ESMAP
Energy Sector Management Assistance Program

Energy Efficient Cities Initiative

GOOD PRACTICES IN CITY ENERGY EFFICIENCY

Tianjin, China – Enforcement of Residential Building Energy Efficiency Codes

Project title	Enforcement of residential building energy codes
Sector	Buildings
Type of project	Building energy codes
City and country	Tianjin, China
City population	12.28 million, 2009
Capital cost/initial investment	Estimated incremental cost for energy efficiency: 750 million yuan (US$90.6 million[1])
Reduction in annual energy use	870 GWh heat energy at building level
Project status	Ongoing. Period covered: 2005-2009

Project Summary

Tianjin is one of the most successful Chinese cities in compliance enforcement of building energy efficiency codes (BEECs). Results of recent annual national inspections organized by the Ministry of Housing and Urban and Rural Development (MoHURD) indicate that compliance of BEECs in new residential and commercial buildings in Tianjin is close to 100 percent, compared to the 80 percent average across nearly three dozen large cities inspected by MoHURD in 2008. More remarkable is the fact that, in terms of building envelope thermal integrity, the currently enforced residential BEEC in Tianjin (identified as DB29-1-2007) is 30 percent more stringent than what is required by the pertinent national BEEC (identified as JGJ 26-95).

In 1997, Tianjin introduced its first mandatory residential BEEC (identified as DB29-1-97), which is equivalent to the requirements of the JGJ 26-95, the national model BEEC for cold climate regions enacted in 1995. DB29-1-97 was enforced from 1998 to 2004. Enforcement actually began on January 1, 2005; it was based on an earlier version which was updated and reenacted on June 1, 2007. This case study covered five years of enforcement of DB29-1-2007, from 2005 to 2009.

From 2005 to 2009, about 70 million m^2 of new residential buildings were completed in the urban areas of Tianjin. Many were subject to compliance of DB29-1-97 because their construction permits were issued before January 1, 2005. About 50 million m^2 of them were designed according to Tianjin's DB29-1-2007. This puts the upper range (assuming full construction compliance) of the calculated space heating energy savings of these new buildings at about 870 GWh/year, compared with the baseline of complying with DB29-1-97 (or the national JGJ 26-95). Heat energy saved would be sufficient to provide winter space heating for about 200,000 apartments (at 100 m^2 each) built to comply with DB29-1-2007. Compared with the baseline, the estimated simple payback period for compliance with DB29-1-2007 based on avoided cost of heating service is less than seven years, attractive even if the energy efficiency (EE) measures have a lifespan of 15 years.

Tianjin's efforts to go beyond national BEEC requirements marked a departure from the mostly central government-driven BEEC regulation of the past in China. Tianjin began piloting residential BEEC in the late 1980s, despite the fact that it has taken about 15 years for Tianjin to achieve a high degree of compliance. Tianjin has demonstrated the importance of the following factors in achieving BEEC compliance: (i) a well-established building

[1] Based on 2004 exchange rate of US$1.00=8.28 Chinese yuan.

construction management system, (ii) standardized and structured procedures for compliance enforcement, (iii) broad-based capacity of the construction trades to meet compliance requirements, including technical skills and availability of parts and materials, (iv) consumers' ability and willingness to pay for the costs of BEEC compliance, and (v) local government resources, support, and commitment to implementing increasingly stringent BEECs.

1. Introduction

Tianjin is one of four municipalities in China with provincial-level administrative status, which gives the city significant authority in policy making, including enacting regulations more stringent than pertinent national ones. Located about 150 km southeast of Beijing and near the shore of Bohai Bay, the Tianjin municipality covers 15 districts and three counties with a total area of 11,760 square km. At the end of 2009, total population in Tianjin was 12.28 million, of which 78 percent was urban. Tianjin's gross domestic product (GDP) in 2010 was 910.9 billion yuan (equivalent to about US$140.1 billion at end of 2010 exchange rate), of which manufacturing accounted for 53 percent, services 45 percent, and agriculture 2 percent. Tianjin is also a major hub for higher education as well as scientific and engineering researchers in China.

The total building stock in urban built-up areas of Tianjin was 244.51 million m^2 (about 61 percent was residential) in 2006, the last year such official statistics was available. The urban residential building stock grew from 134.65 million m^2 in 2004 to an estimated 200 million m^2 in 2009, averaging about 13 million m^2 per year.

For building thermal design purposes, China is divided into five climate zones (Figure 1). Tianjin is located in the cold zone and has an average winter temperature of -2ºC. Cities in the cold and severe cold zones, where space heating lasts three months or more, were the first to be regulated by a national residential BEEC to reduce spacing heating coal consumption and associated air pollution. Tianjin was among the first cities to pilot residential BEEC in China in the late 1980s. It introduced a mandatory residential BEEC in 1997 (DBJ 29-1-97), two years after the pertinent national residential model code JGJ 26-95 (for cold and severe cold zones) was promulgated.

The national residential model code JGJ 26-95, from which all provincial-level BEECs are derived, sets the minimum thermal performance requirements for the building as a whole (maximum building heat consumption index – BHCI) and for each component of the building envelope (maximum overall heat transfer coefficient, also known as the U factor).[2] This includes the roof, exterior wall, windows, balcony doors, ground floor exposed to outdoor air or non-heated basement, and parts of non-heated stairwell. The BHCI is a theoretical threshold for heat supply at building level to compensate for heat losses through the building envelope, calculated according to methodology defined by the model code.[3] The smaller the BHCI is, the less heat is lost through the building envelope. For this reason, less active heat

[2] Overall heat transfer coefficient, or U factor, is the rate of heat transfer through a given area of a building envelope component (roof, exterior wall, or window, for examples) in a given time under standardized ambient conditions. For example, laboratory tests need to be conducted to confirm the U factor of a window assembly.

[3] BHCI is defined as the net heat consumed in unit time by unit construction floor area (W/m^2) at outdoor mean air temperature during the official heating season to maintain the indoor design air temperature. In disaggregate terms, BHCI equals to the sum of net heat losses through all building envelope components via conduction, plus heat losses through infiltration, minus internal heat gains, all on a seasonal average basis. The solar heat gains are factored into the calculation of the net heat losses through each building envelope component by applying a set of predetermined coefficients.

supply is needed to keep the building interior at a given temperature. The BHCI simplifies building energy analysis (for space heating) but generally underestimates actual heat consumption of buildings because the methodology applies ideal or generalized operating conditions. Most importantly, the BHCI is used as an overall EE design compliance control target.[4] If the calculated BHCI of a particular building design exceeds the threshold BHCI, the design needs to be revised until it achieves compliance.

Figure 1: Climatic zoning for building thermal design purpose in China

Severe cold zone—average temperature in the coldest month: at or below –10°C

Cold zone—average temperature in the coldest month: –10 to 0°C

Hot-summer/cold-winter zone—average temperature in the coldest month 0 to 10°C and average temperature in the hottest month 25 to 30°C

Hot-summer/warm-winter zone—average temperature in the coldest month: above 10°C and average temperature in the hottest month 25 to 29°C

Temperate zone—average temperature in the coldest month: 0 to 13°C and average temperature in the hottest month 1 to 25°C

Table 1 compares Tianjin's first generation residential BEEC (DBJ 29-1-97), which was derived from the current national model code JGJ 26-95, with Tianjin's current residential BEEC (DBJ 29-1-2007), which has a threshold BHCI that is 30 percent lower than the last generation residential BEEC. In terms of components, the current BEEC is significantly more stringent on insulation and glazing.

Tianjin has been among the most progressive cities in China and a pioneer in economic reforms. The World Bank has been working with MoHURD and Tianjin on urban heating sector reform and BEEC compliance enforcement since 1999. Tianjin was the pilot city of the GEF-financed China Heat Reform and Building Energy Efficiency (HRBEE) Project, which was launched in 2005. During the preparation of the HRBEE project, national and international experts advised Tianjin on a range of issues, including heat metering and consumption-based billing, formulation of two-part heat tariff, BEEC compliance enforcement procedures, and revision of the existing residential BEEC.[5]

[4] The national model code JGJ 26-95 identified 15 sub-climate zones within the cold and severe cold zones with 0.9°C separating each sub-zone by average outdoor temperature during the heating season. It further specified BHCIs for 110 representative cities.

[5] Centralized heating in China still is charged based on a flat rate assessed on floor area of dwellings, regardless how much heat is actually consumed. Consumption-based billing introduces a variable cost component into the service charge to reflect actual heat consumption. This will require at minimum building-level heat metering while allocate the variable costs among apartments using special devices which are cheaper than installing individual apartment heat

The revision of the existing BEEC (DBJ 29-1-97) at the time of the HRBEE project preparation (2003-2004) provided a benchmark for demonstrating the technical and economic feasibilities of more stringent and enhanced EE design requirements for new residential buildings. Tianjin took one step further and made the revised BEEC mandatory for all new housing constructions beginning January 1, 2005. This revised BEEC was further updated in 2007 to address key issues arising during the first two years of implementation, including provisions for cooling and ventilation, sun shading, as well as structural integrity related to exterior wall insulation.

Table 1: Key Parameters of Tianjin's Residential BEECs

	DBJ 29-1-97		**DBJ 29-1-2007**	
Overall Building Threshold BHCI	**20.5** W/m^2 of construction floor area		**14.4** W/m^2 of construction floor area	
Building Envelop Component Requirement	**U Factor** (W/m^2-K)		**U Factor** (W/m^2-K)	
	Shape coefficient* <= 0.30	0.30<Shape coefficient <=0.35	Buildings with 4 or more stories	Buildings with 3 or fewer stories
Roof	0.80	0.60	0.50	0.40
Exterior wall	1.16	0.82	0.60	0.45
Un-heated stairwell				
Partition wall	1.70	1.70	1.50	1.50
Apartment entry door	1.70	1.70	1.50	1.50
Window	4.00	4.00	2.70	2.50
Balcony door				
Glazed portion	4.00	4.00	2.70	2.50
Non-glazed portion	1.70	1.70	1.50	1.50
Building entry door				
Glazed portion	NA	NA	4.00	4.00
Non-glazed portion	1.70	1.70	1.50	1.50
Ground floor exposed to outside air	0.50	0.50	0.50	0.50
Ground floor above unheated basement	0.55	0.55	0.55	0.55

* Shape coefficient is defined as the exterior surface area of a building divided by the enclosed volume. A higher value indicates a larger area for heat loss per unit interior volume. This condition is simplified in the current BEEC by dividing buildings into two categories by the number of floors.

Centralized heating systems where multiple buildings or city blocks are supplied with heat from a common source (either heat-only boilers or combined heat and power stations) through a network are the dominant space heating mode in Chinese cities in the cold and severe cold zones. However, the centralized heating service is charged by heated floor area, a legacy of the bygone central planning era which remains largely intact. In well-insulated new buildings, overheating has become fairly common, significantly offsetting the energy savings potential made possible by BEEC compliance. The World Bank/GEF project was designed to assist the government of China in holistically addressing the EE issues associated with space heating, from heat sources to buildings, so that technical efficiency gains in heat supply systems and in buildings can be fully materialized.

2. Project Description and Design

When MoHURD and the World Bank began to work with Tianjin on improving compliance enforcement and tightening building EE design requirements in 2003, Tianjin already

meters. Two-part heat tariff include a fixed charge (for recovering the fixed cost of service provision) and a variable charge on actual energy consumption (to recover the variable cost, which is mostly energy cost).

possessed significant compliance capacity and had enforced its first mandatory residential BEEC DBJ 29-1-97 for about 5 years. There are two major issues Tianjin sought to address:

- *Inconsistencies of BEEC compliance enforcement in the housing construction cycle*. There was much better control in the design review process than in the construction supervision process. A significant portion of completed buildings were not constructed according to BEEC compliant design specifications due to inadequate construction inspections, as well as the lack of a well-structured supervision approach for BBEC compliance during construction; and
- *The technical and economic feasibilities of adopting more stringent residential BEEC* than DBJ 29-1-97, which was derived from the national model code JGJ 26-95 using Tianjin specific climate parameters. Tianjin's interest in adopting a more stringent residential BEEC was also inspired by Beijing which was already working on a revised residential BEEC in 2003. The preparation of the HRBEE project provided additional momentum.

The World Bank provided technical assistance to Tianjin on both issues through national and international experts and BEEC compliance practitioners. Based on national and international best practices, guidelines for BEEC compliance supervision and inspection were developed and to be tested on GEF-supported demonstration projects. The technical and economic feasibilities of reducing the threshold BHCI of DBJ 29-1-97 by 30 percent were analyzed and confirmed. Relevant design requirements were incorporated into the architectural designs of GEF-supported demonstration projects.

By mid-2004, Tianjin had already formalized the revision of DBJ 29-1-97 and issued the revised version under the code series number DBJ 29-1-2004 on July 1, 2004. They made clear that the new code would be fully enforced beginning January 1, 2005, giving the local construction sector six months to adapt. The current residential BEEC, DBJ 29-1-2007, inherited the threshold BHCI and component specific U factors prescribed in DBJ 29-1-2004, but added additional requirements as described in the previous section. Thus, new buildings complied with DBJ 29-1-2004 would still meet the basic thermal integrity requirements of DBJ 29-1-2007.

BEEC compliance enforcement process

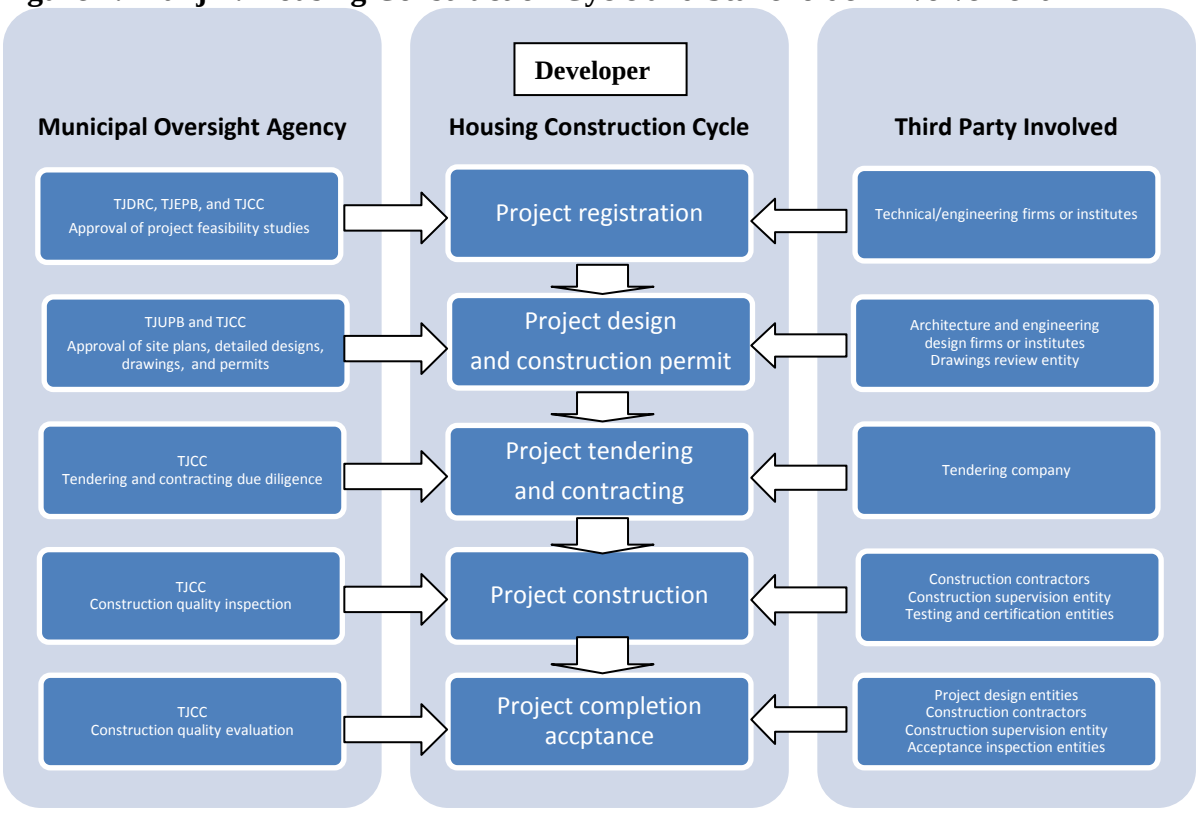
Urban construction in China is regulated nationally (by MoHURD) but managed and enforced locally. Provincial governments are responsible for adapting national regulations and codes to regional conditions (e.g., seismic and climatic) and municipal (and lower level) governments are responsible for actual enforcement. In Tianjin, the provincial and municipal roles are combined. The implementation of residential BEEC has been led by Tianjin Construction Commission (TJCC), which regulates and oversees the local construction sector, including basic urban infrastructures, such as roads, gas distribution, district heating, water supply, as well as building construction.

The reform to commercialize housing supply in the late 1980s brought drastic changes to the way the government manages the urban housing construction sector. Over a period of about ten years, urban housing supply (and supply of other urban building types) in China was transformed from a predominantly government planned and sponsored activity to one that relies on commercial entities subjected to government regulations and oversight. Real estate developers are obliged to comply with various government regulations during the different phases of the construction cycle.

BEEC enforcement, a later development of housing construction regulation, needed to be integrated into this system of construction management to be successful. Tianjin Municipality was a pioneer in integrating BEEC compliance into the regular housing construction cycle. A key aspect of the integration was to streamline BEEC compliance procedures with the regular construction permit review and construction inspection process.

A housing development project in Tianjin goes through a five-phase sequence before the keys are turned over to apartment owners. The developer needs to interact with government oversight agencies, including various departments of TJCC, Tianjin Development and Reform Commission (TJDRC), Tianjin Environmental Protection Bureau (TJEPB), and Tianjin Urban Planning Bureau (TJUPB), to obtain necessary government approvals in each phase. The developer has to rely on the services of multiple third-party entities to comply with basic requirements needed for those approvals (Figure 2).

Figure 2: Tianjin: Housing Construction Cycle and Stakeholder Involvement



TJCC, through its functional divisions, is the designated line agency involved in the entire construction cycle. This includes the overall supervision and coordination provided through the Building Energy Conservation Office, due diligence in design review through the Construction Design Management Department, due diligence in the tendering and contracting process through the Tender and Contract Management Office, and compliance enforcement during construction through the General Station for Building Construction Quality Supervision, as well as overall technical and enforcement support provided by Tianjin Wall Materials Reform and Building Energy Conservation Management Center (BECMC in short), a quasi government agency reporting to TJCC. Historically, the role of the BECMC has been critical and remains essential to ensuring BEEC compliance because it has been the main repository of local BEEC technical competence. It also acts as the municipal government's

BEEC inspector (although the enforcement authority lies with the General Station for Building Construction Quality Supervision).

Although oversight of the government agencies remains critical, the BEEC compliance process in Tianjin (and in other cities of China) relies heavily on due diligence of the developer through licensed third-party services: architects have to make sure the designs are BEEC compliant, design review entities must certify the construction drawings as BEEC compliant, testing facilities need to conduct tests of samples of materials and components to certify BEEC compliance, construction supervision entities have to perform required checks and inspections, and independent technical entities will evaluate overall BEEC compliance as part of the completion acceptance inspection. The role of the government agencies is to confirm that these procedures are properly followed and penalties are enforced if violations are found. For example, licenses of third-party entities can be suspended or revoked if they are found to be negligent. Violations during construction are more frequent. In these cases, construction is stopped until issues (e.g., improperly installed insulation) are resolved.

For such a distributed-responsibility system to work effectively, the third-party entities must be proficient in their specialty areas and keenly aware of their due-diligence responsibilities in the BEEC compliance chain. In fact, they are required to take training courses and pass fairly stringent national licensing exams. The government also needs to have a clear sense of responsibility and adequate human resources to monitor these entities to maintain a credible threat to potential violators. Potential negligence or abuse of power of involved parties notwithstanding, this system of accountability is a critical step toward broad-based BEEC compliance.

The third-party compliance approach has its advantage in alleviating government resources constraints in view of the huge scale of China's urban construction. It also effectively internalizes the cost of compliance enforcement, since the developer pays for third-party services and passes the cost to home buyers.

3. Cost, Financing, Benefits, and Effects

The costs and benefits of BEEC compliance are often distributed among multiple parties. Singling out those which are most relevant to EE, which parties bear the costs and benefits, is complex. For example, double-glazed windows can significantly reduce heat losses compared with single-glazed models. But they are also highly valued by city dwellers for cutting down on noise, a value which is difficult to quantify. In Tianjin, because consumption-based billing for heating is still not universal, individual households are not able to receive financial benefits for reduced heating demand. Another issue is that the effect of BEEC compliance on reduced cooling in summer is not well-documented. Therefore, a full account of direct energy cost savings is difficult.

This case study took a rather simplified best-case scenario approach using data and information gathered through the World Bank/GEF project. The incremental cost of complying with DBJ 29-1-2007, using DBJ 29-1-97 compliance as baseline, is compared with the incremental benefit of avoided cost of heating service provision due to reduced heat demand (Table 2). Assuming that home buyers are well informed about such information, this would represent their view of the financial cost and benefit of buying a more energy-efficient apartment, taking into consideration the benefit of avoided heating service cost only.

If households are able to recover their full cost savings of reduced heating, the simple payback time would be lowered to between five to seven years for choosing a DBJ 29-1-2007

compliant apartment over a DBJ 29-1-97 compliant model. In reality, heating companies would not pass the capacity reduction benefit to individual households, thus households are only able to recover savings from consumption charges which they control. In this case, the simple payback time rises to 11 years.

The compliance cost of the residential BEEC is essentially internalized and passed on to the home buyers. It was a significant barrier and concern when the government first introduced the code in late 1990s. Developers resisted the BEEC out of concern it would driving up housing prices and they would lose sales when home prices were still low. The government had also been careful on potential cost run-up and had supported large scale demonstrations before the code became mandatory.

Table 2: Estimated Incremental Costs and Benefits of Compliance (2004 prices)

	Baseline DBJ 29-1-97 Compliance	**Actual DBJ 29-1-2007 Compliance**
Threshold BHCI	20.5 W/m^2-floor area	14.4 W/m^2-floor area
Average heat demand reduction		6.1 W/m^2-floor area
Annual heat energy reduction		17.4 kWh/m^2-floor area
Value of heating service*		
Capacity charge	0.133 yuan/W	0.133 yuan/W
Consumption charge	0.0813 yuan/kWh	0.0813 yuan/kWh
Avoided consumption charge		**1.4 yuan/m^2-floor area**
Avoided annual heating service cost		**2.2 yuan/m^2-floor area**
Incremental construction cost**		**10-15 yuan/ m^2-floor area**
Simple payback time Considering full heating service cost		**5-7 years**
Simple payback time Considering consumption charge only		**7-11 years**

* This was the cost-recovery two-part heat tariff proposed for Tianjin based on analyses of costs of service provision of six local heating companies.

** Based on local expert verified construction costs of two typical apartment buildings, one six stories (lower cost) and stories. Incremental costs of compliance due diligence of the government and developers are considered negligible.

From 2005 to 2009, about 70 million m^2 of new residential buildings were completed in the urban areas of Tianjin. About 50 million m^2 of them were designed according to Tianjin's DB29-1-2007. Taking the upper bound of the incremental cost at 15 yuan/m^2-construction floor area in 2004 prices, the overall incremental cost of the 50 million m^2 DB29-1-2007 compliant residential buildings would be 750 million yuan (US$91 million using 2004 exchange rate $1=8.28yuan), a small price to pay for potential annual savings of 870 GWh. The cost of saving one metric ton of heating coal is 240 yuan (a total of 3.1 million metric tons of coal savings over 15 years), compared to a heating coal price of about 400 yuan/metric ton in Tianjin in 2004. The reduced annual coal consumption of about 200,000 metric ton also contributes to about 400,000 metric ton of CO_2 emission reduction per year, as well as reduced emissions of air pollutants. By enforcing a more stringent residential BEEC, Tianjin avoided the capital investment in a minimum of 300 MW additional district

heating capacity.[6] Although these are simplified estimates, they provide an excellent snapshot of the magnitude of impact of implementing the revised residential BEEC.

4. Project Innovation

Tianjin's efforts to go beyond national BEEC requirements marked a departure from the mostly central government-driven BEEC regulation in the past in China.

Although Beijing (another provincial administrative status city) mounted a similar effort about a year earlier than Tianjin and a few more provinces/cities followed suit, what really set Tianjin apart from other large cities in the cold and severe cold zone has been its paralleled efforts to realize the energy savings potential of BEEC compliant buildings: district heating sector reform, or more specifically, introducing consumption-based billing.

Tianjin was the first among Chinese cities in the cold and severe cold zones to seriously pursue heat metering and consumption-based billing, an effort which has been supported by World Bank/GEF HRBEE project. Acknowledging the difficulties of untangling the web of vested interests in the system of flat-rate heating charges, Tianjin adopted a two-pronged approach: (1) pushing aggressively in enabling new apartment buildings for consumption-based billing. Requirements for installation of thermostatic radiator valves (for controlling room temperature) and apartment-level heat meters were mandated since 2005 (in a separate regulation) and referred to in the current residential BEEC, so all new DBJ 29-1-2007 compliant buildings are capable of indoor temperature control and are consumption-based billing ready; and (2) carrying out large scale pilots for consumption based-billing and incrementally scale up the program. As of 2009, Tianjin has 26 million m^2 of housing involved in pilots for heat metering and consumption-based billing. The government plan is to increase the area of consumption-based billing to 100 million m^2 by 2015.

5. Lessons Learned

Four aspects of Tianjin's efforts, which also reflect the national efforts, to mainstream BEEC compliance are particularly noteworthy:

- *Establishment of a streamlined urban construction management system.* Internationally, integration of BEEC enforcement into the regular building construction management system is often cited as a key to success in scaling up BEEC compliance. But this experience comes from industrialized countries where the construction sector is mature and rules and regulations are relatively well established and followed. In that respect, the Chinese efforts to develop a functional government-regulated but commercially operated urban construction market have been fundamental to BEEC compliance. The current reliance on third-party services for BEEC compliance is a direct product of mapping BEEC requirements into the new urban construction management system.
- *Development of capacity and compliance methods at the local level.* In Tianjin's earlier efforts to adopt the national model code, much attention was paid to the development of locally suitable compliance methods and capacity of the construction

[6] The estimated heat energy savings are at building level. Coal savings are estimated by assuming at least 15 years of EE measure life (thus 15 years of cumulative savings) and taking into consideration of 10 percent transmission and distribution losses and 80 percent thermal efficiency of heat-only central boiler stations. One metric ton of heating coal has a heating value of 20.9 GJ. Additional district heating capacity only covers the incremental 6.1 W/m^2 if the building had been built to baseline requirements.

trades. Specific technical designs for building envelope components were provided, (e.g., the drawings of insulated exterior wall, roof, and thermal bridges using alternative materials). Trainings were conducted for local architects, and pilots were implemented to get local developers and builders familiarized with the compliance techniques and materials before the code become mandatory.

- *Development of market for materials and components for BEEC compliance.* The availability of parts and materials for BEEC compliance and the lack of experience in using them were major constraints to scaling up BEEC compliance in the 1990s. The BECMC was initially established to promote alternative wall construction materials but later it became the local champion for implementing BEEC and related capacity building and market development. MoHURD encouraged experiments with different insulation materials and techniques. In the cold-climate region, the exterior cladding system using expanded polystyrene (EPS) panels became the dominant exterior wall insulation method in the early 2000s because it is easy to manufacture, quick to install, and relatively cheap, while also providing good thermal insulation.[7] Double-glazed vinyl windows were initially introduced for BEEC compliance, but quickly became popular because they also provided good sound insulation. In recent years, as the housing market continues to move up the amenity ladder, casement windows, more expensive but more durable and more airtight than sliding windows, have become popular.

- *Government Leadership and commitment to implementing BEEC.* The high degree of BEEC compliance in Tianjin was achieved over a period of about 15 years. During that time, the municipal government, through TJCC, has provided unwavering support to mainstreaming BEEC compliance in building construction, including giving the BECMC major responsibilities for developing and implementing local BEECs. The BECMC has been one of the most well-funded local BEEC champions among major Chinese cities. It has been largely funded out of a surcharge on local new building constructions for promoting resources-saving construction materials.

Experiences of demonstration projects in the World Bank/GEF supported HRBEE project also provided some specific lessons:

- A review of the *technical offer* by the construction company to the developer locally could help ensure that it complies with the technical specifications and construction drawings.
- Workshops should be held locally to communicate BEEC requirements in a user-friendly and practical manner to the quality inspection station, the construction supervisor, and the developer's project manager to strengthen understanding of requirements.
- Checklists as part of acceptance procedures, prepared during key stages of the project construction cycle, should be adopted locally.
- Training of the construction workers and construction supervisors by quality inspection stations (training could focus on one building element for one month, then another in a step-by -step capacity-building effort).
- Verification of the technical documentation: certification of products and installation standards could be done with spot checks.

[7] EPS panels are flammable and banned, for example, in the United States and Russia. An alternative, but more expensive insulation material is rockwool.

6. Financial Sustainability, Transferability, and Scalability

The costs of BEEC compliance have now been internalized by the market. There is no longer a financial barrier to implementing the current residential BEEC. In fact, Tianjin is already encouraging developers to do more on sustainable construction and buildings. It has drafted green building guidelines, which are currently being piloted in another World Bank/GEF project: Sino-Singapore Tianjin Eco-City, where new residential buildings are not only expected have further improved thermal integrity compared to the current BEEC but also to incorporate additional green building attributes, including water conservation and the use of renewable energy.

There are large disparities in climate conditions, technical capacities, and the level of economic development among Chinese cities, leading to significant variations in compliance efforts and results among different cities. Recent national inspections, however, indicate large improvements in large cities. Anecdotal evidence demonstrates that BEEC compliance rates in medium and small cities are generally much lower than in large cities. In the near term, the big challenge for China is to replicate the recent success in BEEC compliance in a few dozen large cities in hundreds of medium and small cities. This will require continued political pressure and technical assistance from the central and provincial governments to local governments.

The government is tapping into the market forces for improved BEEC compliance, especially in the area of increasing consumer awareness and rights about the basic BEEC obligations of developers. MoHURD has been promoting labeling and certification for insulation materials and fenestration products and more recently initiated piloting of whole building EE labeling. Such efforts will further broaden the geographical coverage of BEEC compliance and enhance quality and transparency of compliance. However, the construction industry is still prone to "corner cutting" by using substandard materials and components, aided by some testing laboratories that, while certified, do not employ very rigorous testing protocols and allow manufacturers to shop around for the best results.

Building labeling is now recognized as a valuable tool to influence real estate buyers and thus create incentives for developers to pay closer attention to BEECs. Under MoHURD's pilot building labeling system, developers pay for participation. This labeling goes from one to five stars, according to EE performance and utilization of renewable energy sources.

The fact that quite a few large cities, including Tianjin, Beijing, Shanghai, Chongqing and a couple of provinces, are now able and willing to go beyond the requirements of national BEECs indicates that the driving force for market transformation has begun to shift toward regions. This new dynamism will serve China well. The larger and more advanced markets will lead in innovations and provide the rest of the country with ideas and experiences.

References

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2. *Tianjin Statistics, Tianjin Statistical Information Net, http://www.stats-tj.gov.cn/*
3. *Various project documents, China Heat Reform and Building Energy Efficiency Project, the World Bank*

ANNEX: CITY AND PROJECT PROFILE

CITY PROFILE

1. Name of the City	**Tianjin**
2. Area	**11,760 square km**
3. Population	**12.28 as of 2009**
4. Population Growth Rate	**2.5% from 1999 to 2009**
5. GDP of the City	**910.9 billion yuan in 2009**
6. GDP Growth Rate	**15.5% from 2004 to 2009**
7. GDP per Capita	**74,177 yuan in 2009**
8. Official exchange rate	**1 yuan = 0.147 USD in 2009**

PROJECT PROFILE

1. Project Title	**Enforcement of residential building energy code**
2. Sector	**Buildings**
3. Project Type	**Building energy codes**
4. Total Project Capital Cost	**750 million yuan**
5. Energy/Cost Savings	**30% annual heating energy**
6. Simple Payback	**7 years**
7. Project Start Date	**January 1, 2005**
8. Project End Date	**Continuing**
9. % of Project Completed	**Not applicable**

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