

## Building Energy Codes in China: Recommendations for Development and Enforcement

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### 1. Introduction

Buildings use more energy than any other sector in the world and account for roughly 40% of the global greenhouse gas emissions (GHGs) from energy use (IEA 2013a). The Chinese building stock is rapidly expanding as a result of urbanization which is a driving force behind increased consumption. Under China's current development plan, its building sector will use more energy than any other country's building sector in the world by 2030 and will double by 2050 (IEA 2013a).

Improving building energy performance in China represents an enormous opportunity to avoid global GHGs. While a multitude of strategies exist to capture this opportunity (PI & CCIEE 2014), the most impactful approach to capturing these savings is through building energy codes programs. These programs are proven mechanisms for improving the efficiency of buildings around the world, impacting new construction as well as major renovations.

Fortunately, the best practices for developing, implementing, and enforcing building energy codes have been studied and understood to a large degree. The purpose of this paper is to shed light on the gap between these international best practices and China's practices, make recommendations to close the gap, and provide an opportunity for China's global leadership. Many of the international best practices can be found in China (Levine et al. 2012), so we are comparing China to a hypothetical country where all best practices of the world are practiced.

### 2. Gap Analysis

A best practice building energy codes program has mandatory, enforced, and ambitious whole-building and equipment standards that are supplemented by labeling programs with associated financial incentives that drive performance beyond code (Levine et al 2012). Building codes should be part of a dynamic process where targets are enhanced at regular intervals, roadmaps define a viable path toward attainment, and supporting packages are developed and deployed through a structured and time-bound process (GBPN 2014). This section assesses the gap between international best practices and China practice along the dimensions of 1) coverage and stringency; 2) compliance process; 3) industry readiness; 4) ratings and labels; and 5) incentive programs.

#### 2.1 Coverage and stringency

Impactful building energy codes should be mandatory and cover all new construction and retrofits. The stringency for energy efficiency should reach optimal levels, with some jurisdictions leading the way by adopting higher performance codes that go beyond national level requirements to serve as exemplars or pilot programs and make the case for additional stringency.

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Beginning in the 1980s, China has developed comprehensive national and local building codes and standards. The national level code spans design, construction, and operation stages, including three variations of the urban residential code for each of three climate zones<sup>1</sup>. Each province can develop its own more stringent commercial and residential building codes. Some provinces (e.g. Beijing, Tianjin) have developed and implemented standards that are roughly 10–15% more efficient than the national codes.

Chinese buildings on average consume much less energy than those in the U.S. and Europe; however, this is due to differences in operation practices and not necessarily because the building codes and standards in China are more stringent. Code-compliant Chinese commercial buildings use more energy than the U.S. and could use up to 80% more, if all operated in U.S. conditions. Commercial buildings operated under the Chinese code will have higher site energy use intensity (120 kWh/m<sup>2</sup> in 2015) compared to that of the current version of the U.S. standard ASHRAE 90.1-2013 (100 kWh/m<sup>2</sup>) when differences in operating practices are taken into account (Figure 1)<sup>2</sup>. If the Chinese buildings defined by the code are operated in the same way as U.S. buildings, they will have even higher energy use intensity values (180 kWh/m<sup>2</sup> in 2015). Similarly, if U.S. buildings operated using Chinese settings, then an additional 10% energy would be saved (Feng et al 2014).

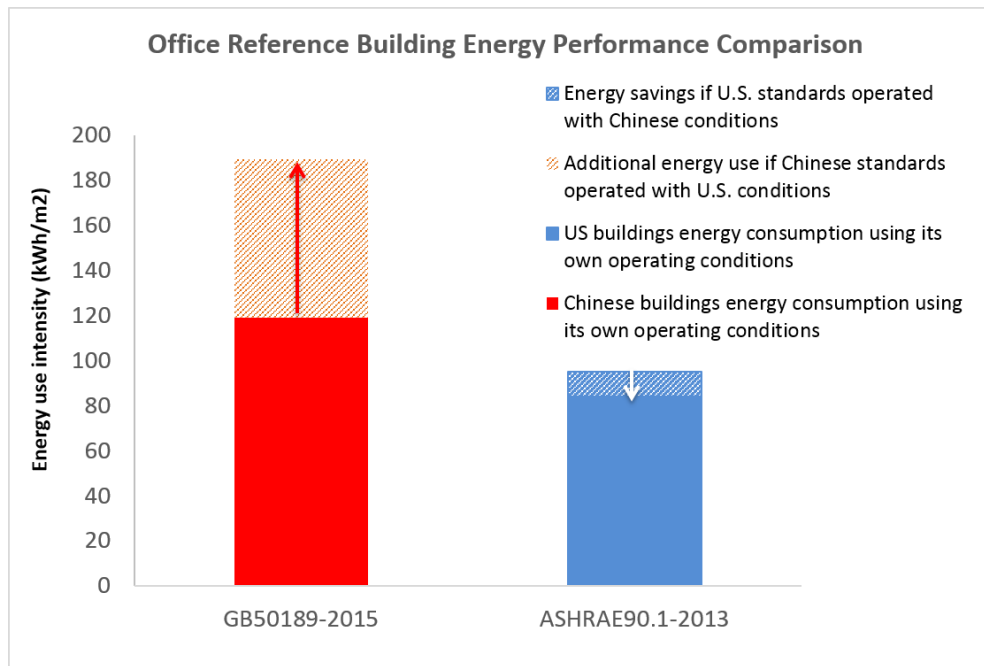


Figure 1. Comparison of performance prescribed by Chinese and U.S. commercial building energy codes (Feng et al 2014)

<sup>1</sup> JGJ-26, cold and severe cold; JGJ-75, hot summer and warm winter; JGJ-134, hot summer and cold winter

<sup>2</sup> The ASHRAE 90.1 estimated building performance is based on a study of office buildings built in accordance with the Department of Energy code program. Both China and the U.S. buildings here include major regulated end use such as lighting, heating, ventilation and air-conditioning (HVAC), plug load, water heating. However, Chinese codes and standards often only include lighting and HVAC for performance evaluation.

## 2.2 Compliance process

The effectiveness of building energy codes depends on the level of compliance, which requires rigorous monitoring, verification and enforcement. Penalties should include stopping construction, withholding permits, and levying fines. Compliance and enforcement procedures need to be transparent and well documented to ensure that all stakeholders are fully aware of requirements and implications for non-compliance. International best practices show that the use of code compliance software (e.g. REScheck or COMcheck in the U.S.) simplifies the task of evaluating designs to assure code compliance. In addition, it is best practice for individuals completing this task to have received trainings and registration (e.g. building assessor registration in Portugal and Denmark).

In China, energy efficiency codes for new buildings are supervised and enforced through regular inspections of new construction during the project approval process and random inspections of completed projects. Regular inspections for new construction follow a “loop system” that includes four separate phases of administrative review and licensing (Levine et al 2012). Finished projects that fail to comply with the standards are considered illegal construction that cannot be sold or occupied until shortcomings are addressed. In addition, the government also introduced in 2007 other penalties for noncompliance that include revocation of licenses, imposition of fines, and requirements to correct noncompliant buildings or building components.

According to China’s Ministry of Housing and Urban-Rural Development (MOHURD), compliance rates have dramatically improved and held steady over the last 15 years (Figure 2). Independent city-level inspections have confirmed the high compliance rates reported by MOHURD (Evans, Shui, Halverson & Delgado 2010). However, this assessment of compliance does not include two components: 1) smaller cities and rural areas and 2) post-construction phase.

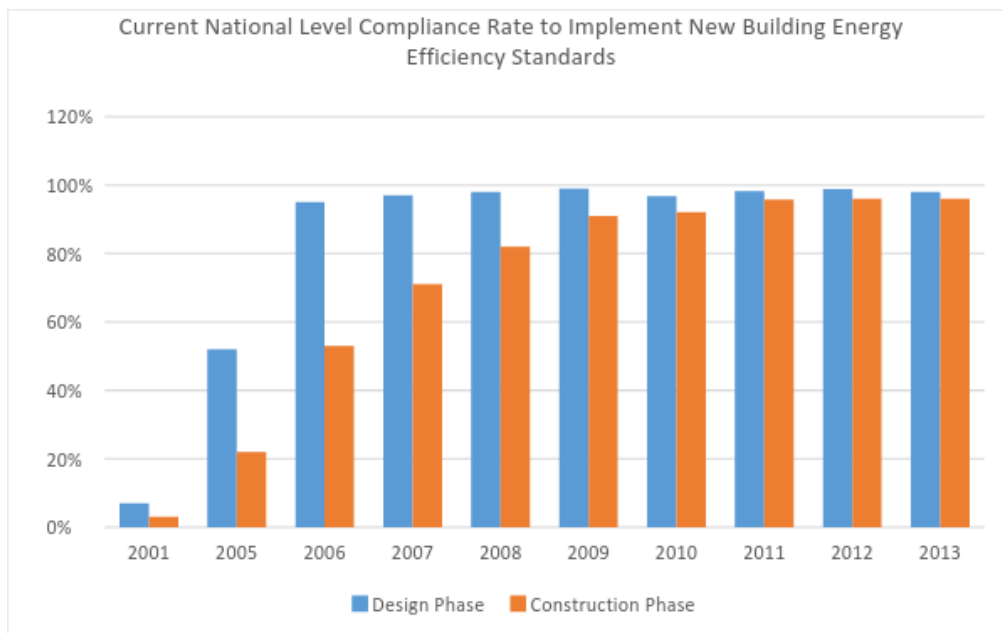


Figure 2. National Level Building Codes Compliance Rate in China (source: China Association for Building Energy Efficiency)

Evidence suggests that compliance for these two components are low. Enforcement entities in smaller cities often struggle to enforce codes due to a lack of staff, lack of expertise in building energy efficiency, and reliance on paper documents rather than digital files. In addition, mayors of smaller cities can be challenged by a sometimes-conflicting interest of attracting real estate developers and enforcing stringent energy codes. Finally, developers and their representatives often organize post-construction inspection with little to no government oversight.

### 2.3 Industry readiness

A well functioning codes program enables industry to develop technologies and building designs that comply with more stringent regulation at low incremental cost, often through maximizing economies of scale. The key is to define a set of national targets for codes and standards coupled with outreach or collaboration with key stakeholders. For example, some countries in the European Union have established a series of targets over time that reach net zero energy by 2020 or later. In addition, the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) provides a platform for U.S. industry to have a continuous influence on their energy code development.

In China it can be difficult for industry to predict when codes will be updated and to what degree. When MOHURD decides it is time for a code revision, it initiates a multi-stakeholder process to conduct research (e.g. cost-benefit analysis) and develop a revision plan (Figure 3). The China Academy of Building Research (CABR) is the technical lead in this process. CABR organizes a code revision committee that consists of experts from universities, local building research institutes, design institutes, developers, and building technology companies. Each code upgrade process takes approximately three years to complete the research, issue a draft for public comment, conduct a technical committee review, and receive final approval by MOHURD.

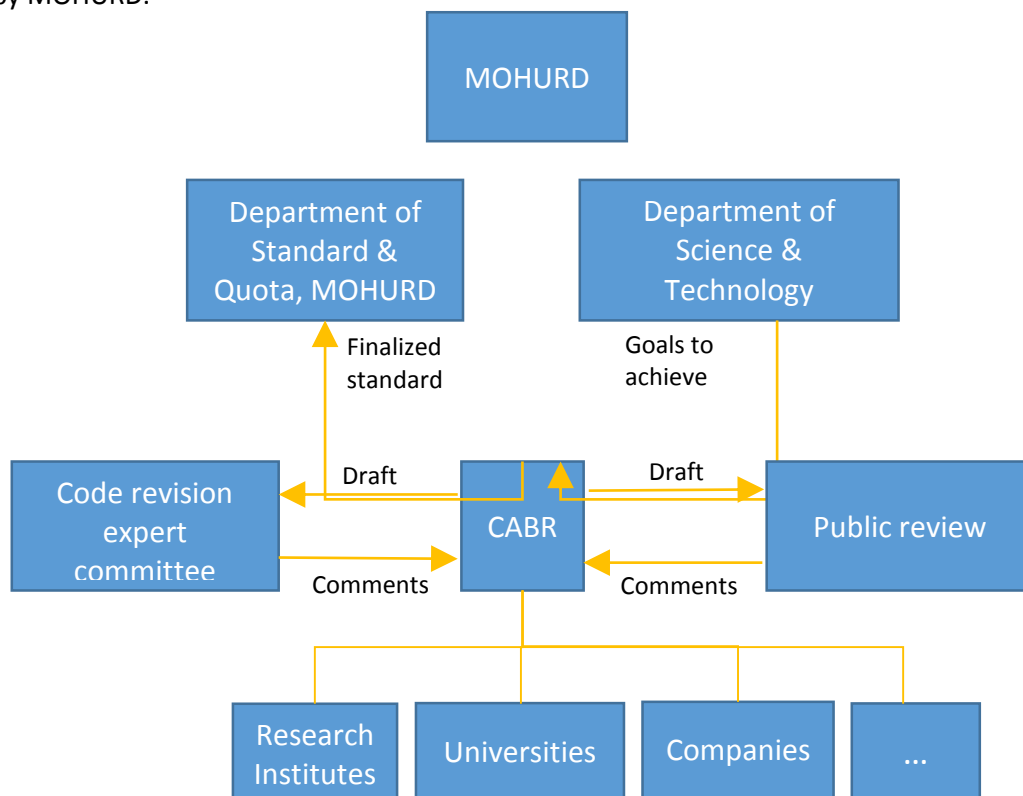


Figure 3. China national level code development process

There is currently no platform for industry in China to be continuously involved in the code development process. Stakeholder engagement only happens when the code is being revised. Usually there is a six-month preparation period between MOHURD approving a new code and the code finally becoming effective. This preparation period is used to train local MOHURD enforcement staff, real estate developers, and other members of industry to prepare for the new upgrade.

## **2.4 Ratings and labels**

Rating and labeling of actual building performance brings market forces to bear to reward buildings performing beyond code and create market pressure to upgrade underperforming buildings.<sup>3</sup> Ratings and labels often track the performance of buildings as they operate, which may differ from the performance that was intended in the design and construction, and therefore serve an important role in keeping building energy use low. Finally, governments that require high performance labeled buildings for their own use drives market value and adoption.

Best practice certification schemes come in many varieties. They can be mandatory or voluntary, offer recommendations on how to improve performance or simply state performance levels, and can involve mandatory disclosure to the public or be confidential for reference by the building owner. The European Performance Building Directive (EPBD) is a mandatory scheme that also includes recommendations on how to cost-effectively improve the building's energy performance (Levine et al 2012). The National Australian Built Environment Rating System (NABERS) is a voluntary scheme that provides a straightforward and credible standard to communicate a rating. The government of Ireland has a National Administration System (NAS) that enables statistical analysis of energy use and the development of benchmarks for existing buildings. For each example above, buildings above a certain size threshold must disclose their certified energy performance to relevant parties upon sale or lease.

Ratings and labeling is fairly new in China and consists of two domestic programs, the Green Building Evaluation and Labeling (GBEL) Program and the Building Energy Efficiency Evaluation and Labeling (BEEL) program, both of which were established by MOHURD in 2008. GBEL is a voluntary program consisting of a green building design label (GBDL) and the green building label (GBL) for building operations. The GBDL rates buildings on a scale of one to three stars in terms of energy efficiency, land use, water efficiency, construction material resource efficiency, indoor environmental quality, and operational management. BEEL is an energy efficiency focused program, is very similar with the concept of "Asset Rating" used in the U.S., and is mandatory for buildings that apply for GBEL. Chinese projects have also used the international and voluntary Leadership in Energy and Environmental Design (LEED) green building rating system, which certifies and rates projects as silver, gold, or platinum based on evaluation criteria that are similar to the categories in the Three-Star GBL.

Chinese labeling faces challenges that are common to nascent programs, including the lack of expertise in building energy performance evaluation and subsequent high costs, as well as challenges resulting from a lack of oversight. The BEEL is based on modeling energy performance rating, which is complex and only a small number of highly experienced experts are able to use the software. This has led to high costs which hamper voluntary participation and result in most pilot projects being demonstration projects funded by national government incentives (Mo, Burt, Hao, Cheng, Burr, & Kemkar, 2010). The program also faces ambiguity regarding how to integrate the measured BEEL rating with the theoretical GBEL star rating. Measured rating is more costly than theoretical rating and as a result faces low uptake, as there is no incentive for developers and building owners to pay extra (Mo, Burt, Hao, Cheng, Burr, & Kemkar, 2010).

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<sup>3</sup> Lower utility bills and sometimes better comfort largely drive the value of high performance buildings for occupants.

Moreover, the current GBEL system involves experts who act as developers of the GBEL, oversee compliance, and designers who consult on project design. This lack of third-party oversight has likely hampered the adoption rate of GBEL.

Governments that require their occupied buildings to be rated above code performance help drive demand and can ultimately create value for those labeled buildings. In the U.S. the passage in March 2015 of Executive Order 13693 to accelerate federal sustainability targets, the Energy Efficiency Improvement Act of 2015 in April, and the Clean Power Plan in August are causing federal agencies to target larger energy reductions and install more renewable energy resources in their buildings, even aiming for net-zero energy.<sup>4</sup> Governments leading by example can drive demand for buildings that perform beyond code, and as a result can increase their value, ultimately catalyzing greater adoption and resulting energy savings. In China, the 12th Five Year Plan has requirements that 80% of new large government buildings will need to have GBEL rating and many cities have more aggressive targets.

## 2.5 Supporting programs

Despite the potential for cost effective energy savings, numerous barriers impede building owners from making investments in efficiency beyond what is required by code. At the root of many of these barriers is the higher upfront cost. Therefore, financial incentives in the form of direct payments (e.g., rebates) or low-cost financing can play a key role in driving homeowners and businesses to invest in energy efficiency.

A few countries directly tie such incentives to the achievement of certain levels designated building certification schemes. In the U.S., a number of incentives offered by states and cities encourage building owners to achieve certification. The state of Connecticut, for example, offers a “green building tax credit” which provides a tax incentive for building owners and developers of certain commercial properties that meet or exceed the LEED gold certification standard.<sup>5</sup> Another example is the Kreditanstalt für Wiederaufbau (KfW) program in Germany, which provides low-interest loans and grants for construction and renovation projects that meet certification ratings beyond code performance.

While China has implemented one of the largest incentive programs in the world to transform the market for air conditioners (de la Rue du Can 2015)—spending USD1.85 billion over 18 months in manufacturers subsidies to help pass a more stringent standard—no major national incentive program exists to support the financing of high performance building construction. A few economic incentives have been implemented to support fixed asset investment and the production and use of new wall materials (Li and Shui 2015). However, the national government has transferred grants to large cities only. In 2011, 40 cities were selected to receive a national retrofit subsidy of 20 Yuan (USD 3) per m<sup>2</sup> to meet more stringent 20% and 30% energy-intensity reduction targets for their government and large commercial buildings, respectively (Levine et al 2012). The central government is also supporting the construction of green eco-cities and eco-districts with total funding allocation of 50 million Yuan (USD 8 million), which is insufficient to make material impact. More recently, the Ministry of Finance and MOHURD have announced financial incentives for qualifying GBEL Two-Star and Three-Star rated green buildings. While these schemes are very encouraging, little information is yet available on their uptake and their general efficacy.

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[http://blog.rmi.org/blog\\_2015\\_10\\_08\\_2015\\_energy\\_exchange\\_taking\\_energy\\_retrofits\\_further\\_with\\_the\\_federal\\_government](http://blog.rmi.org/blog_2015_10_08_2015_energy_exchange_taking_energy_retrofits_further_with_the_federal_government)

<sup>5</sup> <https://www.cga.ct.gov/2015/rpt/pdf/2015-R-0061.pdf>

### 3. Recommendations

#### 3.1 Coverage and stringency

##### 3.1.1 Provide a long-term roadmap

To further increase codes stringency, the government should set a long-term roadmap to define targets, pathways, key policies and timelines. A long-term roadmap will guide future building codes updates and help set up targets. Developing a long-term energy efficiency roadmap will contribute to regulating future energy consumption in buildings. Also, a long-term view would provide signals to industry to ensure readiness at an economical cost, and to better inform enforcement and compliance entities.

MOHURD is developing a 2030 building energy efficiency roadmap to further reduce building energy use. Under MOHURD's direction, CABR developed a draft roadmap that indicates future code upgrades every 5 years (Figure 4). Such a roadmap should be adopted and enforced by the legal system. Potential areas for improving the roadmap include: making the baseline relevant to international best practice (e.g. ASHRAE standards), enhancing stringency, and specifying a code that is based on the real performance (i.e. the outcome).

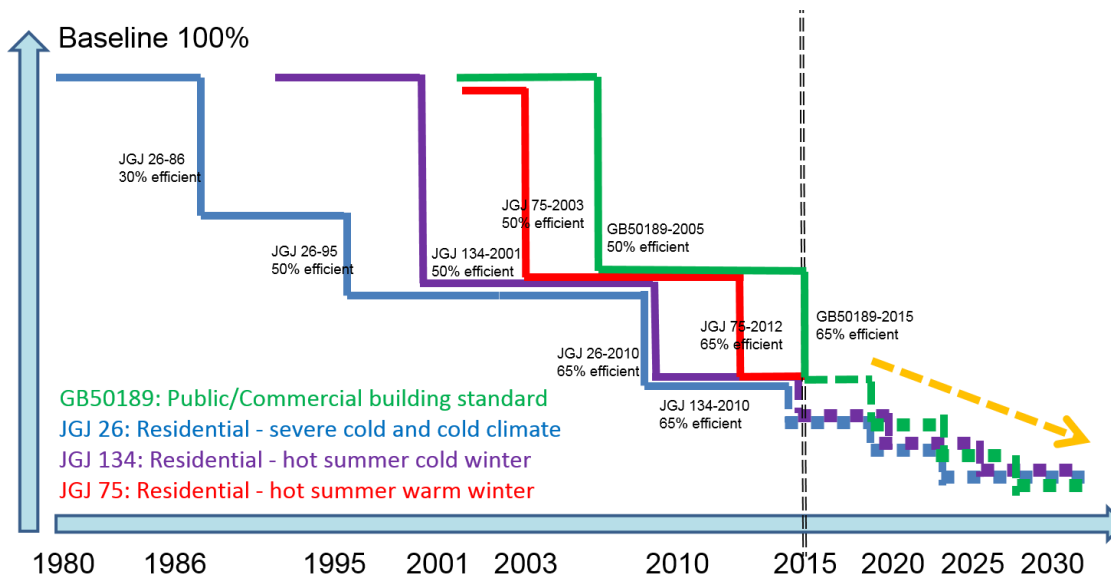


Figure 4. A preliminary roadmap on commercial and residential buildings with a 5-year upgrade cycle (source: CABR)

##### 3.1.2 Increase funding to support development and management of building codes

To further develop and manage building codes in China, more quantitative research to indicate the potential for stringency improvement is needed. These studies would include cost-benefit analyses tailored for specific economic regions as well as research into the implications for meeting economic and environmental goals. Continuous and substantial funding should be provided, with the ultimate intent of setting up long-term targets such as reaching to “net or nearly zero energy buildings.” The U.S. Department of Energy (DOE) has established a building code program to support code research, development, and compliance. Such a dedicated national level code program providing continuous support has proven to be very effective.

## **3.2 Compliance process**

### **3.2.1 Mandate post-construction inspection and reporting by government or independent third parties, not developer self-reporting**

Post-construction compliance is often reported by building developer and representative companies. Instead, mandatory post construction inspection should be enforced by government agencies or quasi-governmental third parties. Post-construction compliance should also be required before permits are issued to occupy and operate the buildings.

### **3.2.2 Improve competency and independence of compliance and enforcement staff**

Enforcement agents benefit from having a fundamental understanding of building energy efficiency when conducting compliance checks and enforcing codes. Some countries develop trainings accredited by a central body, which regularly carries out quality assurance procedures. In addition, it may be helpful to introduce third party certified enforcement personnel into the enforcement process to help reduce cost and increase efficiency. This creates an independent enforcement team and expands the market to include third party for-profit compliance companies.

### **3.2.3 Develop software tools and guidelines for more scientific and comprehensive compliance procedure**

China building codes and standards need to strengthen the specificity of whole building performance compliance procedures and provide detailed modeling guidelines. The U.S.-based organizations ASHRAE and COMNET offer good examples of standards and guidelines. More limited performance-based approaches utilize simplified software tools for demonstrating performance trade-offs between major energy-using systems and are also very important. In the U.S. COMcheck and REScheck are well-developed commercial and residential building compliance check software that support ASHRAE 90.1 and IECC respectively. The availability of similar software tools with proper trainings to workforce in China would greatly facilitate the compliance checking and enforcement process. Digitizing building information and enforcement is also very important to enhance the workflow of enforcement and increase transparency.

### **3.2.4 Increase capacity for smaller cities**

The above-mentioned recommendations should be prioritized for smaller cities where improved compliance and enforcement procedures are needed most.

## **3.3 Industry readiness**

It is important to involve key stakeholders from government entities, industries, research institutes, building developers, utilities, and NGOs in the code development process. Setting up a professional society (e.g. ASHRAE) or equivalent organization enables stakeholders to discuss code upgrades and research more regularly. This will also facilitate the communication of lessons stakeholders learned in their code development and implementation process and help future code development.

## **3.4 Ratings and labels**

### **3.4.1 Promote the use of ratings and labels**

The current rating scheme in China needs to become more widely adopted and effective at clarifying energy reduction opportunities. This can be accomplished through driving down the costs of certification through workforce capacity building and identifying common cost-effective energy efficiency measures for owners to consider. Developing pilot projects to mandatorily apply building energy labels and disclose their



energy performance can be helpful to enhance the penetration building energy labels. Finally, third party evaluation (e.g. such as what LEED uses) that can guarantee quality control should also build confidence in the label and promote its use.

#### 3.4.2 Enable market to value building energy performance

Building energy data are not in the public domain, and as a result cannot be properly taken into account during the building investment and appraisal process. Market awareness and performance disclosure programs are needed to develop so that the value of investing in energy efficiency is well understood. The information collected from rating and labeling programs can be stored in a central database that can then be used to benchmark performance of buildings and incentivize market agents to improve how the performance of their building compares to peers.

#### 3.4.3 Government can lead by example to drive market value

Various levels of China's government can lead by example by setting even more aggressive targets for their occupied buildings, and commit to achieving this top tier performance in both owned and leased space.

### **3.5 Incentive programs**

#### 3.5.1 Evaluate alternative incentive schemes

For many countries, there is a question of what types of incentives drive most energy savings in buildings at least cost. It is important to diligently and continuously evaluate incentive schemes and compare them with one another to inform future efforts. Internationally, it is rather common to set aside 2–4% of the program funding on evaluation, both prior to initiation of the program to identify the impact and after the program completion to evaluate the effectiveness (Zhou 2012). What is also important is that before an incentive program is made, to conduct comprehensive research to design an incentive program properly to define how the incentive flow, who will be benefited what market segment the incentive program is going to affect. Post evaluation of a previous incentive program can also provide useful guidance for developing future incentive programs.

#### 3.5.2 Pilot new and innovative incentive programs

In order to continue to evolve the portfolio of financial incentives, some innovative best practice approaches should be piloted. Innovative strategies can span financing energy efficiency technologies, providing tax rebates, and offering subsidies. For example, in the European Union, a broad array of incentives are deployed, evaluated, and evolved with each passing year (Levine et al 2012).

Table 1. Summary of gap analysis and recommendations.

<b>Program Dimensions</b>	<b>Gap Analysis</b>	<b>Recommendations</b>
Coverage and stringency	Buildings codes in China covers residential and commercial buildings in climate zones across the nation. However, the current building codes are not as stringent as international best practice—new code-compliant Chinese buildings could use up to 80% more energy than those in the U.S.	<ul style="list-style-type: none"> <li>● Provide a long-term roadmap for code stringency</li> <li>● Increase funding to support development and management of building code (including a national level program dedicated to codes)</li> </ul>
Compliance process	Compliance rate for design and during construction is high in larger cities but likely much less in smaller cities. For both large and small cities, the post-construction phase of the enforcement process is not enforced by the government.	<ul style="list-style-type: none"> <li>● Mandate post-construction inspection and reporting by government or independent third parties, not developer self-reporting</li> <li>● Increase regulatory capacity for smaller cities</li> <li>● Improve competency and independence of compliance and enforcement staff</li> <li>● Develop software tools and guidelines for more scientific and comprehensive compliance procedure</li> </ul>
Industry readiness	It can be difficult for the industry to predict when the codes will be updated and to what degree.	<ul style="list-style-type: none"> <li>● Create a platform for stakeholder engagement</li> </ul>
Ratings and Labels	Certification schemes are voluntary and would benefit from energy performance protocols that are easily accessible and standardized.	<ul style="list-style-type: none"> <li>● Promote the use of building performance certification programs (including pilot disclosure programs)</li> <li>● Enable market to value building energy performance</li> <li>● Government can lead by example to help drive market value of efficient buildings</li> </ul>
Incentive programs	Some incentive programs have recently been implemented but their efficacy has not yet been assessed nor evaluated.	<ul style="list-style-type: none"> <li>● Set aside specific funding to research the most effective mechanism for the design of the incentive programs in order to evaluate the incentive schemes</li> <li>● Pilot new and innovative incentive programs</li> </ul>

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**Abbreviation:**

ASHRAE: American Society of Heating Refrigerating and Air-conditioning Engineer

IECC: International Energy Conservation Code

MOHURD: Ministry Of Housing and Urban Rural Development

CABEE: China Association of Building Energy Efficiency