Applicability of Building Energy Codes in Emerging Asian Countries: The case of China

Second “Policy Meets Research” Workshop
Sustainable Housing
Helsinki, March 2012

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IGES
IGES energy efficient building projects
Objectives

- Understand **drivers, trends** in EEH, and review existing policies and opportunities;

- Identify **systemic and infrastructural barriers** to stakeholder participation;

- Provide **policy recommendations** for governments and agencies engaged in the sector on how to remove these barriers and how to provide incentives towards sustainable EEH;
stakeholder analysis

Macro factors

Economy, geography, demography, technology, etc

Triple I

Interest, influence, Instruments

Actor

Impacts

Environmental, Social, Economic

Akenji and Bengtsson, 2009
IGES framework: SCP and sustainable housing

- Education
- Lifestyles
- Agency
- Labelling systems

Values, Knowledge

- Right stakeholder attitude

Facilitating System
(cultural, legal, administrative…)

Incentives, Constrains

- Building codes
  - Regulation
- Standards
  - Economic
- Incentives

Appropriate Infrastructure

Bldgs, appliances, Services

- Sustainable buildings
  - Appliances use
  - Energy carriers

Akenji, 2010
## Preconditions for SCP (e.g. housing)

<table>
<thead>
<tr>
<th>Key condition</th>
<th>(Other related details)</th>
<th>Facilitators/determinants</th>
<th>examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right stakeholder attitude</td>
<td>(mindware – relates to individual and personal aspects) Stakeholders: individuals (as citizens and actors in various sectors – e.g. business leaders)</td>
<td>Education Lifestyles Agency</td>
<td>Values Knowledge</td>
</tr>
</tbody>
</table>
● Scope
  ● urban, residential buildings

● Focus countries:
  ● China (Beijing, Xiamen)
  ● India (Delhi and Bangalore)

● Control countries
  ● Indonesia
  ● Thailand

● Activities
  ● Reviews
  ● Surveys/Interviews
  ● Facilitated Workshops
  ● Pilot projects
China and building energy consumption - the big picture
China’s Economy in Comparison with some others

<table>
<thead>
<tr>
<th>Countries</th>
<th>China</th>
<th>India</th>
<th>Japan</th>
<th>US</th>
<th>EU-27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>100</td>
<td>87.5</td>
<td>9.5</td>
<td>23.1</td>
<td>37.5</td>
</tr>
<tr>
<td>Land Area</td>
<td>100</td>
<td>31.9</td>
<td>3.9</td>
<td>98.1</td>
<td>46.4</td>
</tr>
<tr>
<td>Population Density</td>
<td>100</td>
<td>244.5</td>
<td>243.7</td>
<td>23.5</td>
<td>80.9</td>
</tr>
<tr>
<td>GDP (current US$)</td>
<td>100</td>
<td>29.1</td>
<td>92.1</td>
<td>246.1</td>
<td>273.7</td>
</tr>
<tr>
<td>GDP per capita (current US$)</td>
<td>100</td>
<td>33.3</td>
<td>967.3</td>
<td>1065.9</td>
<td>729.7</td>
</tr>
<tr>
<td>Urban population (%)</td>
<td>45%</td>
<td>30%</td>
<td>67%</td>
<td>82%</td>
<td>74%</td>
</tr>
</tbody>
</table>

Data Source: Calculated based on the Data of World Bank 2010

- In 2010, China became the second biggest economy in the world, just behind the US. And its GDP (5.93 Trillion US$) in 2010 is about **37% of that of EU-27**;

- However, China’s per capita GDP is still very low (4428 US$), around 1/10 of that of US and Japan, and around **1/7 of that of EU-27**;

- Although China is undergoing rapid urbanization, however, China’s urban population share is **only 45%**, compared to 82% in the US and 74% in the EU-27;
## China’s Energy Consumption in 2009

<table>
<thead>
<tr>
<th>Countries</th>
<th>World</th>
<th>China</th>
<th>India</th>
<th>Japan</th>
<th>US</th>
<th>EU-27</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPES (Mtoe)</td>
<td>12150</td>
<td>2257</td>
<td>676</td>
<td>472</td>
<td>2163</td>
<td>1656</td>
</tr>
<tr>
<td>Net Imports/ TPES</td>
<td>0%</td>
<td>12%</td>
<td>27%</td>
<td>81%</td>
<td>26%</td>
<td>57%</td>
</tr>
<tr>
<td>Electricity Consumption (EC) (TWh)</td>
<td>18451</td>
<td>3503</td>
<td>689</td>
<td>997</td>
<td>3961</td>
<td>3037</td>
</tr>
<tr>
<td>CO₂ Emission (Mt)</td>
<td>28999</td>
<td>6831</td>
<td>1586</td>
<td>1093</td>
<td>5195</td>
<td>3577</td>
</tr>
<tr>
<td>TPES/ population (toe/capita)</td>
<td>1.80</td>
<td>1.70</td>
<td>0.58</td>
<td>3.71</td>
<td>7.03</td>
<td>3.31</td>
</tr>
<tr>
<td>EC/population (kWh/capita)</td>
<td>2729</td>
<td>2631</td>
<td>597</td>
<td>7833</td>
<td>12884</td>
<td>6070</td>
</tr>
<tr>
<td>CO₂ Emission/population (t CO/capita)</td>
<td>4.29</td>
<td>5.13</td>
<td>1.37</td>
<td>8.58</td>
<td>16.90</td>
<td>7.15</td>
</tr>
<tr>
<td>TPES/GDP (toe/ thousand 2000 US$)</td>
<td>0.31</td>
<td>0.77</td>
<td>0.77</td>
<td>0.10</td>
<td>0.19</td>
<td>0.17</td>
</tr>
</tbody>
</table>

- China is the biggest energy consumption country (18.6% of global total) and the biggest GHGs emitter (23.6%) - 2009;

- However, per capita TPES (1.7 toe/capita) is still below world average - around ¼ of US, and ½ of that in the EU-27;

- Per capita electricity consumption is around 1/5 of US, and 43% of EU-27;

- high energy intensity (EI) of 0.77 - about 8 times of Japan’s, 4 times of US’ and 4.5 times of the EU-27’s;

Source: IEA 2009
## % Energy Consumption by Sectors

<table>
<thead>
<tr>
<th>Sector Share</th>
<th>China</th>
<th>US</th>
<th>Japan</th>
<th>Germ’y</th>
<th>France</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>28.3</td>
<td>32.0</td>
<td>35.5</td>
<td>42.4</td>
<td>40.7</td>
<td>41.0</td>
</tr>
<tr>
<td>Industry</td>
<td>47.4</td>
<td>17.7</td>
<td>26.2</td>
<td>21.4</td>
<td>17.2</td>
<td>19.5</td>
</tr>
<tr>
<td>Transportation</td>
<td>11.2</td>
<td>39.5</td>
<td>24.3</td>
<td>24.1</td>
<td>27.7</td>
<td>31.6</td>
</tr>
<tr>
<td>Others</td>
<td>13.1</td>
<td>10.8</td>
<td>14.0</td>
<td>12.1</td>
<td>14.4</td>
<td>7.9</td>
</tr>
</tbody>
</table>

Source: based on the Data of IEA 2009

- Building sector is the biggest energy consumer in many developed countries
- In 2009, China’s total building energy consumption (405 Mtoe), was bigger than total energy consumption of Germany and France
New, demanding buildings

- In 2009, newly constructed buildings had a total area of 2. billion m²;

- From 2001 to 2009, the average growth rate of new constructed building areas is 12.2% yearly;

![Graph showing the total building stock of China's urban residential sector from 1996 to 2007.](image)

![Graph showing the building energy increase from 1996 to 2006.](image)
Structure of China’s Energy Consumption (2009)

- coal: 70.40%
- oil: 17.90%
- gas: 3.90%
- electricity (nuclear, hydro, wind): 7.80%

Decoupling Challenge

China's GDP and TEC Growth (2000-2008)

- 10.5% GDP yearly growth;
- vs
- TEC 11.6% yearly growth

expect more...

Per capita energy use in res. & comm. Bldgs
Building Energy Codes in China
Quick code facts…

- 1 design standard for public buildings
- 3 “design standards” for residential buildings
- Cover building envelope and HVAC
- (Separate standard for lighting design)
- Two options for compliance:
  - Prescriptive path (specifications for building components)
  - Performance path (energy consumption benchmarked to reference building)
- Prioritization:
  - Residential > public buildings
  - Northern > Southern area
  - New > existing bldgs
China’s Climate Zones for Buildings

**Cold & Severe Cold:**
- .550 million people,
- .43% of urban res. & comm. bldgs

**HSCW:**
- .500 million people in,
- .42% of urban res. & comm. bldgs

**HSWW:**
- .160 million people
- .12% of urban res. & comm. bldgs
# Criteria of China’s Building Climate Zones

<table>
<thead>
<tr>
<th>Zone Name</th>
<th>Criteria</th>
<th>Requirements for Building Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sever Cold</strong></td>
<td>Average temperature of coldest month ≤-10°C</td>
<td>Design for heating is a must; Design for cooling not required</td>
</tr>
<tr>
<td></td>
<td>Days of averagely daily temperature ≤5°C: ≥145 days</td>
<td></td>
</tr>
<tr>
<td><strong>Cold</strong></td>
<td>Average temperature of coldest month 0~10°C</td>
<td>Design for heating is a must; Design for cooling can be required in some areas</td>
</tr>
<tr>
<td></td>
<td>Days of averagely daily temperature ≤5°C: 90~145 days</td>
<td></td>
</tr>
<tr>
<td><strong>Hot Summer and Cold Winter</strong></td>
<td>Average temperature of coldest month 0<del>10°C; Average temperature of hottest month 25</del>30°C</td>
<td>Design for cooling is a must; Design for heating can be required</td>
</tr>
<tr>
<td></td>
<td>Days of averagely daily temperature ≤5°C: 0<del>90 days; Days of averagely daily temperature ≥25°C: 40</del>110 days;</td>
<td></td>
</tr>
<tr>
<td><strong>Hot Summer and Warm Winter</strong></td>
<td>Average temperature of coldest month &gt;10°C; Average temperature of hottest month 25~30°C</td>
<td>Design for cooling is a must; Design for heating not required</td>
</tr>
<tr>
<td></td>
<td>Days of averagely daily temperature ≥25°C: 100~200 days;</td>
<td></td>
</tr>
<tr>
<td><strong>Temperate</strong></td>
<td>Average temperature of coldest month 0<del>13°C; Average temperature of hottest month 18</del>25°C</td>
<td>Design for heating should be required in some areas; Design for cooling not required</td>
</tr>
</tbody>
</table>
Progress of Building Energy Code in China (national level)

- **Residential Buildings:**
  - **For Northern Area:**
      
  
  - **For HSCW Area:**
      
      (2001 Code-Phase 2 Code:50%; 2001 Code-Phase 3 Code:65%)
  
  - **For HSWW Area:**
      
      (2003 Code-Phase 2 Code:50%)

- **Commercial Buildings:**

- **Long national code revision cycles (about 10 years);**
- **Provinces can issue own codes, but must be stricter than current national code;**
- **Beijing will issue its new code in 2012 Code (75% energy saving than 1980 level)**
## e.g.: National 2010 Northern code vs. Beijing 2012 Code

<table>
<thead>
<tr>
<th>Building Envelope</th>
<th>National Energy Code for Cold Area</th>
<th>Beijing Energy Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010</td>
<td>2006</td>
</tr>
<tr>
<td><strong>Exterior Walls</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 3 stories</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>4~8 stories</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>≥ 9 stories</td>
<td>0.70</td>
<td>0.60</td>
</tr>
<tr>
<td><strong>Roofs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 3 stories</td>
<td>0.35</td>
<td>0.45</td>
</tr>
<tr>
<td>4~8 stories</td>
<td>0.45</td>
<td>0.60</td>
</tr>
<tr>
<td>≥ 9 stories</td>
<td>0.45</td>
<td>0.60</td>
</tr>
<tr>
<td><strong>Windows (WWR&lt;0.4)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 3 stories</td>
<td>2.0</td>
<td>2.8</td>
</tr>
<tr>
<td>4~8 stories</td>
<td>2.5</td>
<td>2.8</td>
</tr>
<tr>
<td>≥ 9 stories</td>
<td>2.5</td>
<td>2.8</td>
</tr>
<tr>
<td><strong>Windows (WWR≥0.4)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 3 stories</td>
<td>1.8</td>
<td>2.8</td>
</tr>
<tr>
<td>4~8 stories</td>
<td>2.0</td>
<td>2.8</td>
</tr>
<tr>
<td>≥ 9 stories</td>
<td>2.3</td>
<td>2.8</td>
</tr>
</tbody>
</table>

2) 2012 code has not been issued yet, the related data are from the draft;
3) Beijing 2006 code has a different sorting for building envelope, but for convenience a little change is made here;

Beijing’s 2012 Code is stricter than national 2010 code on all the envelope performance (K value of windows, from 2.8 to 2.0);
Procedure
Key code enforcement steps in Chinese building Construction

Source: US DOE 2010
Construction site inspection roles

- **Construction Company**
  - Quality control system

- **Construction Supervision Company**
  - Checks work on site; orders tests; prepares documentation on compliance

- **Testing Labs**
  - Tests components from construction site

- **Quality Control and Testing Station**
  - Collects and reviews documentation; conducts periodic site inspections; prepares completion report

- **Developer**
  - Takes completion report to construction administration dept.

- **Construction Administration Dept.**
  - Accepts and files documents and issues occupancy permit

Source: US DOE 2010
Analysis
Implementation Effectiveness of Building Code

Administration:
- Ministry of Housing and Urban-Rural Development of China (MOHURD)
- Construction Commission in each province
- Construction Bureau in each city and county

Survey Results:

2000 MOHURD Survey in Northern Areas:
Share of Energy Efficiency Buildings in Urban areas: 2.3%;

2005 MOHURD Survey in whole country:
Shares of buildings meeting the in-place codes in Urban areas:
57.7% in design phase/ 23.8% in construction phase;

2009 MOHURD Survey in whole country:
Shares of buildings meeting the in-place codes in Urban areas:
99% in design phase/ 90% in construction phase;

(Data source: Center of Science and Technology of MOHURD)
Government efforts for improvement

- More Trainings held for engineers from design, construction, supervising and quality check companies or agents;

- More demo buildings built in cities across Chinese cities;

- More local implementation and regulatory details to explain to stakeholders at local level;
Challenges

- Weak monitoring mechanism
  - Limited expertise, funds, etc
  - Rapid new construction rate
- Hierarchical, unclear, overlapping structure of responsibilities
  - Complex construction process
  - Gap between design and implementation
- Legal enforcement of penalties
  - Hardly any penalties given
  - Inadequate training for judges
  - Corruption
- No enforcement in smaller towns and rural areas
- Unreliability of test lab results
  - No rigorous certification requirements
  - Low costs of tests
  - Faulty equipment
- Software difficulties
  - Inconsistent results
  - User errors from complexity
- Ineffectiveness
  - Public distrust in eco-labels
  - Rebound effects of increasing consumption
Challenges to Stakeholders in Building Sector of China

• Lack of reliable information on building energy performance in the building market for buyers;

• Lack of enough financing source and mechanism to support the retrofitting of huge stock of existing buildings;

• Lack of initiatives from local governments, particularly at the level of city governments;

• Weak economic (tax) incentives for building developers to build energy efficient buildings;

• Short-term view - for architects and engineers home owners
Thank you

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### Building Energy Code Progress in Beijing

<table>
<thead>
<tr>
<th></th>
<th>Average Heating Load during Heating Season (building end)</th>
<th>Efficiency of District Heating Systems</th>
<th>Average Heating Load during Heating Season (fuel end)</th>
<th>Energy Saving Control Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(w/m²)</td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
</tr>
<tr>
<td>Benchmark (1980 average level)</td>
<td>31.7</td>
<td>55</td>
<td>85</td>
<td>46.8</td>
</tr>
<tr>
<td>1988 Code</td>
<td>25.3</td>
<td>60</td>
<td>90</td>
<td>54.0</td>
</tr>
<tr>
<td>1997 Code</td>
<td>20.6</td>
<td>68</td>
<td>90</td>
<td>61.2</td>
</tr>
<tr>
<td>2006 Code</td>
<td>14.5</td>
<td>68</td>
<td>90</td>
<td>61.2</td>
</tr>
<tr>
<td>2012 Code*</td>
<td>10.5</td>
<td>68</td>
<td>93</td>
<td>63.2</td>
</tr>
</tbody>
</table>

Note: 1) 1988 Code (DBJ01-4-88); 1997 code (DBJ01-602-97); 2006 code(DBJ11-602-2006); 2012 code (DBJ11-602-2012); 2) 2012 code has not been issued yet, the related data are from the draft in November 2011; 3) The benchmark was based on the energy consumption of reference building, “80住2-4”, which is a 6-storey and 4 units residential buildings with a shape factor of 0.28;

- The 1988 code was designed to save 30% energy from the benchmark; 1997 code - 50% saving; 2006 code - 65% saving; the up-coming 2012 code – 75% saving;

- On the building end, the savings potential is around 20% for 1988 code; 35% for 1997 code; 55% for 2006 code; 65% for 2012 code;
Future Plan for Energy Efficient Buildings in China

- Setting up energy management system for government buildings and large-scale public buildings (>20,000 sq. meters), including energy consumption statistics, energy audit and dynamic monitoring for some designated buildings;

- Setting up the system of building energy performance labeling and public display;

- Setting up the system of Energy Saving Performance Contract (ESPC) and fostering Energy Service Company (ESCO) industry;

- Requiring each sub-national government to include building energy conservation into their goal of local EI decrease;

- Issuing mandatory green building criteria in some developed areas of China;

- Strengthening the R&D in new and high-performance building envelope materials;

- Promoting the integrated application of renewable energy in buildings, like PV, solar thermal for urban buildings and biogas for rural buildings;

(Data source: Center of Science and Technology of MOHURD)