Third Parties in the Implementation of Building Energy Codes in China

BY SHUI BIN

AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY

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My understanding of third parties was acquired through participation in a two-year US-China collaboration project that was undertaken to support the implementation of building energy codes in China. The project was supported by the U.S. Department of State for the Asian-Pacific Partnership for Clean Development and Climate. One of the outcomes of this project was a better understanding of the issues related to implementation of building energy codes in China. I would like to thank the project team members for their support and assistance throughout the project: Haiyan Lin, Bo Song and Xiaojiao Zhu at CABR; Meredydd Evans and Mark Halverson at Pacific Northwest National Laboratory; and Cong Yu and Jingru Liu at the Energy Research Institute of the National Development and Reform Committee. I had a great experience learning from and working with them.

ABSTRACT

In recent years, China has been adding 17.2 to 21.5 billion square feet (or 1.6 to 2.0 billion square meters) of new residential and commercial buildings each year, making it the largest market for new construction in the world. Though the enforcement of China's building energy codes has been widely viewed as fraught with challenges, in recent years China has seemingly achieved unusual progress in improving its compliance rate at both design and construction stages. According to China's annual national inspection of building energy efficiency in urban areas, the compliance rates with building energy codes at both design and construction stages in urban areas have improved from 53% (design) and 21% (construction) in 2005 to 99.5% and 95.4%, respectively, in 2010.

What is the definition of the compliance rate in China's enforcement of building energy codes? If the improvement data are accurate, how is it that China has been able to bring about such impressive improvements in only five years? This paper will try to answer the above questions, with a focus on the role of third parties in the implementation of building energy codes. The paper concludes that strong governmental support and effective employment of third parties, coupled with strict quality control and supervision, are the key factors for China's impressive improvement of compliance with building energy codes.

INTRODUCTION

China, the world's largest residential and commercial building market, has in recent years added 17.2 to 21.5 billion square feet (or 1.6 to 2.0 billion square meters) of new construction annually (Center of Science and Technology of Construction, 2011). In order to improve the energy efficiency of such a large stock of new buildings at the design and construction stages, since 2005 the Chinese government has launched a series of national policies and projects to promote the enforcement of building energy codes, including the release of new building energy codes (2005, 2007), the *Energy Conservation Law* (the second version published in 2007) and the *Regulation of Energy Conservation in Civil Buildings* (2008).

According to China's annual national inspection of building energy efficiency, compliance rates have improved from 53% (design stage) and 21% (construction stage) in 2005 to 99.5% and 95.4%, respectively, in 2010. What is the definition of the compliance rate in China's enforcement of building energy codes? If the improvement data are indeed accurate, how did China make it happen in only five years?

This report focuses on the introduction of third parties in the enforcement of compliance with building energy codes, including a brief introduction to China's building energy codes (Section 2), the role of third parties in ensuring compliance with building energy codes (Section 3), the administration of third parties (Section 4), and the existing issues related to the management of third parties in China (Section 5).

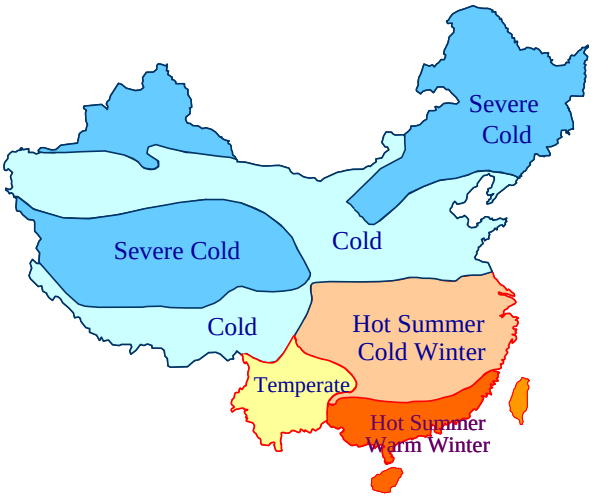
1. BUILDING ENERGY CODES IN CHINA[1]

China's building energy codes system includes both design standards and acceptance codes.

Design standards address compliance with building energy codes at the design stage, including thermal characteristics of the building envelope, HVAC systems, trade-offs, and the building performance approach. China has one design standard for public and commercial buildings (issued in 2005) and three design standards for residential buildings. The three residential design standards cover three different climate zones (Figure 1), including a heating (severe cold and cold) zone (issued in 1986, updated in 1995 and 2010), a hot-summer and cold-winter zone (2001, 2010), and a hot-summer and warm-winter zone (2003).

A comparison of China's design standards with its American commercial and residential counterparts is listed in Table 1. Note that energy-efficient lighting is not covered by the existing Chinese design standards but by a separate lighting standard.

[1] Please refer to Shui et al. (2009) and Evans et al. (2010) for related information.



Climate Zone	Mean Monthly Temperature	
	Coldest	Hottest
Severe Cold	≤ 14° F	≤ 77° F
Cold	14 - 32° F	64-82° F
Hot summer and cold winter	32 -50° F	77 - 86° F
Hot summer and warm winter	>50° F	77 - 84° F
Temperate	32 - 55° F	64 - 77° F

Figure 1 China's Climate Map

Source: The map is from Huang and Deringer (2007) and the table was translated and converted from CABR (1993)

Table 1: 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 Zone (2010)	Hot-Summer and Cold-Winter Zone (2010)	Hot-Summer and Warm-Winter Zone (2003)	ASHRAE 90.1 2007	IECC 2009
Envelope	√	√	√	√	√	√
HVAC	√	√	√	√	√	√
Service hot water and pumping	X	X	X	X	√	√
Lighting	A separate lighting standard	X	X	X	√	√
Electrical power	X	X	X	X	√	X
Trade-offs and building component performance approach	√	√	√	√	√	√
Renewable energy	X	√	√	X	√	√

Note: The presence or 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. (2011a)

Acceptance Codes are building energy codes for compliance during the construction stage. Acceptance refers to the final approval before, during and after the construction process. 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 (see Appendix 1).

The development and deployment of the Acceptance Codes mandates compliance with building energy efficiency requirements in the final acceptance of a construction project, lifting building energy efficiency standards and codes to equal importance with safety-related building codes (such as fire codes and structural codes related to earthquake resistance).

2. KEY STAKEHOLDERS[2]

Development of and compliance with building energy codes involve many stakeholders (see Figure 2), including:

Developers initiate the project by providing financing, submitting applications for land use, construction and occupancy, and forming a project team consisting of a building design company, a drawing inspection company, a construction company, and a construction inspection company.

The research and development group includes (1) the China Academy for Building Research (CABR), the national code developer of all design standards for building energy efficiency and of the Acceptance Codes; (2) local building research entities that may be associated with CABR and which provide technical support to local construction departments; (3) research centers of universities; and (4) other related research institutes.

Governmental and related agencies include:

- **Ministry of Housing and Urban-Rural Development (MOHURD**) is responsible for macro-level construction-related strategic planning and policy development. 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 (Shui and Li, 2012).
- **Local construction departments** are local branches of MOHURD at provincial, city and county levels. A local construction department is in charge of local compliance and enforcement activities, such as the issuing of permits for construction and occupancy, organizing training and outreach activities for local stakeholders, and developing local policies and regulations to promote building energy codes.

[2] Please refer to Evans et al. (2010) and Shui et al. (2011a) for related information.

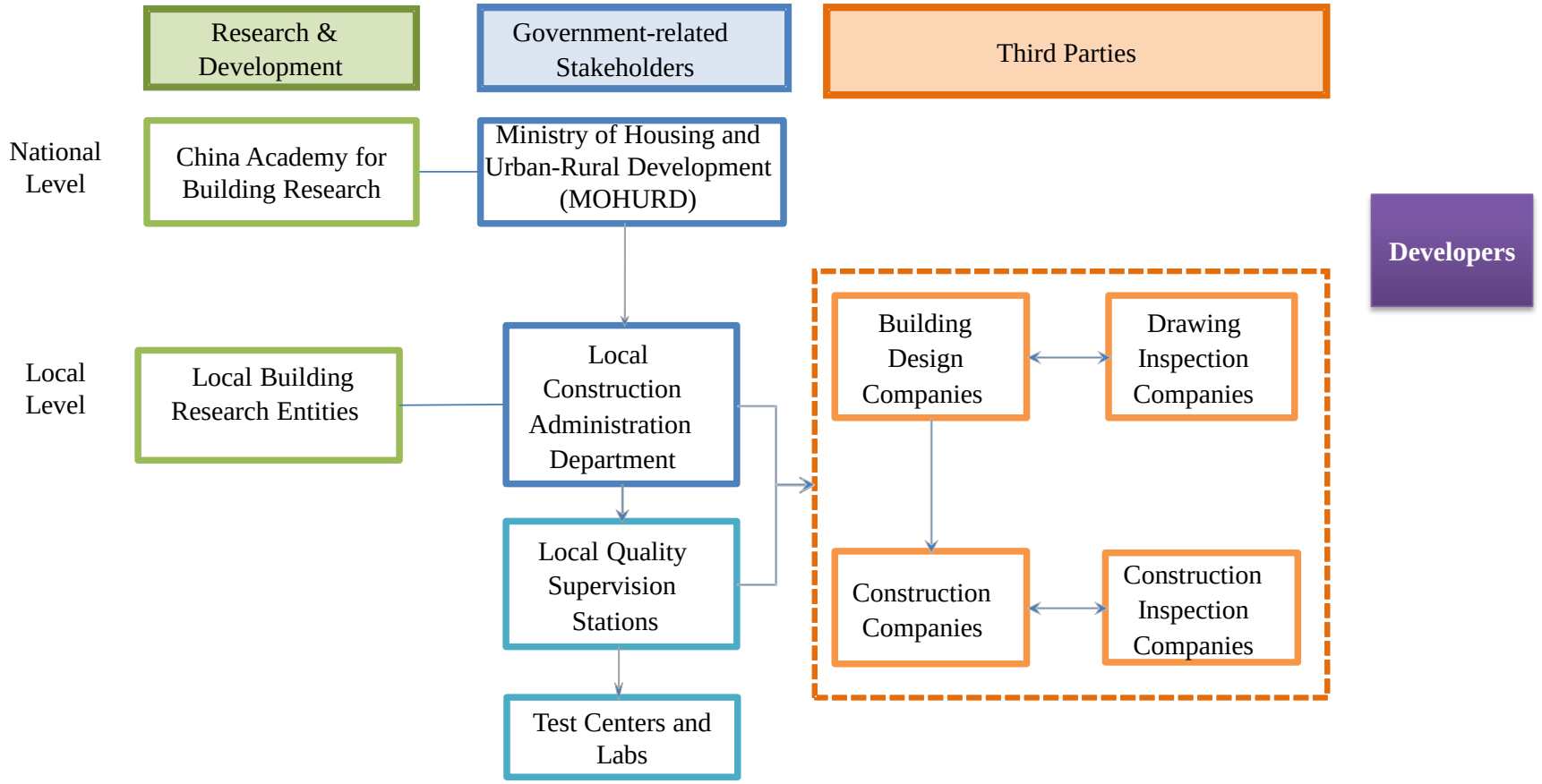


Figure 2: Key Stakeholders in the Implementation of Building Energy Codes in China

Source: Shui et al. (2011b)

- **Local quality supervision stations** are semi-governmental agencies, working for local construction departments. They supervise the work quality of third parties, especially construction companies and construction inspection companies. Their work activities include inspecting construction sites during key construction phases and collecting, reviewing, and approving documents related to construction and code compliance.
- **Testing centers and labs** are semi-governmental entities, working for local quality supervision stations. Staffed by technicians and engineers, the testing centers and labs are responsible for the testing of building materials and construction components as required by the Acceptance Codes.

Third parties include:

- **Building design companies** consist of architects and engineers. They are required to follow all design standards at the design stage and any requirements set by developers.
- **Design inspection companies** often consist of senior technicians retired from building design companies and local research institutes. Their responsibilities are to assess the compliance of building designs to design standards at the design stage.
- **Construction companies** are required to follow the approved building design and the Acceptance Codes in the construction phase of a building project.
- **Construction inspection companies** consist of technicians and engineers. They are required to determine whether the construction complies with the approved building designs, construction codes and the Acceptance Codes, as well as any additional requirements presented by developers (such as cost control).

In some cases, building design companies and construction companies belong to the same company. Such joint companies need to be certified by MOHURD.

3. ENSURING COMPLIANCE IN THE IMPLEMENTATION PROCESS[3]

Ensuring compliance with building energy codes throughout the implementation process consists of four stages: (1) preparation, (2) building design and inspection, (3) construction and inspection, and (4) completion (see Figure 3).

It seems that not every new building undergoes such a comprehensive process. In 2001, MOHURD issued a regulation to specify the scope and scale of construction projects for construction inspection. Any new residential community of 50,000 square meters or over is required to undergo construction inspection. Local MOHURD at the provincial and municipal level will determine if construction inspection will take place for a residential project under 50,000 square meters. A construction project for public and commercial buildings with a total investment over RMB 30 million needs construction inspection. In addition, any schools, cinemas and stadium buildings and buildings supported by foreign aid and loans are subject to construction inspection (MOHURD 2001).

[3] Please refer to Evans et al. (2010), Shui et al. (2011a) and Shui et al. (2011b) for related information.

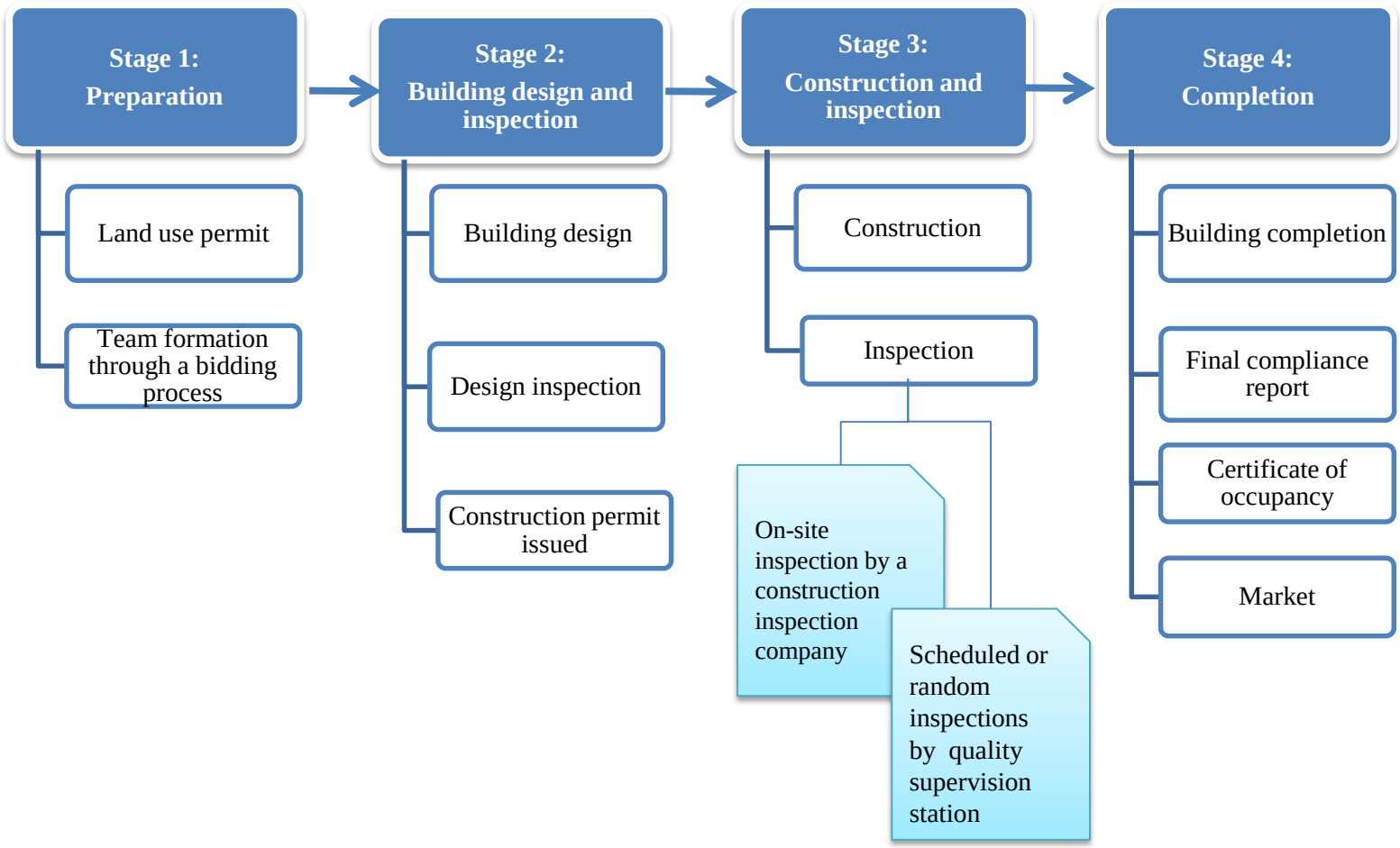


Figure 3: Implementation Process of Building Energy Codes in China

Stage One: Preparation

Land use permit A developer must submit its project application to the local planning department for a land-use permit. Once the developer's application meets all of the requirements (including its plan to comply with building energy codes), the local planning department issues the land-use permit to the developer.

Team formation through a bidding process With the approved land-use permit, the developer will enter the required bidding process to form its project team.

All new construction projects open for bidding along with the company information of bidding participants are announced on local, provincial or national websites. The websites are managed by the construction department of the corresponding level. The developer can choose its team members from the companies that participate in the bidding process.

The third parties (i.e., building design companies, construction companies, and construction inspection companies) must be certified and registered before entering the bidding process.

Stage Two: Building design and inspection

A building design company works on building drawings and the design which must comply with design standards. Once finished, a separate drawing inspection company is required to check and ensure that the drawings comply with related design standards. Having had the drawings and design inspected and now possessing an officially approved drawing, the project becomes eligible to apply for a construction permit.

Stage Three: Construction and inspection

Construction With the approved construction permit, a construction company can begin construction, which must comply with a series of building codes, including the Acceptance Codes.

Inspection A construction inspection company conducts frequent on-site construction inspection activities during the construction process, ensuring that the construction work complies with the relevant building codes including the Acceptance Codes. The local quality supervision station conducts scheduled and random inspection activities throughout the construction phase.

Stage Four: Completion

Building completion Once a construction project is completed and inspected, the local quality supervision stations must collect all documentation (including drawing inspection reports, construction inspection reports and their own inspection reports), and issue a quality supervision report to the developer describing the quality of the construction work and its compliance with the Acceptance Codes.

Once all work is inspected and officially qualified, a developer can then apply for an occupancy permit. The local construction department will verify that the status of all documentation is satisfactory and thereafter issue an occupancy permit.

Market Once it has received the occupancy permit, the developer can sell, rent or occupy the building. In some cities, when the new building is placed on the market for sale, the seller is required to present building energy efficiency information to consumers. For example, the city of Changsha in Hubei Province requires a seller to disclose such information as (1) the type of energy-efficient lighting installed, (2) whether the building is able to make use of any solar, geothermal or wind energy sources, (3) the buildings' heating and cooling energy requirements in Watts per square meter, and (4) the building's energy efficiency compared to the requested level defined by building energy codes, etc.

4. ADMINISTRATION OF THIRD PARTIES

The administration of third parties is a complex management practice, which includes regulatory support from the central government (Section 5.1), financial resources for key stakeholders (Section 5.2), management of construction inspection companies (Section 5.3), certification and registration of third parties (Section 5.4), violation and penalties (Section 5.5), and conducting national inspection of building energy efficiency (Section 5.6).

4.1 REGULATORY SUPPORT FROM THE CENTRAL GOVERNMENT[4]

The administration of third parties is rooted in strong regulatory support provided by the Chinese government.

The *Energy Conservation Law* is China's highest legislative effort to regulate and promote energy conservation at all levels. In its first version, enacted in 1998, Article 37 states that, "the design and construction of the building should be in accordance with relevant law and administrative regulation, adopt energy-efficient building structure, material, and products, improve the thermal and insulating performance, and reduce energy consumption in heating, refrigerating and lighting."

To better interpret provisions related to building energy efficiency stipulated in the first version of the *Energy Conservation Law* (1997), China issued its first national administrative rule focused solely on building energy efficiency, the *Rules on Energy Conservation in Civil Building* in 2000, which were later revised and issued in 2006. The *Rules* request that the inspection of building energy efficiency be carried out at all stages of the process (approval, design, construction, and operation of a construction project). The Rules also describe the responsibilities of relevant stakeholders and the penalties for failure to comply with the legislation.

In 2007, China issued the second version of the *Energy Conservation Law*, directly addressing (1) the administrative structure for developing and deploying building energy codes (Article 34), (2) compliance with and enforcement of building energy codes in design, drawing

[4] Please refer to Shui et al. (2009) and Evans et al. (2010) for related information.

inspection, construction, and construction inspection activities (Article 35), (3) the disclosure of building energy efficiency information when selling or renting buildings on the market (Article 36), and (4) the use of building materials, solar and renewable energy in promoting building energy efficiency (Article 40).

The issued energy efficiency design standards for residential and public/commercial buildings (Section 2.1) include items with which compliance is mandatory. The release of the Acceptance Codes (2007), which contain approximately twenty mandatory items (Appendix 1), is another vital regulatory effort to enforce building energy codes at the construction and acceptance stages. The release of the Acceptance Codes lifts building energy codes to equivalent importance with safety-related building codes.

Driven by the Central Government, these legislative and regulatory efforts set the tone for mandatory compliance with building energy codes.

4.2 Financial Resources for Key Stakeholders

Local construction departments obtain their budgets from both their overarching construction departments (their superiors) and from local governments. For example, a provincial construction department is funded by both MOHURD (its superior in the ministerial hierarchy) and by the provincial government. The salaries of employees of local construction departments are not related to fees collected from the compliance and enforcement process, such as construction permit fees and occupancy permit fees.

Developers are required to pay permit fees to local construction departments for land use, construction, and occupancy. They also pay a service fee to participate in the bidding process and for the hiring of third parties (they pay these fees directly to the hired third parties). The service fee for hiring a building design company is a certain portion of the total estimated capital cost of the building project (excluding land cost). Service fees for drawing inspection companies and construction companies are related to the construction square footage of the building project. There is a governmental document regulating the cost calculation for service fees provided to construction inspection companies (See Section 5.3). Compared to the cost of building materials and land use, the two largest expense items, the permit fees and any service fees paid to third parties are relatively small.

Local quality supervision stations are semi-governmental agencies whose staff salaries are provided by their local construction departments. Although developers pay third-party companies directly, the required bidding process and the fact that local construction department and quality supervision station staff are paid with government funds helps to reduce corruption in the process.

4.3 Construction Inspection Companies

Construction inspection activities have existed in China since the 1980s, for the purpose of ensuring construction quality and compliance with safety-related building codes at the construction stage. Early inspection activities were mainly carried out by developers. In the mid-1990s, third-party construction companies, which are private companies and not spin-offs from

governmental agencies such as quality supervision bureaus, flourished due to a strong construction inspection demand created by the central government. The central government later published a series of governmental regulations and rules to manage construction inspection companies.

In 2007, MOHURD issued a regulation that categorized construction inspection companies into three types: comprehensive (covering all types of construction projects related to residential and commercial, transportation, industrial, and utility sectors), specialized (covering construction projects of a sector or subsector(s)) and firm (focusing on construction management and providing consultant services). The application for certification requires a construction company to meet certain criteria, such as registered capital, number of certified construction inspectors, availability of business and technical documentation, inspection equipment, and no violation activities in the past year prior to the application. A certificate is valid for five years.

Moreover, the same regulation established the management relationship between MOHURD and certified construction inspection companies: MOHURD issues certificates to all construction inspection companies, and certified construction inspection companies are under supervision of MOHURD, or of provincial and city-level branches of MOHURD. MOHURD, in 2007, also released a governmental document to specify service fee calculation for construction inspection companies. The service fee is related to the estimated budget for a new construction project, the sector that this project belongs to, the complexity of this project, the altitude at which the project will be built, and a reasonable profit margin.

In the past five years, the central government has pushed the integration of compliance with design standards into the existing construction acceptance. The release of the Acceptance Codes and other relevant governmental rules mandates that compliance with building energy codes is on an equal status with safety-related construction codes.

By 2009, China had nearly 5,500 certified construction inspection companies with 582,000 employees. About 89% of these companies were specialized for residential and commercial building projects, and 22% of the total employees (or 128,000) were registered construction inspectors (China Statistics Bureau, 2011).

4.4 Certification and Registration of Third Parties[5]

Third-party companies are required to meet certain requirements in order to be eligible to enter the market. For example, a certified third-party company needs to have a minimum number of engineers who have passed the national title exams (see Table 2).

MOHURD and provincial construction departments are the entities that issue certification to third parties. MOHURD and provincial and city-level construction departments also maintain a comprehensive online public database that contains certified third-party companies. The online database provides general company information (such as addresses and level of certification).

[5] Please refer to Shui et al. (2011a) for related information.

Table 2: Title Exams for Certificates

Key Stakeholders	Title Exams for Certificate by Employee	
	Employees	**Title Exams for Certificates**
Building design companies, building research entities	Building designers	Registered architect, certified structural engineer, certified electrical engineer, certified equipment engineer, quality inspector, geotechnical engineer, interior designers, certified cost engineer, cost engineer, etc.
Drawing inspection companies	Drawing inspectors	
Construction companies	Construction managers	Constructor, certified cost engineer, cost engineer, construction workers, technician, security engineer, quality inspector, etc.
	Construction workers	
Construction inspection companies	Construction inspectors	
Testing companies or labs	Testing engineers	Certified testing engineer
Quality supervision stations	Quality supervisors	Supervision engineer

Source: Shui et al. (2011a)

4.5 VIOLATIONS AND PENALTIES

The *Rules of Energy Conservation in Civil Building* (2006) specifies penalties for violations of compliance with building energy codes during the different phases of the construction process (see Box 1).

Box 1: Penalties for Violation

If a building developer directly or indirectly induces its (externally hired) building design company and/or construction company to violate any of the mandatory provisions of the building energy codes, a fine shall be imposed on the developer ranging between RMB 200K (US$ 30K) and RMB 500K (US$ 76K).

If a building design company fails to correct a flawed building design inspected by a drawing inspection company, the building design company shall be warned and fined between RMB 100K (US$ 15K) and RMB 300K (US$ 46K). A building design company that fails to correct flaws three times over the course of two years shall be suspended until rectification, and their qualification certificates will be downgraded or revoked.

A construction company is required to correct any flawed construction activities detected by a construction inspection company. Construction companies shall be responsible for any rectification costs attributable to necessary corrections. In the event of a serious violation, the construction company will pay as much as two to four percent of the construction contract cost as a penalty for its violation. The violating company also faces the possible downgrading of its certification, or even its suspension.

Source: *Rules of Energy Conservation in Civil Building, 2008*

Local quality supervision stations determine whether a non-compliant company is to be fined, and if so, then the local quality supervision station submits a recommendation record to the local market management station (another semi-governmental agency). The local market management station then makes a decision and issues any fines to the non-compliant company. The local construction department would rule on whether to revoke the qualifications of the third parties involved.

4.6 ANNUAL NATIONAL INSPECTION OF BUILDING ENERGY EFFICIENCY[6]

Since 2005, MOHURD has conducted an annual nationwide inspection of building energy efficiency to evaluate the compliance of 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. MOHURD usually sends approximately ten survey teams to conduct the annual inspection. Each team consists of officials from MOHURD, building energy codes experts from CABR and other research institutes, as well as local code officials (who do not inspect 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 the mandatory code requirement, 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, naming 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.

5. ISSUES IN THE CURRENT COMPLIANCE PROCESS

The definition of compliance rate. The dramatic improvement in enforcement, coupled with high compliance rates, has raised some concerns among international building energy efficiency experts. Chinese building energy codes experts expressed their confidence in the credibility of

[6] Please refer to Shui et al. (2009) and Evans et al (2010) for related information.

the data related to the improvement of compliance rates at the design stage[7]. Building design in China is often aided by employing specialized software for construction design that includes components of both Auto CAD and building energy efficiency, which are of great assistance in integrating building energy efficiency with building design and for assessing compliance with building energy codes at the design stage. Evans et al. (2010) argued that the lack of protocols to test the software and the lack of protocols for building simulation would affect the compliance rate at the design stage.

Chinese experts have admitted that the compliance rate at the construction stage is somewhat misleading. The reported compliance rates only reflect the compliance with mandatory items in the design standards and in the Acceptance Codes (Appendix A) for the cities selected for inspection. The announced compliance rate does not reflect the surveyed areas' compliance with *non-mandatory* items, or the actual building energy efficiency of the inspected construction project or the enforcement status in small towns and rural areas. Some Chinese experts are concerned that the sample size of the annual national inspection is too small to be representative.

Though the compliance rates declared by China's annual national inspection of building energy efficiency are narrowly defined and possibly overestimated, the dramatic improvement in the defined compliance rates between 2005 and 2010 nevertheless indicates the impressive performance of the overarching institutions, notably national and regional regulatory support, the functioning of third parties, as well as by other relevant policy instruments (such as public exposure for provinces which need improvements). Some international experts suggested that the improvement of the compliance index could be considered as one of China's next steps to further its building energy efficiency. Under the current implementation system, an improved compliance index could be put in place with much less delay and to greater effect than would be the case in a scenario in which no such system exists.

Enforcement in small towns and rural areas.[8] Local construction departments are currently focused on enforcement of building energy codes in urban areas (especially in large- and medium-sized cities), and such an enforcement system seems to be lacking in small towns and rural areas. In addition, certified and registered third-party companies prefer construction projects in urban areas due to their higher profitability. Construction teams carrying out new projects in small towns and rural areas generally have less training than their urban counterparts, while in small towns and rural areas compliance with building energy codes tends to be much more relaxed.[9] Since 2010, China has begun to address the development of and compliance with building energy codes in small towns and rural areas. For example, Harbin City in Heilongjiang Province has recently retrofitted and built 60,000 residential housing units in rural areas, with 80% of them achieving building energy efficient standards (Lu 2011).

[7] Personal communication with Chinese building energy codes experts.
[8] Please refer to Evans et al. (2010) and Shui et al. (2011b) for related information.
[9] Personal communication with Chinese building energy codes experts.

The quality of construction workers. The average level of education of construction workers is roughly elementary school, while the average level of education of key employees in design and inspection companies is college and university. The level of knowledge and understanding of construction workers has been identified as a weakness in ensuring compliance with Acceptance Codes. Some local construction departments have conducted training targeted at construction workers, while construction companies have also been encouraged to better educate and train their labor force (Shui et al. 2011b).

Training and information dissemination. Though China has employed training as one of the key approaches to promote the enforcement of building energy codes, training and information dissemination appear to be a weak link in the current compliance process (Evans et al. 2010; Shui et al. 2011b). A recent focus group study revealed that a lack of knowledge in identifying the quality of building materials, such as materials' durability and strength, and a lack of knowledge of building techniques have been among the main difficulties facing construction companies. In addition, lack of a thorough understanding of the Acceptance Codes has hampered the work quality of construction inspection companies, local quality supervision stations and testing companies (Shui et al. 2011a). A recent report provided by Pacific Northwest National Laboratory identified these issues and suggested a series of training subjects and strategies (such as providing on-line free training) to improve training and information dissemination (Shui et al. 2011b).

The bidding process. The public disclosure of information concerning bidding for construction projects seems to be inadequate in relation to corruption prevention. Companies involved in bidding are still sometimes able to find creative ways to rig the bidding process (such as collusion in price setting and cheating during the actual bidding process). China is still in the learning process with respect to the development of a strict and effective bidding process.

6. CONCLUSIONS

China has achieved impressive progress in improving its compliance rate at both design and construction stages in urban areas. Though the compliance rates declared by China's annual national inspection of building energy efficiency are narrowly defined and possibly overestimated, the dramatic improvement in compliance with building energy codes nevertheless indicates the impressive performance of the overarching institutions (especially the employment and administration of third parties).

This success is rooted in (1) strong regulatory support provided by the Chinese government (e.g., the release and deployment of the Acceptance Codes mandates compliance with building energy codes in the final acceptance of a construction project); (2) a stable government-allocated budget for the code implementation agencies (e.g., local construction departments and quality supervision stations obtain government budgets for their operation); (3) transparent management of the certification and registration of third-party companies (e.g., MOHURD runs an on-line database for registered third-party companies); (4) clear rules for responsibilities and penalties for non-compliance; and (5) an effective national program of inspection carried out by MOHURD.

There is still room for improvement in China's third-party compliance process. However, China's experience represents an interesting case study of the effective employment and management of third-party companies in the enforcement of building energy codes.

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APPENDIX 1: SELECTED MANDATORY ITEMS FROM THE ACCEPTANCE CODES (2007)

Selected Chapters & Sections	Specific Mandatory Items
1 General Provisions	Completion acceptance of a unit engineering work shall be conducted only after the divisional work of building energy efficiency is qualified and accepted (1.0.5).
3 Basic Requirements 3.1 Technologies & Management	The variation of design shall not lower the energy efficiency of building. Design variation relevant to building energy efficiency shall be examined by the original construction drawing examiner and shall process the design variation procedures before implementation and shall be confirmed by the supervision brigade or the employer (3.1.2).
3.3 Construction & Control	Building energy efficient work shall be carried out in accordance with the qualified design drawings and approved construction plan after examination (3.3.1)
4 Energy Efficient Work of Wall 4.2 Dominant Items	Thermal conductivity, density, compressive strength & burning behavior of thermal insulation materials used in energy efficient work of wall shall be in compliance with the design requirements (4.2.2). Construction of energy efficient work of wall shall be in accordance with the following requirements (4.2.7): 1. Thickness of insulation materials shall comply with the design requirements. 2. Bonding & connection between insulation boards and substrate and between layers shall be tight. Bonding strength and connection methods shall comply with the design requirements. In-situ pullout tests shall be conducted to test the boding strength between the insulation boards and the substrate. 3. Insulating mortar shall be constructed by layers. When insulating mortar is used for external thermal insulation, the bonding between insulation layer & substrate and between layers shall be tight and no delamination, hollowing and crack shall be found. 4. When the insulation layer in wall energy efficient work is fastened with embedded or post-installed anchors, the quantity, location, depth and tensile strength of anchors shall be in compliance with the design requirements. In-situ pullout test on anchoring strength shall be conducted for post-installed anchors.
6 Energy Efficient Work of Doors and Windows 6.2 Dominant Items	Air-tightness, insulating performance, dew points of insulating glass, shading coefficients of glass and visible light transmittance of building exterior windows shall be in compliance with the requirements of design (6.2.2).

Selected Chapters & Sections	Specific Mandatory Items
7 Energy Efficient Work of Roofing 7.2 Dominant Items	Thermal conductivity, density, compressive strength & burning behavior of thermal insulation materials used in energy efficient work of roofing shall be in compliance with the design requirements (7.2.2).
9 Energy Efficient Work of Heating 9.2 Dominant Items	Installation of heating systems shall be in compliance with the following requirements (9.2.3): 1. Modes of heating systems shall comply with the design requirements; 2. Installation of a radiant equipment, valves, filters, thermal meters and gauges shall be complete and shall not be added and reduced at will; 3. Installation positions & orientations of indoor temperature control devices, thermal meters and hydraulic equalizers and heating entry devices shall comply with the design requirements and shall be convenient for observation, operation & adjustment.
10. Energy Efficient Work of HVAC 10.2 Dominant Items	Installation of air supply and exhaust systems, air-conditioning air duct systems and air-conditioning water systems in HVAC works shall be incompliance with the following requirements: 1. Modes of the systems shall comply with the design requirements; 2. Installation of the equipment, valves, filters, thermal meters and gauges shall be complete and shall not be added and reduced at will; 3. Installation positions & orientations of hydraulic equalizers, temperature control device and gauges in the branch pipes of water systems shall comply with the design requirements and shall be convenient for observation, operation and adjustment; 4. Function of temperature control by room (zone) and metering of heating and refrigerating supply by building, zone or by household, as required by design, shall be able to be realized.
15. Quality Acceptance of Divisional Work of Building Energy Efficiency	Qualified building energy efficient divisional works shall comply with the following requirements (15.0.5): 1. All sub-divisional works shall be accepted qualified; 2. Quality control documents shall be complete; 3. Results of in-situ inspection of energy efficient construction of external walls shall be in compliance with the design requirements; 4. Results of in-situ inspection air-tightness of external windows in severe cold & cold zones and hot summer & code winter zones shall be qualified; 5. Results of systematic energy efficient performance testing of building equipment works.