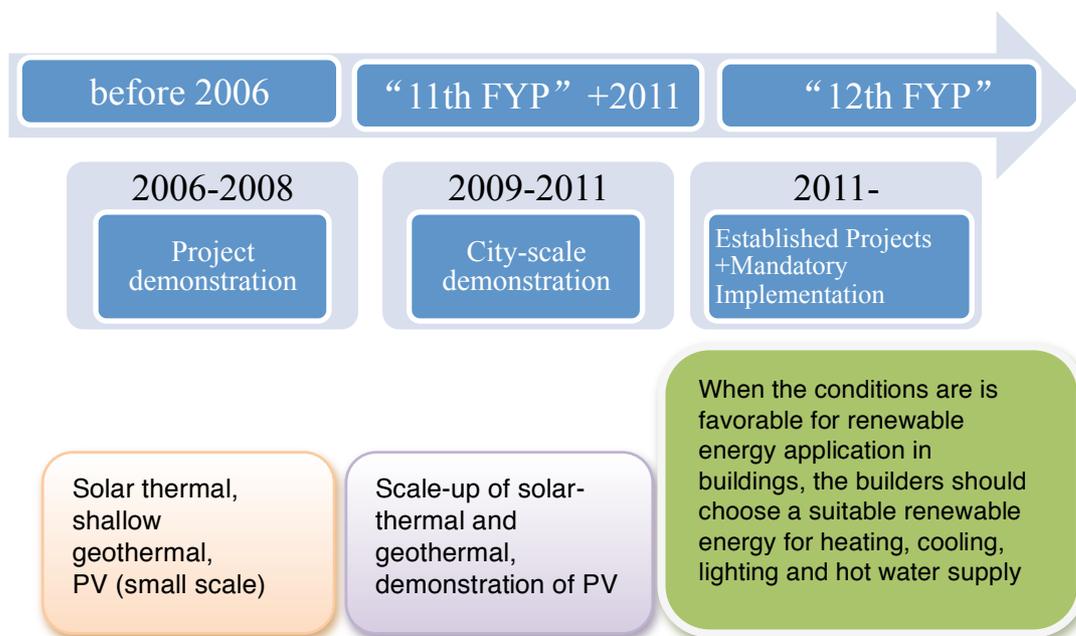


Figure 5-1 The Promotion System for Application of Renewable Energy in Buildings

Source: CSTC (2011)

At the local level, various policy documents for promoting the application and scale-up of renewable energy in the building sector have been successively issued by each province and city⁴⁹. At present, many provinces and cities⁵⁰ have

industrialization for renewable energy applications in buildings. Please see http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/201112/t20111229_208177.html

⁴⁹Shaanxi, Shanxi, Hubei, Hunan, Hebei, Chongqing, Qingdao, Shenzhen, Xiamen, Dalian and other provinces and cities have issued local *Regulations on Building Energy Efficiency*. Fujian, Tianjin, Jilin, Guangdong and other provinces and cities are also reviewing relevant energy-saving

issued local policy regulations for the purpose of promoting renewable energy in buildings. Such policy regulations mainly focus on the promotion and application of renewable energy technologies including photovoltaic power generation, building integrated photovoltaic, solar water heating, and geothermal heat pumps, among others. At the same time, the local Departments of Finance have also issued financial support plans and relevant policies.

5.3 Implementation Status

From the beginning of 2006, the former Ministry of Construction and Ministry of Finance began to develop a nationwide program for the demonstration of renewable energy application in buildings, including the application of solar and shallow geothermal energy. Simultaneously, integrated photovoltaic building demonstration projects were developed by launching the “Solar Rooftop Plan”, while in parallel the demonstration program of renewable energy application in urban and rural buildings also commenced. With the implementation of these demonstration projects, renewable energy application in buildings developed from a single project to incorporate entire regions into the program, thus integrating urban and rural areas and eventually achieving significant development results. The status of renewable energy demonstration projects approved from 2006 to 2008 is shown in Figure 5-2.

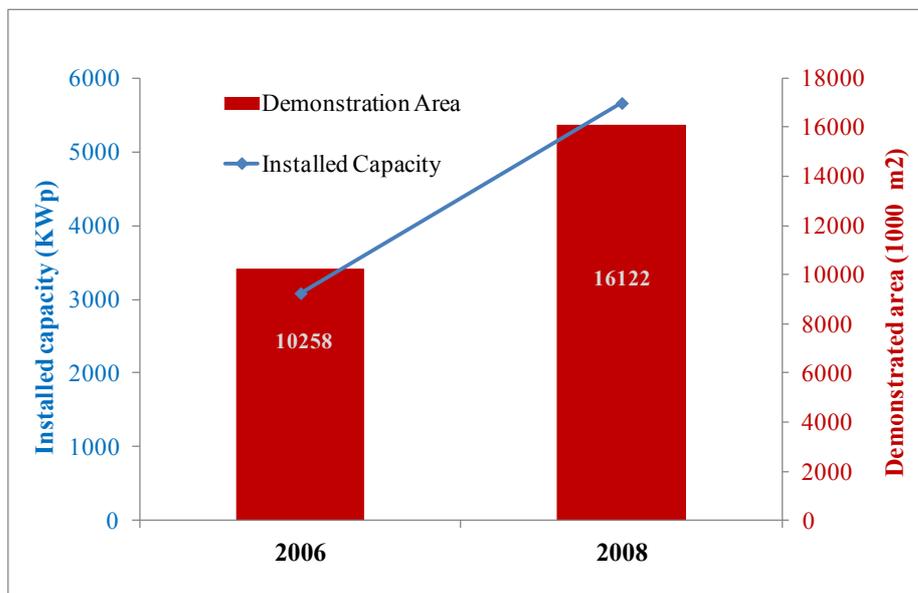


Figure 5-2 Approved Renewable Energy Building Demonstration Projects, 2006-2008

Data source: CSTC (2011)

regulations for local building, while Shanghai, Jiangsu, Guiyang and other cities are compiling the relevant regulations and rules.

⁵⁰ Mainly refers to coastal provinces with developed economies and regions which are relatively short of energy resources.

According to the latest data released by MOHURD, by the end of 2010 MOF had (jointly with MOHURD) implemented 371 demonstration projects related to the application of renewable energy in buildings, 210 demonstration projects for buildings integrating photovoltaic systems, and an additional 47 demonstration city projects and 98 demonstration county projects concerning renewable energy in buildings. Shandong, Jiangsu, Hainan and other provinces have begun to promote mandatory use of solar water heating systems. In 2010, the total building floor space in which solar thermal was applied was 1.48 billion square meters, while for shallow geothermal energy the figure was 227 million square meters, an increase of 25.5% and 63.3% respectively relative to the same totals in 2009.

In addition, the installed power generating capacity of completed and ongoing building-integrated photovoltaic projects reached a total of 850.6 MW, representing a significant improvement and an annual replacement of 14 Mtoe of conventional fossil fuels⁵¹.

⁵¹MOHURD: http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/201104/t20110421_203196.html

CHAPTER 6- RURAL BUILDING ENERGY CONSUMPTION⁵²

6.1 Overview

At present total building floor space in Chinese rural areas is close to 24 billion square meters, accounting for approximately 60% of China's total building area (BEERC 2009).

As there is a huge difference in the economic conditions and standard of living between rural and urban residents, commercial energy consumption and energy intensity in the rural buildings have historically been far lower than those in urban areas. In recent years as economic growth has increased the income of rural residents and raised standards of living, the energy consumption patterns of rural households have also changed. In addition to a continuing rise in total demand, a conspicuous characteristic of energy consumption in rural areas is the increasing proportion of total energy consumption that is attributed to commercial energy, accompanied by a gradual decrease in the proportion of biomass energy.

Rural energy consumption mainly includes heating, cooking, air conditioning, lighting and household appliances. Energy sources include coal, liquefied petroleum gas, electricity and other commercial energy resources, as well as large quantity of biomass energy, which can satisfy demand for heating and cooking (Table 6-1).

The statistical data in the BEERC (2011) and the CSTC (2011) reports showed that average energy intensity in the northern rural buildings in China was higher than that in their southern rural counterparts, which is mainly attributable to heating needs. The unit energy consumption of rural buildings in northern areas is approximately 122 to 309 KWh/m²·a (including biomass consumption) except in Henan province, while in southern areas, the unit energy consumption of rural buildings ranges from 41 to 106 KWh/m² per year in most provinces, excluding Sichuan province⁵³.

⁵² The rural buildings discussed in this Chapter refer to residential buildings. As the number of industrial and commercial buildings of township enterprises as a proportion of the entire stock of rural buildings (area) is fairly low at present, they are therefore not considered in the report.

⁵³ As many rural areas in Sichuan Province have a higher heating demand, the unit energy consumption is higher; however, as there is no heating demand for many rural residential buildings in Henan Province, the unit energy consumption is lower compared with other northern areas.

Table 6-1 Main Characteristics of Energy Consumption for Rural Buildings

Energy Use	Characteristics of Energy Consumption and Existing Problems
Lighting and household appliances	<p>(1) The lighting consumption per unit of built area and energy consumption of household appliances are far lower than those of urban residents. The use of household appliances with low energy efficiency is common. As most rural residents use incandescent lighting, there exists huge potential for energy savings in lighting energy consumption.</p> <p>(2) The purchase of durable consumer goods in rural households is continuously increasing; however, energy-saving lighting and household appliances have not yet been effectively marketed and popularized in most rural areas.</p>
Cooking	<p>Firewood and coal-burning stoves are of low energy efficiency, and can cause indoor and outdoor air pollution, endangering residents' health⁵⁴. In recent years, with the promotion of biogas technology in rural areas, the proportion of households who use the burning of straw as their primary energy source for cooking has gradually declined and the proportion of farmers who use biogas stoves for cooking has shown a marked increase.</p>
Heating	<p>(1) The houses feature a large shape coefficient and the building envelop is of poor energy performance due to a lack of insulation, sub-optimal design, and inefficient heating equipment. As a result, the indoor temperature of rural households in winter is usually quite low.</p> <p>(2) The cold climate zone in northern rural China entails high heating demands, so fuel consumption is much higher than in southern rural areas. However, the proportion of households owning electric radiators, air conditioning and other heating modes is very low.</p> <p>(3) In general, the period (season) during which heating is required in southern rural areas is relatively short. However, energy consumption for heating in rural buildings in some of the more developed provinces shows an obvious increasing trend.</p>
Air conditioning in summer	<p>Energy consumption by air conditioning per unit of built area is low. The average energy consumption by air conditioning per unit area is less than 1KWh/m²a, even in Shanghai and the economically developed areas in the Yangtze River Delta⁵⁵; the proportion of energy consumption for cooling in summer to the total energy consumption of rural residential buildings is still low.</p>

⁵⁴ CSTC (2011) pointed out that if the currently inefficient method of use of solid fuels in rural areas were not improved, the air pollution produced by these methods, together with smoking and other unhealthy habits, would cause the deaths of some 65 million people due to chronic obstructive pulmonary disease, with an additional 18 million people projected to die of lung cancer from 2003 to 2033. At present, the subsidies provided by the Chinese government for the treatment of patients suffering from these diseases is 33.2 billion RMB per year.

⁵⁵ Even in the most developed rural area in Zhejiang Province, the energy per unit area consumption of air-conditioning is only 1.281 KWh/m²a; while such energy consumption in rural areas of Anhui Province is only 0.36 KWh/m²a (CSTC 2011).

At present, the pace of urbanization in China is very rapid, with an increasing number of rural residents moving to cities and towns. According to statistics, from 1996 to 2008 approximately 130 million rural residents left rural areas to settle down in cities, leading to a decline in the rural population from 850 million to 720 million.

At the end of 2010, 51.27 per cent of China's population was living in urban areas (FT 2012). Although it is projected that the rural population will continue to decline, and while the current stock of rural buildings consumes relatively modest amounts of energy (current buildings offer relatively little prospect for additional energy savings), nevertheless, the average household area and total building area will continue to increase, while as income increases in rural areas energy needs are likely to increase and therefore, it can be predicted that the energy demand of rural households will continue to grow for the foreseeable future.

At present, buildings in rural areas in China are built by farmers themselves on house sites and private plots and are thus exempt from the monitoring and regulatory systems of the central and local governments, while no design standards for energy efficiency of rural buildings have been issued by the relevant government institutions⁵⁶. With the promotion of urban-rural integration and implementation of a new rural policy by the central government, an important subject requiring resolution is how to establish effective energy-saving measures and incentive mechanisms for rural buildings to improve their energy efficiency, so as to improve the quality of life of rural residents while promoting sustainable development and the greening of rural buildings.

6.2 Development Review

On the basis of the implementation and promotion of energy efficiency policies for urban buildings, central and local governments successively issued or are actively preparing a series of policies and measures to promote energy efficiency improvements in rural buildings.

As for the “Demonstration of Renewable Energy Application in Rural Buildings”, thirty-eight county-level rural areas were selected for demonstration projects promoting the application of renewable energy in buildings. The desired trend is to

⁵⁶ According to the information obtained during the authors' interviews with Chinese experts in China, at present, the China Academy of Building Research, Tsinghua University and other research institutions have actively contributed to the compilation of the building design and construction standards for rural building energy efficiency. The “National Rural Building Energy Efficiency Design Standard” was accepted by the review committee on November 24, 2011 and awaits final approval. Relevant official standard documents are expected to be issued during the 12th Five-Year Plan.

move from a single project model towards a more comprehensive urban-rural development structure⁵⁷.

In order to implement the policies that aim to improve the housing conditions of rural residents, improve the construction quality of rural housing and promote the building energy efficiency of rural housing, MOHURD, the NDRC, Ministry of Industry and Information Technology (MIIT), Ministry of Land and Resources, and Ministry of Commerce (MOFCOM) jointly issued “*Notification on Expanding the Building Materials Going to the Countryside Pilots Program 2011*”⁵⁸ in September 2011, which put forward the requirements for gradually expanding the rural pilot projects encouraging the use of energy efficient building materials in the countryside⁵⁹, and for providing subsidies to promote the use of energy-efficient building materials.

Seven requirements for improving the subsidy policy related to cement used in rural areas (in the context of the “cement going to the countryside” campaign) were put forward in the notification: establishing a subsidy policy for energy-saving building materials, enhancing the collection and management of funds, enhancing the quality control of building products going to the countryside, enhancing the price management of building products going to the countryside, opening up channels for access to the marketing of building materials and enhancing the management of rural housing construction.

According to relevant documents⁶⁰ from the Ministry of Finance in 2007 (Zhang 2009), experts from MOHURD have suggested that specified subsidies could be provided to demonstration projects for new wall materials and to large-scale energy-saving demonstration projects (particularly those concentrated in specific regions), which would be compatible with the Construction and Development Plans for New Countryside.

6.3 Implementation Status

According to the latest MOHURD data, several provinces and cities have explored building energy efficiency in rural areas. During the Eleventh Five-Year Plan, the city of Beijing organized farmers to build 13,829 earthquake-resistant and energy-efficient new buildings, to implement energy efficiency retrofit of 39,900 existing houses and to construct more than 400 collective solar heating showers in rural

⁵⁷ In July 2009, Ministry of Finance and MOHURD jointly published and distributed the *Notification on Implementation Scheme for Promoting and Accelerating the Application of Renewable Energy in Rural Buildings*.

⁵⁸ Jian Cun [2011] No.142 http://www.gov.cn/zwggk/2011-09/27/content_1957285.htm

⁵⁹ The pilot areas include Beijing, Tianjin, Shandong Province, Chongqing, and Ningxia Hui Autonomous Region.

⁶⁰ *Methods for the Collection, Use and Management of Special Funds for New Wall Materials in 2007*.

areas, saving more than 70,000 toe of fossil fuels and clearly improving the housing quality and living conditions in the affected rural areas.

Harbin City has encouraged farmers to use new wall materials to construct energy-efficient buildings in connection with the renovation of thatched cottages in rural areas. Shaanxi and Gansu Provinces have carried out meaningful exploration of the possibilities for construction of energy-efficient buildings and the application of new energy in rural areas by promoting the use of new wall materials and through the use of straw and other biomass energy⁶¹.

⁶¹Please see MOHURD website
http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/201104/t20110421_203196.html

CHAPTER 7- ASSESSMENT AND FUTURE PROSPECTS

7.1 Making Great Strides

Since the 1980s, China has been actively promoting building energy efficiency with strong support from government, particularly during the 11th FYP (2006 to 2010), when China made great efforts to establish and then further improve an overarching organizational system at both national and regional scales, and began to enforce the implementation of building energy efficiency policies and projects. For example, China completed the residential retrofit of 180 million square meters in the northern heating zones, while also significantly improving the compliance rate within a period of only five years.

China has achieved significant progress in improving building energy efficiency in the last two decades, an achievement that can largely be attributed to the government's careful planning of development strategies, strong and consistent support from central government, and a clear definition of stakeholders' responsibilities with appropriate oversight and monitoring.

7.1.1 Development Strategies for Building Energy Efficiency

The Chinese government has applied the following general strategy to the promotion of building energy efficiency across the country:

- Prioritization of tasks in a clear-cut manner (e.g., when promoting building energy codes, starting from the northern heating regions, then moving on to hot-summer-and-cold-winter regions, and thereafter to hot-summer-and-warm-winter regions; promoting the compliance of building energy codes first in the larger cities, then broadening the focus to middle and smaller sized cities, and finally expanding the scope of promotion to include rural areas);
- Beginning first with the more straightforward undertakings before tackling more complex tasks (e.g., when promoting retrofit projects, starting from government office buildings which feature sole ownership of buildings, then focusing on public buildings that involve relatively simple types of property rights and management, and lastly incorporating other types of buildings characterized by more complex property rights and management); and
- Commencing initiatives from single “points” and expanding to wider “areas” (e.g., implementing demonstration projects at a small scale at first, then examining the implications of these pilots and adapting these methodologies for the drafting of policies, regulations and technical

standards, then ultimately scaling up and promoting these policies at a broader scale).

These sound development strategies have helped China to better utilize limited government resources (such as financial and regulatory support), and effectively promote building energy efficiency policies and projects at both national and regional levels.

7.1.1 Strong Support from Central Government

Strong support from central government is a major impetus behind China's persistent efforts to promote building energy efficiency. For example, President Hu Jintao's 2004 speech concerning the development of energy-efficient and land-saving buildings greatly stimulated the development of green buildings in China. The recent five-year national plans and guidance have all contained chapters and sections that specifically address building energy efficiency.

During the 11th FYP, the Chinese government provided RMB 15.2 billion in support of residential retrofit and heat reform in the northern heating regions. This funding was specifically earmarked for the application of renewable energy in building energy efficiency and for the implementation of other building energy efficiency projects.

Another aspect of this strong support from central government is reflected by its investment in scientific research and technology development. Building energy efficiency, green building, and the application of renewable energy have all received substantial investment as critical scientific R&D activities. Funds to support these areas of research have also been raised in various regions for investment according to the corresponding regional interests in specific technologies and areas of research.

The Chinese government also actively encourages exchange of information related to building energy efficiency at an international level, such as sending domestic building energy efficiency experts and officers to visit countries with experience using advanced methods in building energy efficiency, collaborating with these countries to carry out demonstration projects in China, and hosting international policy seminars and technical exhibitions to learn advanced policy practices and technological development related to building energy efficiency.

Through a wide range of media (e.g., TV, newspaper, radio, and internet), the Central and local governments have been carrying out annual public education events such as Energy Conservation Week⁶² to raise public awareness of energy conservation, the importance of greenhouse gas mitigation and to advocate low-carbon lifestyles.

⁶² <http://baike.baidu.com/view/1936559.htm>

7.1.2 Defining Stakeholders' Responsibilities with Oversight

The *Provisions on the Administration of Energy Conservation for Civil Buildings (1999)* and the *Regulations of Energy Conservation in Civil Buildings (2008)* specify the responsibilities and penalties for any violations by relevant stakeholders in the phases of construction project approval, building design, design inspection, construction, construction inspection, and real estate management.

The implementation of the *Code for Acceptance of Energy Efficient Building Construction* strengthens the inspection of energy efficient components of a construction project, and provides standardized technical requirements to support the relevant quality acceptance.

Since 2005, an annual national inspection of building energy efficiency has been carried out, with inspection results publicized. In order to prepare national inspections, some provinces and municipalities have conducted their own inspections. Each of these governmental inspection activities greatly encourages relevant stakeholders to comply with their responsibilities.

7.2 Outstanding Challenges

Although China has made impressive progress in promoting building energy efficiency, Chinese officials and building energy experts are clearly aware of the outstanding challenges still to be tackled.

Rising building energy consumption China's total building energy use will certainly continue to grow in the years to come, principally due to continued economic growth, rising standards of living, and an annual addition of 1.6 to 2 billion square meters of new buildings. The Chinese government hopes to slow down the pace of growth in building energy consumption through the formulation and implementation of regulations and policies, the use of technology, the establishment of targeted economic measures and market mechanisms, and through public education.

Updating building energy codes not institutionalized⁶³ The first residential building energy codes in heating zones were developed in 1986, which were later updated in 1995 and 2010, respectively. The long interval between revisions reflects how China has not institutionalized the development of building energy codes on a regular basis.

The government has promoted compliance with building energy codes, achieving energy-saving rates of 50 to 65% for new buildings. The baseline for the 50 and 65% energy-saving rate is based on calculated residential energy use for a building in the 1980's without any energy-saving measures but conditioned to

⁶³ Based on a private conversation with Kevin Mo at the China Sustainable Energy Program.

“standard” or ideal comfort conditions. The usage of “50 and 65% energy saving rate” could easily mislead consumers into thinking that new buildings complying with the codes are highly energy-efficient or use that much less energy than previous buildings, while in fact such buildings simply meet the minimum requirements of building energy efficiency (Mo, 2010).

Difficulties in financing retrofit projects China needs a huge amount of capital to finance the residential retrofit of 300 million square meters⁶⁴ in the northern heating regions. However, the less-developed economy in the northern heating regions presents difficulties to efforts to obtain the necessary financial resources from local governments and from the market⁶⁵.

Limited program in scaling up renewable energy in buildings Renewable energy can play an important role in meeting rising energy demand and decarbonizing [do you mean “reducing the carbon intensity”? “Decarbonizing” usually refers to removing carbon deposits from engines] energy use in the built environment. Although the central government has issued several guidelines to encourage the development and large-scale application of renewable energy technologies in buildings, so far most actions have been taken in the context of demonstration or pilot programs. High prices and risk averseness hinder large investments, while financial incentives are still insufficient to stimulate builders and investors to apply these green technologies. More powerful signals should be sent to the market by means of additional public policies.

Capacity building: the average level of education among construction workers in China is roughly primary or middle school, while that of building designers and inspectors is college level. This difference in levels of education may contribute to a much lower compliance rate in the construction stage compared to that of the design stage. The current capacity building activities do not target construction workers. The relevant training materials, if any, may not have been developed to address their education level or the difficulties they frequently encounter during their work (Shui et al. 2011)⁶⁶. Other capacity building activities could include increasing code officials’ competence by improving their overall knowledge of building energy performance, with similar efforts to be made for other key parties involved in the building industry, while additional activities could focus on

⁶⁴ According to research contained in the report by the Building Energy Efficiency and Science and Technology Department of MOHURD.

⁶⁵ Report made by the Ministry of Housing and Urban-Rural Development, *Report about Building Energy Efficiency Inspection Conditions during Special Inspection and Supervision of Energy Efficiency and Emission Reduction in National Housing and Urban-Rural Development Areas in 2010*, www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/201104/t20110421_203196.html

⁶⁶ Shui, B., H. Lin, B. Song, M. Halverson, M. Evans and X. Zhu (2011). Feedbacks from Focus Group Meeting on Training and Implementation of Building Energy Codes in China. Richland, WA, Pacific Northwest National Laboratory.

improving the technical performance and flexibility of building energy codes, and on the development of more robust software compliance tools.

In addition, local building energy efficiency officers are replaced as they are posted to other stations every few years. It usually takes time for new officers to become familiar with the new post, which may lead to delays in carrying out their work.

Slow progress in heat reform Of the total area of new buildings in the northern heating zones, which between 2008 and 2010 was approximately 110 million square meters, only 42% had meters installed, while the quality of many of these meters was poor. In addition, nationwide about 54% of the 700 million square meters that had meters installed were found to be noncompliant with consumption-based billing as required by regulations.

Technologies and management needed for promoting the application of renewable energy in building energy efficiency Key technologies, equipment and raw materials related to the application of renewable energy are heavily dependent on imports. The project approval and management of special funds for the application of renewable energy lack of a unified coordination mechanism⁶⁷.

Enormous scale of promoting building energy efficiency in rural areas By the end of 2009, rural buildings accounted for 60% of the country's total building area. Thus the scale of the work to be done to promote energy efficiency in rural areas is enormous: design standards for rural building energy efficiency have yet to be developed, the system to collect residential energy use statistics in rural areas has yet to be built, and the inspection and supervision system for building energy efficiency has also yet to be established.

7.3 The Next Steps

China's energy intensity (energy consumption per unit of GDP) decreased by 19.1% during the 11th Five-Year period (2006 to 2010), and is projected to decrease by a further 16% compared to its 2010 level during the 12th Five-Year period (2011 to 2015). In September 2011, the State Council issued the *Comprehensive Working Scheme for Energy Conservation and Emissions Reduction during the 12th Five-Year Plan (2011)*⁶⁸, therein outlining working strategies to reach the 16% reduction goal over the next five years.

Bringing about improvements to building energy efficiency will be one of the government's major objectives in the coming period. By 2015, China aims to complete residential retrofit of another 400 million square meters in the northern

⁶⁷<http://www.tjrd.gov.cn/ztjz/system/2010/01/11/010000404.shtml>

⁶⁸http://www.gov.cn/zwgk/2011-09/07/content_1941731.htm

heating regions, and will continue to promote heat reform in this region. In addition, government targets call for the complete residential retrofit of 50 million square meters in the HSCW and HSWW regions, the thermal retrofit of 60 million square meters of public buildings and the development of 2,000 building energy-efficient pilot projects to be implemented by public organizations. Other planned activities related to building energy efficiency include the following:

- Formulation and implementation of action plans for the promotion of green buildings, such as launching the mandatory compliance⁶⁹ green building pilot projects in those regions that meet the relevant criteria.
- Continued enforcement of building energy codes in new buildings, especially targeting compliance in the construction stage and in middle and small-sized cities.
- Promotion of heat reform and retrofit in the northern heating regions; implementation of consumption-based billing and energy quota management.
- Execution of retrofit projects in the HSCW and HSWW regions.
- Promotion of the integration of renewable energy resources in buildings
- Promotion of the application of new energy-efficient building materials and renewable building materials.
- Study and establishment of building life cycle management systems and the strengthening of building decommissioning management.
- Enhancement of lighting management in urban areas with prevention of over consumption of energy by decorative lighting.
- Promotion of energy conservation and emissions reduction activities in service industries (e.g., retail and tourism), including retrofit, energy management, and by advocating green consumption behaviors. Enforcement of compliance with relevant regulations concerning maximum and minimum room temperatures permitted for summers and winters in hotels, commercial buildings, office buildings, airports, and train stations.
- Marketing of highly energy-efficient appliances and lighting products for use in residential buildings.
- Establishment of an inspection and monitoring system for energy efficiency in public buildings, including improving the quality of energy audits, promoting energy efficiency performance labeling, encouraging retrofit and improving operational management. Development and promotion of strict building energy codes for public buildings.
- Improvement of the energy efficiency and implementation of retrofit of key energy-consuming military facilities and equipment.

⁶⁹ Green building is a voluntary policy instrument promoted by the Chinese government. In the 12th Five-Year plan period (2011-2015), the Central government will conduct pilot projects to implement green building as a mandatory policy instrument in selected cities. See www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjjskj/201104/t20110421_203196.html

- Improvement of energy efficiency and carbon mitigation methods in agricultural and rural areas. Promotion of energy-efficient residential housing in rural areas.

CHAPTER 8- CONCLUSIONS

Since the 1980s China has been actively promoting building energy efficiency. This process has been characterized by four distinct phases: (1) research preparation (early 1980s to 1986), (2) pilot projects (1987 to 1993), (3) system formation (1994 to 2005), and, (4) system improvement and policy implementation (2006 to the present).

Over the course of the past thirty-years, China has established relatively comprehensive administrative, regulatory, and technical development systems at a national level, developed and deployed an array of building energy efficiency policies and projects, and obtained impressive results. For example, China completed the energy efficiency retrofit of 180 million square meters of residential housing in the northern heating region within five years, while also dramatically improving the compliance rate with building energy codes in urban areas from 53% (design stage) and 21% (construction stage) in 2005 to 99.5% and 95.4%, respectively, in 2010.

The main factors contributing to China's success in achieving these results include sound development strategies, strong governmental support, defining responsibilities with strict supervision, and provision of ample financial support. Chinese officials and building energy experts also clearly recognize that China still faces challenges in its promotion of energy efficiency building, including insufficient local regulatory and financial support, difficulties in financing building retrofit, slow progress on heat reform, and also the enormous scale of promoting building energy efficiency in rural areas that has only just begun.

During the 12th FYP period (2011-2015), China will continue to promote building energy efficiency at national and local levels by various means, including by launching mandatory compliance green building pilot projects in regions meeting relevant criteria, carrying out the retrofit of 400 million square meters of buildings in the northern heating regions, and by developing pilot projects to enforce the mandatory application of renewable energy.

Due to a combination of factors including continued economic growth, rising standards of living, and the annual addition of 1.7 billion square meters of new buildings, China's total building energy use will certainly continue to increase. The core objective that China's building energy efficiency current and future strategy must achieve is a reduction of the pace of growth of building energy consumption. The means by which this could be achieved include the formulation and implementation of regulations and policies (e.g., the implementation of building energy codes and the promotion of green building practices), the use of technology (e.g., the application of renewable energy), the establishment of economic measures and market mechanisms (e.g., finance, taxation and energy

efficiency labeling of building products), and finally by cultural means (e.g., information dissemination and public education relating to energy conservation and lifestyles).

While it is clear that building energy efficiency policies in China have been developed within the country's unique political, economic and cultural contexts, and are therefore not in all instances necessarily applicable to other national contexts, it is nonetheless equally evident that the success of energy efficiency policies in China is critical not only to the energy security and sustainable development of China itself, but indeed of the entire world.

There can be no doubt that the acquisition of a solid understanding of China's building energy efficiency policies and related activities by international practitioners would be conducive to increased exchange of ideas and experiences between China and other countries, thereby directly contributing to the promotion of building energy efficiency in China and elsewhere around the globe.

CHAPTER 9- REFERENCES

1. BECON (2009). Report Review of Chinese Building Energy Efficiency Policy Beijing Energy Efficiency Center.
2. BEERC (2009). Research Report on Annual Development of Building Energy Efficiency in China, 2009, Building Energy Efficiency Research Center at Tsinghua University.
3. BEERC (2011). Research Report on Annual Development of Building Energy Efficiency in China, 2011, Building Energy Efficiency Research Center at Tsinghua University.
4. China Urban Studies Society (2011). Green Buildings, China Building Industry Press.
5. CSSB (2010). China Statistics Yearbook 2009, China State Statistics Bureau.
6. CSSB (2012). China Statistics Yearbook 2010, China State Statistics Bureau.
7. CSTC (2011). China Building Energy Efficiency Development Report. Beijing, Center of Science and Technology of Construction of MOHURD.
8. David G. Fridley, Nina Zheng, Nan Zhou. 2008. Estimating Total Energy Consumption and Emissions of China's Commercial and Office Buildings. Ernest Orlando Lawrence Berkeley National Laboratory.
9. EURIMA, 2005.Ecofys III - Cost-Effective Climate Protection in the EU Building Stock
10. Evans, M., B. Shui and A. Delgado (2009). Shaping the Energy Efficiency in New Buildings - A Comparison of Building Energy Codes in the Asia-Pacific Region, Pacific Northwest National Laboratory.
11. Evans, M., B. Shui, M. Halverson and A. Delgado (2010). Enforcing Building Energy Codes in China: Progress and Comparative Lessons, Pacific Northwest National Laboratory.
12. Financial Times. 18 Jan 2012. China hits milestone in shift to cities.
13. Huang, J. and J. Deringer (2007). Status of Energy Efficient Building Codes in Asia
14. Li, G. and Y. Dong (2010). An Analysis of the Reform of Heat Supply System in Hohhot City. [Inner Mongolia Sciencetech and Economy], Vol. (6) 208.
15. Li, J. 2008 Towards a Low Carbon Future in China's Building Sector- a Review of Energy and Climate Models Forecast. Energy Policy, 36 (5) 1736–1747.
16. Liang, C. and Chen, S. (2011). China PV Industry Development, by DIGITIMES Research, Taipei.
17. McKinsey, 2008. Preparing for China's Urban Billion.
18. Mo, Z. (2010). Relevant Policies and Actions in the Field of Low Carbon Building.
19. MOHURD (1993). Standard of Climatic Regionalization for Architecture, GB50178-93.

20. MOHURD (2001). Regulation for Scope and Scale Standard of Construction Inspection.
21. MOHURD. (2006, 2007, 2008, 2009, 2010, 2011). "Annual National Inspection for Building Energy Efficiency."
22. Zhang, X. (Ed.) (2011) Report on Northern Residential Buildings Energy Efficiency Retrofit Construction Science and Technology. 2011. No.9. p14-27.
23. Qi, Y. (Ed.) (2010) Report on China's Low Carbon Development in 2010. Climate Policy Initiative at Tsinghua University. Science Press.
24. Shui B, M Evans, H Lin, W Jiang, B Liu, B Song, and S Somasundaram (2009). Country Report on Building Energy Codes in China. PNNL-17909, Pacific Northwest National Laboratory, Richland, WA
25. Shui, B. (2012). Third Parties in the Implementation of Building Energy Codes in China, GBPN, ACEEE and IMT.
26. Shui, B., H. Lin, B. Song, M. Halverson, M. Evans and X. Zhu (2011). Feedbacks from Focus Group Meeting on Training and Implementation of Building Energy Codes in China. Richland, WA, Pacific Northwest National Laboratory.
27. Sun Youhong, et al. Application and Development of China's Geothermal Heat Pump Technique in 2010. [Rock Exploration Engineering]: Vol. 37 (10).
28. Wang, X.2011. On China's Energy Intensity Statistics: Toward a Comprehensive and Transparent Indicator. Energy Policy Volume 39, Issue 11, Pages 7284-7289.
29. Xu, P., S. Huang, and R. Yin (2010) Analysis and Study on the Carbon Emission Conditions of China's Buildings. Berkley Buildings Research and Technologies (BBRT).
30. Yang, X., S. Zhang, Y. Qi and Y. Jiang (2011). Design Standards for Building Energy Efficiency and the Estimation of the Quantity of Energy Efficiency. Research on Urban Development 18(10).

APPENDIX 1: PROMOTION OF BUILDING ENERGY EFFICIENCY PRODUCTS

In addition to policies such as design standards for building energy efficiency and building energy performance labeling programs, the Chinese government has also unveiled a series of policies and measures for promoting energy efficiency in energy-consuming products during the period of the Eleventh Five-Year Plan. At the same time, additional benefits of energy efficiency policies such as the “*Home Appliances Going to the Countryside*” and the “*Project to Promote Energy-Efficient Products for the Benefit of the People*” include the rapid growth in the production and sales of highly energy-efficient home appliances. Relevant policies and the outcomes of their implementation are listed in the table below.

Table Promotion Policies of China’s Energy-Efficient Products

Policy name	Specific contents of policy	Implementation outcome
Project to promote energy-efficient products for the benefit of the people	The “project for the benefit of the people”, was mainly adopted as a form of financial subsidy to speed up the promotion and use of highly energy-efficient domestic air conditioners and lighting devices (e.g. subsidies of several hundred RMB per energy-efficient air conditioner that has been granted energy performance grades 1 and 2, and gave 30% and 50% financial subsidies to bulk buying customers and urban and rural residents who purchase energy-efficient lighting products according to the agreed supply price defined in the bid).	During the implementation period from June 2009 to December 2010, more than 34 million highly energy-efficient air conditioners and more than 360 million energy-efficient lamps were promoted, saving 19.5 billion KWh of electricity annually.
Home appliances going to the countryside	In March, 2010, MOF, MOFCOM and MIIT issued <i>Implementation Program of Subsidies for New Home Appliances Going to the Countryside</i> , confirming subsidies for nine categories of home appliances in provinces and cities. Color televisions, refrigerators, air conditioners, computers, water heaters, microwave and electronic ovens could all receive subsidies and were included in this policy.	

Policy name	Specific contents of policy	Implementation outcome
Promotion of high efficiency lighting products	Since 1996, the Chinese government has implemented a green lighting project and formulated energy performance standards for high efficiency lighting products. In 2009, high efficiency lighting products were included in the “project to promote energy-efficient products for the benefit of the people” and promoted by means of financial subsidies. The Chinese government has gradually established a national mandatory standard system for lighting product energy performance that includes eight standards.	During the Eleventh Five-Year Plan, 360 million energy-efficient lamps in total were promoted, contributing to an increase in demand valued at RMB 4.1 billion, and which resulted in electricity savings of 12.5 TWh annually and 62.7 TWh within the life cycle of the products.
Government procurement of energy efficient products	As of July 2011, ten periodical government procurement lists of energy efficient products had been published, covering energy-efficient air conditioners, refrigerators, lighting products, televisions, water heaters, computers, washing machines, solar water heating systems, insulated glazing, building insulation systems and insulation materials, and other energy-efficient products.	
Product energy performance standards and energy efficiency	In 2010, the Chinese government issued seven compulsory national standards, of which four standards concern home appliances ⁷⁰ . NDRC, General Administration of Quality Supervision Inspection and Quarantine (AQSIQ) and Certification and Accreditation Administration respectively issued the <i>Catalog of Energy Efficiency Labeling Products of the People's Republic of China</i> , of which eight lists have been issued to date. These lists are related to 23 kinds of energy-consuming products in the categories of home appliances, offices, business, industry and lighting. In total 57 kinds of energy-efficient products were certified.	

Data source: China National Institute of Standardization (2011)

⁷⁰ The four standards respectively were: 1. Minimum allowable values of energy efficiency and energy efficiency grades for room air conditioners (GB 12021.3-2010); 2. Minimum allowable values of energy efficiency and energy efficiency grades for household and similar microwave ovens; 3. Minimum allowable values of energy efficiency and energy efficiency grades for flat panel televisions; 4. Minimum allowable values of energy efficiency and energy efficiency grades for digital television adapters.

APPENDIX 2: INDEX OF BUILDING ENERGY EFFICIENCY POLICIES CITED IN THE REPORT

	Building Energy Efficiency Policy	Official Numbers for Legal Standards / Codes	Date of Issuance	Date of Implementation	Issuing Bodies	Implementation Bodies	Chapters & Sections
1	<i>Energy Conservation Design Standard for Civil Building (Heating of Residential Building)</i>	JGJ26 -86	1986		MOC	Local construction departments in northern provinces, municipalities and autonomous regions.	1.3
2	<i>Opinions on Speeding up the Innovation of Wall Materials and Promotion of Energy-efficient Buildings</i>		11/9/1992	11/9/1992	National Building Material Bureau ,MOC, Ministry of Agriculture, National Land Administration Bureau	Leading Groups of Innovative Wall Materials	1.3
3	<i>Energy Conservation Design Standard for the Hot Work and Air Adjustment in the Tourist Hotel Buildings</i>	GB 50189-93	1993	1994.7.1	MOC		1.3
4	<i>Energy Conservation Design Standard for Civil Building (Heating of Residential Building)</i>	JGJ26 -95	1995	1996.7.1	MOC		1.3
5	<i>The first Energy Conservation Law of the People's Republic of China</i>		1997.11.1	1998.1.1.	The Standing Committee of the National People's Congress	State Council and local governments	1.3

	Building Energy Efficiency Policy	Official Numbers for Legal Standards / Codes	Date of Issuance	Date of Implementation	Issuing Bodies	Implementation Bodies	Chapters & Sections
6	<i>Provisions on the Administration of Energy Conservation for Civil Buildings</i>		1999.10.28	2000.10.1	MOC	MOC	1.3
7	<i>Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Cold Winter Zone</i>	JGJ134-2001	2001	2001.10.1	MOC		1.3
8	<i>Design Standard for Energy Efficiency of Residential Buildings in Hot Summer and Warm Winter Zone</i>	JGJ75-2003	2003	2003.10.1	MOC, NDRC and MOF		1.3
9	<i>Design Standard for Energy Efficiency of Public Buildings</i>	GB 50189-2005	2005.4.4	2005.7.1	MOC		1.3
10	<i>Provisions on the Administration of Energy Conservation for Civil Buildings (Amended)</i>		2005.11.10	2006.1.1	The Standing Committee of the National People's Congress		1.3
11	<i>Opinions on the Guide for the Reform Pilot Work of Heat Supply System in Cities and Towns</i>	Jiancheng [2003] No.148	2003.7.21		MOC, MOF, NDRC, Ministry of Human Resources, Ministry of Civil Affairs, Ministry of Labour and Social Security, State Administration of Taxation and State Environmental Protection Administration		4.1

	Building Energy Efficiency Policy	Official Numbers for Legal Standards / Codes	Date of Issuance	Date of Implementation	Issuing Bodies	Implementation Bodies	Chapters & Sections
12	<i>Code for Acceptance of Energy Efficient Building Construction</i>	GB 50411-2007	2007		MOHURD		1.3
13	<i>Energy Conservation Law of the People's Republic of China (Amended)</i>		2007	2008.4.1	The Standing Committee of the National People's Congress		1.3
14	<i>System of Statistical Report on the Energy Consumption of Civil Building</i>		2007		Science and Technology Department of MOC		1.3
15	<i>Regulation on Energy Conservation in Civil Building</i>	Order of the State Council of the PRC No.530	2008.7.23	2008.10.1	State Council	Local construction administration	1.3
16	<i>Regulations on Energy Conservation of Public Institutions</i>	Order of the State Council of the PRC No.531	2007	2008.10.1	State Council	Local governments	1.3
17	<i>Detecting Standard for Public Building Energy Efficiency</i>	JGJ/T 177-2009	2009.12.10	2010.7.1	MOHURD		1.3
18	<i>Detecting Standard for Residential Building Energy Efficiency</i>	JGJ/T 132-2009	2009	2010.7.1	MOHURD		1.3
19	<i>Provisional Rules on Adjustment Tax for the Orientation of Fixed Asset Investment of PRC</i>		1991		State Council		3.2
20	<i>Decisions on Enhancing Energy Conservation</i>		2006		State Council		3.3
22	<i>Notice on Printing and Issuing "Comprehensive Working Scheme for Energy Saving and Emission Reduction"</i>		2007				3.3

	Building Energy Efficiency Policy	Official Numbers for Legal Standards / Codes	Date of Issuance	Date of Implementation	Issuing Bodies	Implementation Bodies	Chapters & Sections
23	<i>Tentative Methods for Managing Civil Building Energy Performance Labels</i>		2008		MOHURD		3.3.2
24	<i>Technical Guide for Labeling, Testing and Evaluating Civil Building Energy Performance.</i>		2008		MOHURD		3.3.2
25	<i>100 Demonstration Projects of Green Buildings and 100 Demonstration Projects of Low-Energy Consumption Buildings</i>		2007		MOHURD		3.4
26	Project to promote energy-efficient products for the benefit of the people		2009		NDRC, MOF		Appendix
27	<i>Implementation Program of Subsidies for New Home Appliances Going to the Countryside</i>		2010		MOF, MOFCOM and MIIT		Appendix
28	<i>Catalog of Energy Efficiency Labeling Products of the People's Republic of China</i>		2008-2011		NDRC, AQSIQ, CAA	Local governments	Appendix
30	<i>Regulations for Energy Efficiency Retrofitting of Existing Heating Residential Buildings</i>	JGJ129-2000	2000.10.11		MOC		4.1
31	<i>Comprehensive Working Scheme of Energy Conservation and Emission Reduction during the "12th Five-Year Plan</i>		2011.8.31		State Council		7.3

	Building Energy Efficiency Policy	Official Numbers for Legal Standards / Codes	Date of Issuance	Date of Implementation	Issuing Bodies	Implementation Bodies	Chapters & Sections
32	<i>Technical Guide for Energy Efficiency Renovation and Heat Supply Measurement of Existing Residential Buildings in Northern Heating Areas (Trial)</i>		2008		MOHURD, MOF		4.2
33	<i>Notice on Accelerating Efforts to Achieve the Targets of Heat Metering and Residential Buildings Retrofitting in Northern Heating Areas.</i>		2010		MOHURD, MOF		4.2
34	<i>Implementation Opinions on Enhancement of Energy Efficiency Management for Government Buildings and Large-Scaled Public Buildings</i>		2007		MOHURD, MOF		4.3
35	Solar Rooftop Program		2006		MOC, MOF		5.3
36	<i>Report about Building Energy Efficiency Inspection Conditions during Special Inspection and Supervision of Energy Efficiency and Emission Reduction in National Housing and Urban-Rural Development Areas</i>		2010		MOHURD		7.1
37	<i>Implementation Opinions on Promoting the Application of Renewable Energy in Building</i>	Jianke(2006) No.213	2006		MOC, MOF		5.2
38	<i>Notification on Accelerating the Application and Scale- up of Solar Water Heating System</i>		2007		MOC, NDRC		5.2

	Building Energy Efficiency Policy	Official Numbers for Legal Standards / Codes	Date of Issuance	Date of Implementation	Issuing Bodies	Implementation Bodies	Chapters & Sections
39	<i>Notification on Implementation Scheme for Promoting and Accelerating the Application of Renewable Energy in Rural Buildings</i>		2009.07.06	2009.07.06	MOHURD, MOF		6.2
40	<i>Provisional Method for Managing the grant fund Employed for Boosting Heat Supply Measurement Reform and Energy Efficiency Retrofitting of Existing Residential Buildings in Northern Heating Areas</i>		2007		MOF		4.1
41	<i>Opinions on Implementation of Boosting Heat Supply Measurement Reform and Energy Efficiency retrofitting of Existing Residential Buildings in Northern Heating Areas</i>		2008		MOHURD, MOF		4.1
42	<i>Opinions on Further Boosting Heat Supply Measurement Reform</i>		2010		MOHURD, NRDC, MOF and AQSIQ		4.1
43	<i>Notice on Making More Efforts for Ensuring Heat Supply Measurement and Energy Efficiency Retrofitting of Existing Residential Buildings in Northern Heating Areas</i>		2010		MOHURD, MOF		4.1
44	<i>Opinions on Boosting Heat Metering and Measurement</i>		2006		MOC	Local construction commissions	Appendix