



# **Low Carbon & Energy Buildings in China**

## **Current Situations, Policies, and Outlooks**

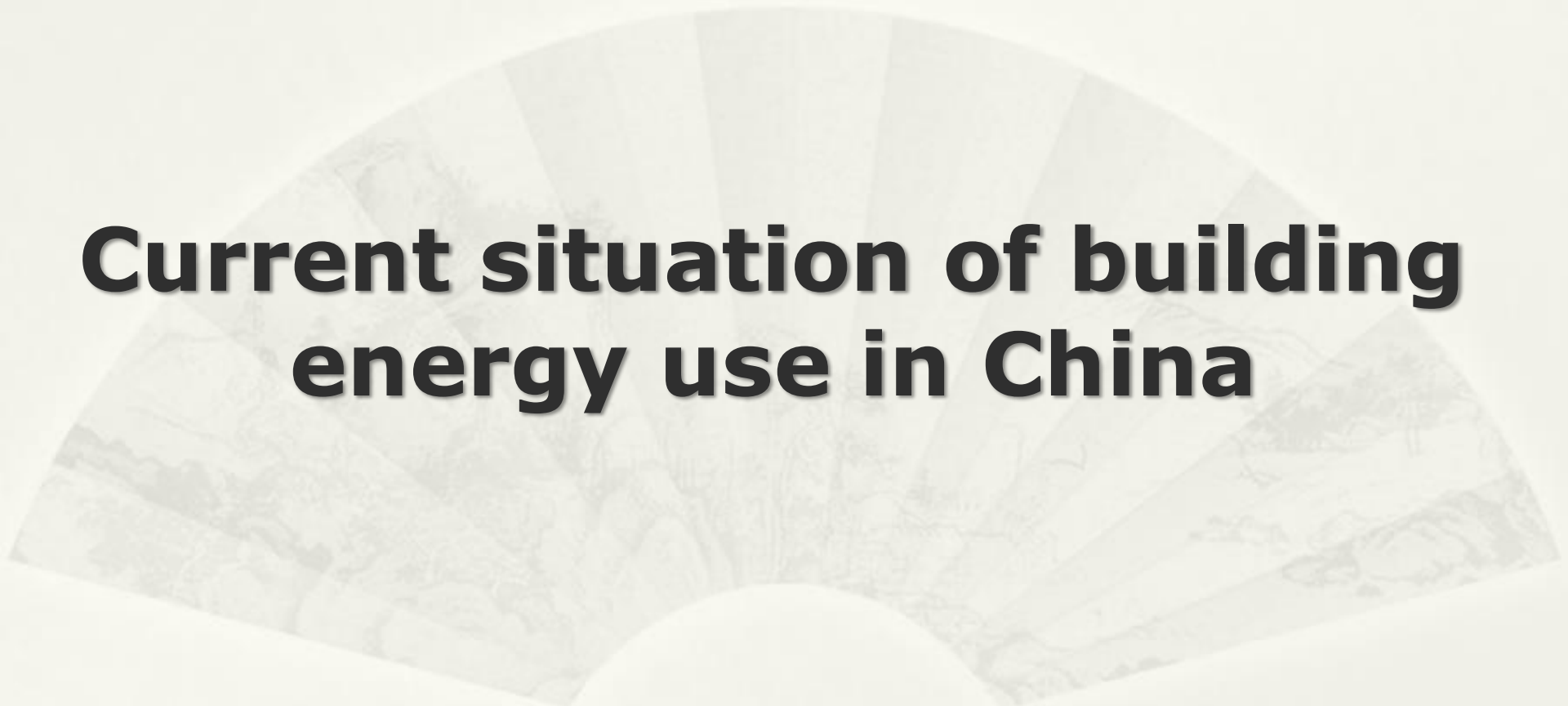
**Yingxin Zhu**  
**Professor, Vice-Dean**  
**School of Architecture**  
**Tsinghua University**

# Outline

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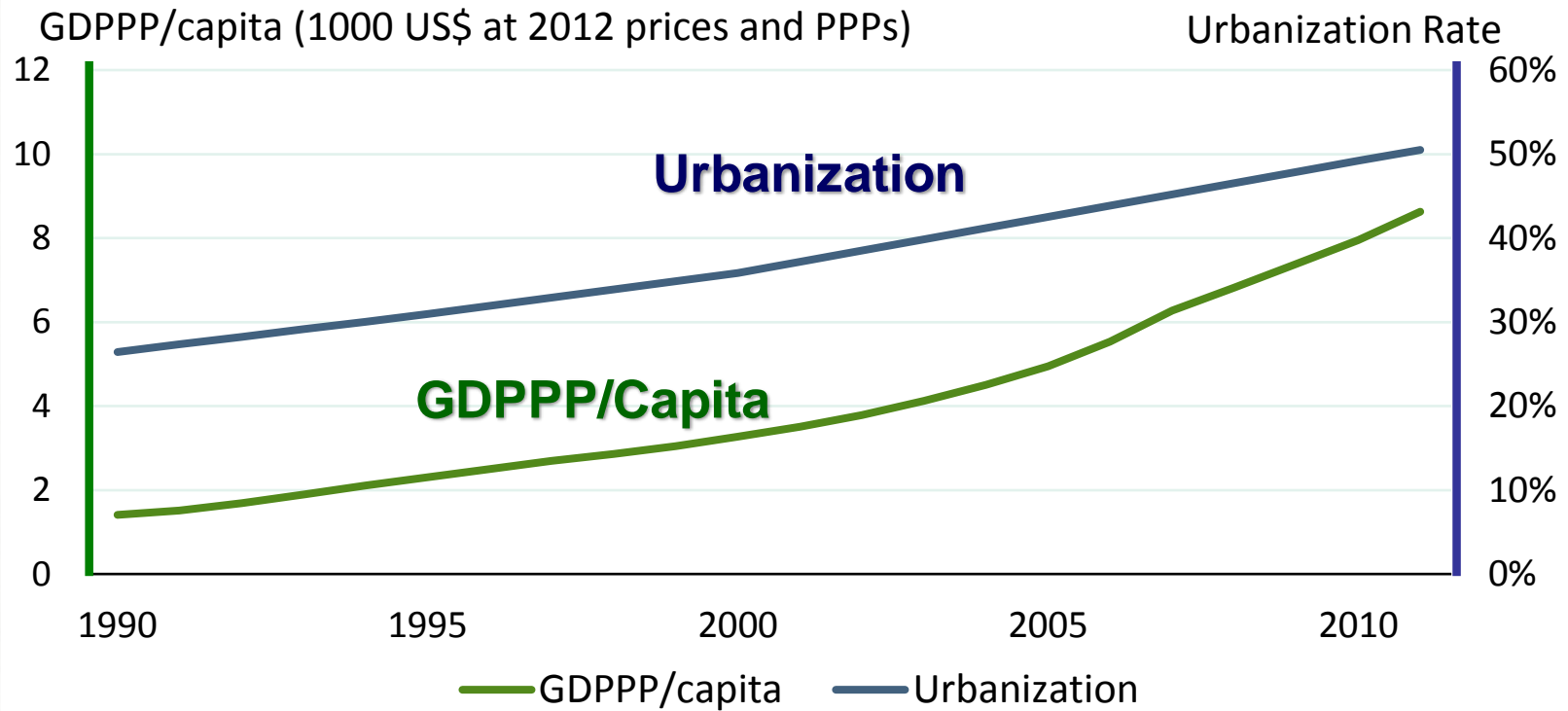
- \* **Current situation of building energy use in China**
- \* **Policies to lower building energy use & carbon emission in China**
- \* **Outlooks of building energy in China**

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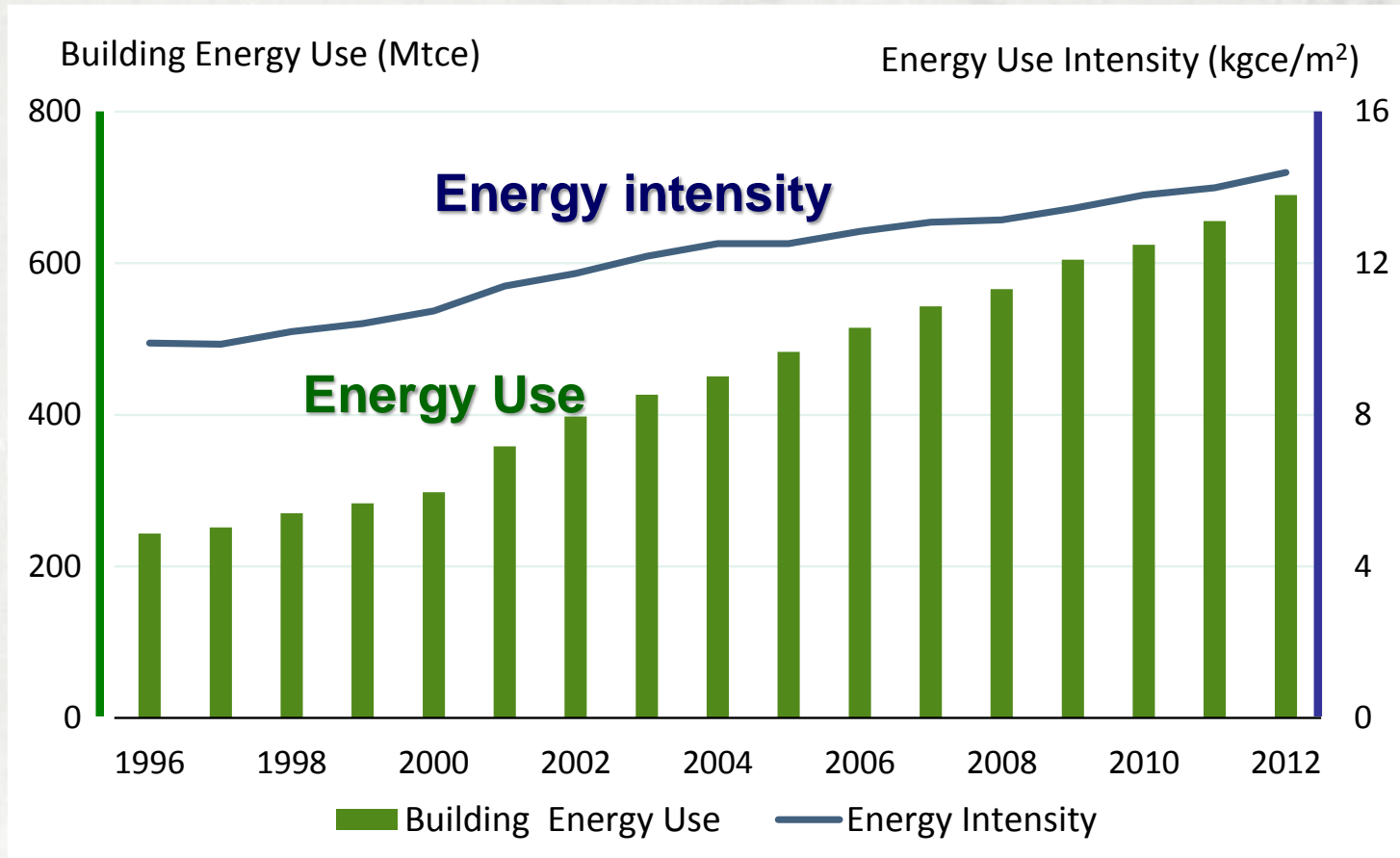


# **Current situation of building energy use in China**

# GDP and urbanization Growth in China

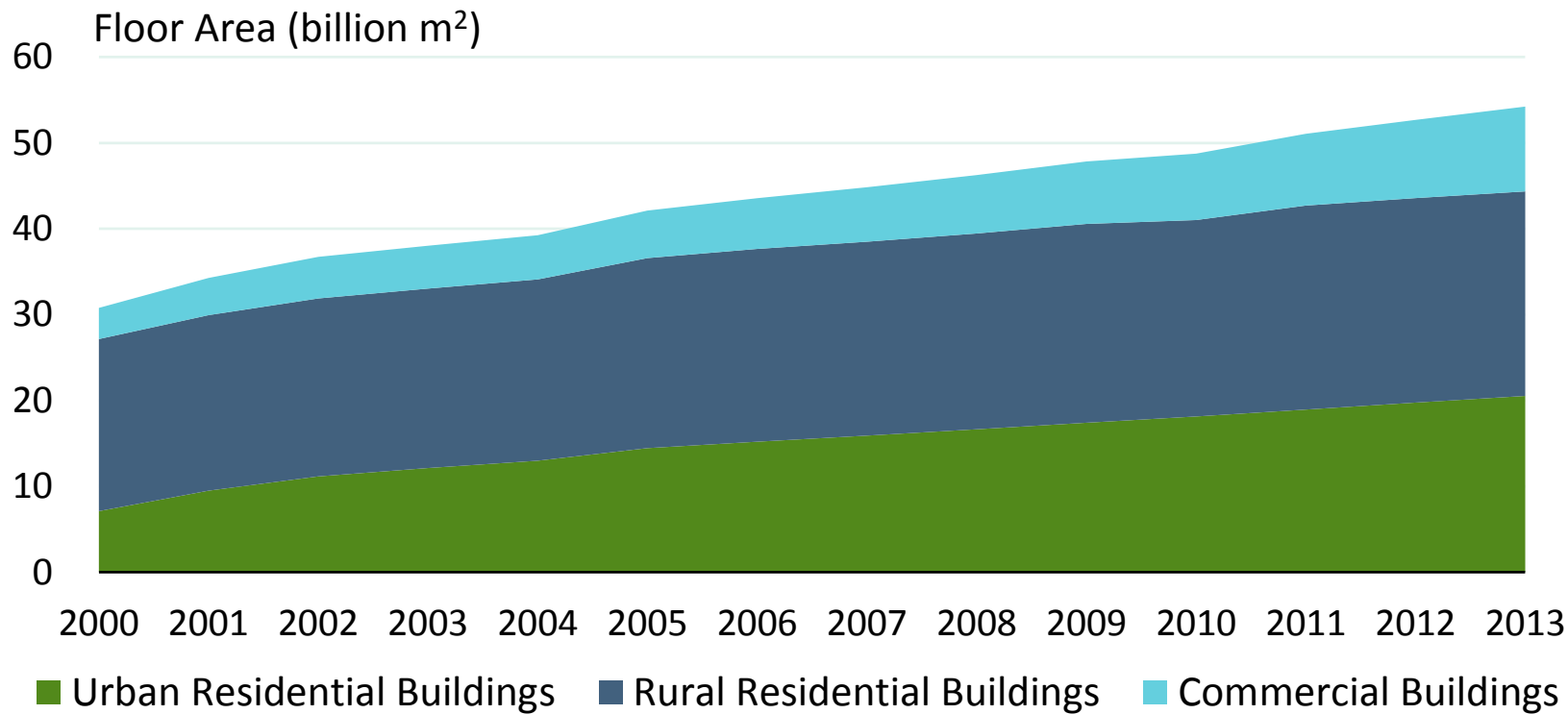


# Status of China Building Energy



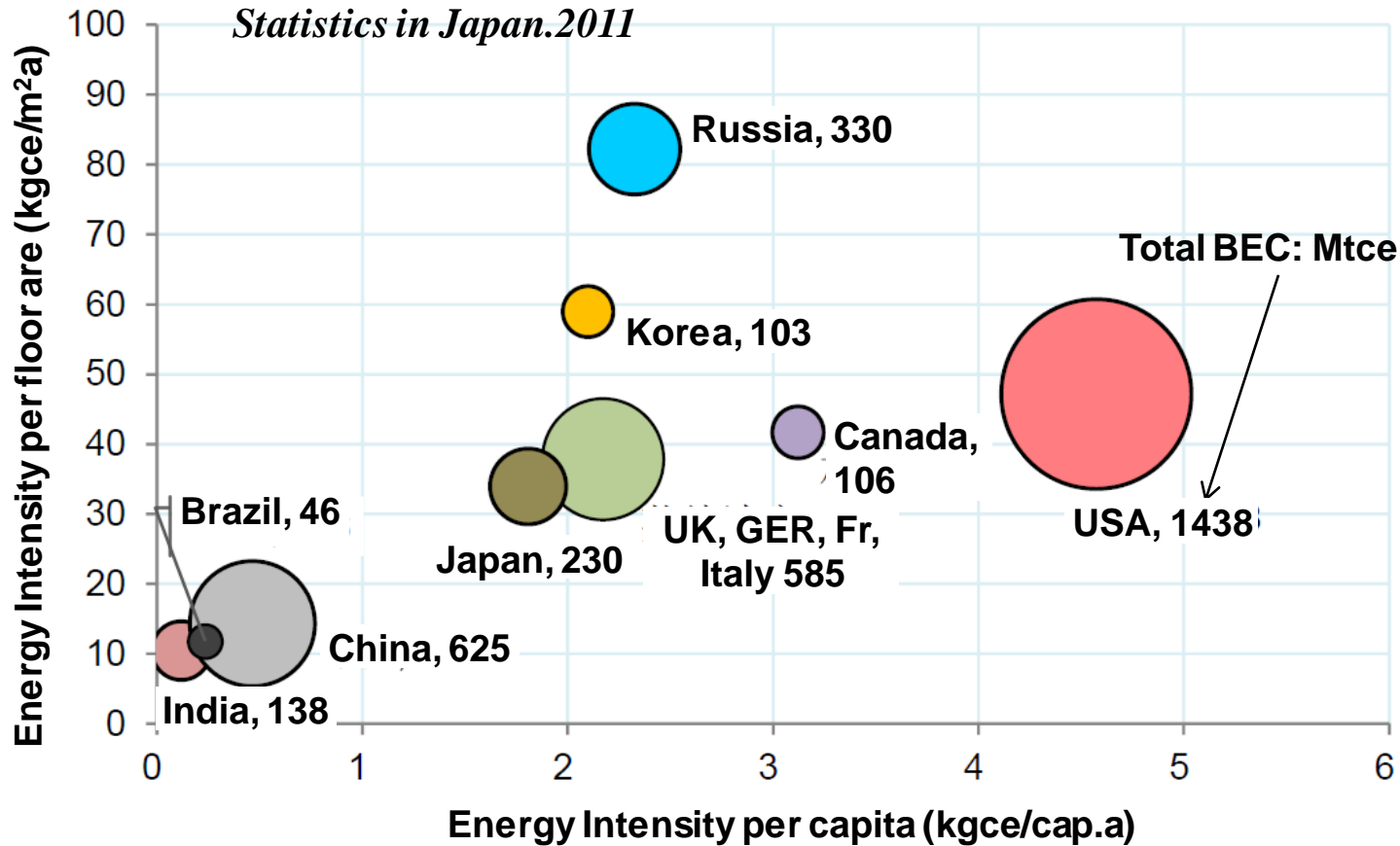
- \* Consuming around 20% of total energy use in China
- \* Keeps rapidly growing up although last 20 years

# Building Floor Area



# Total Building Energy Consumption

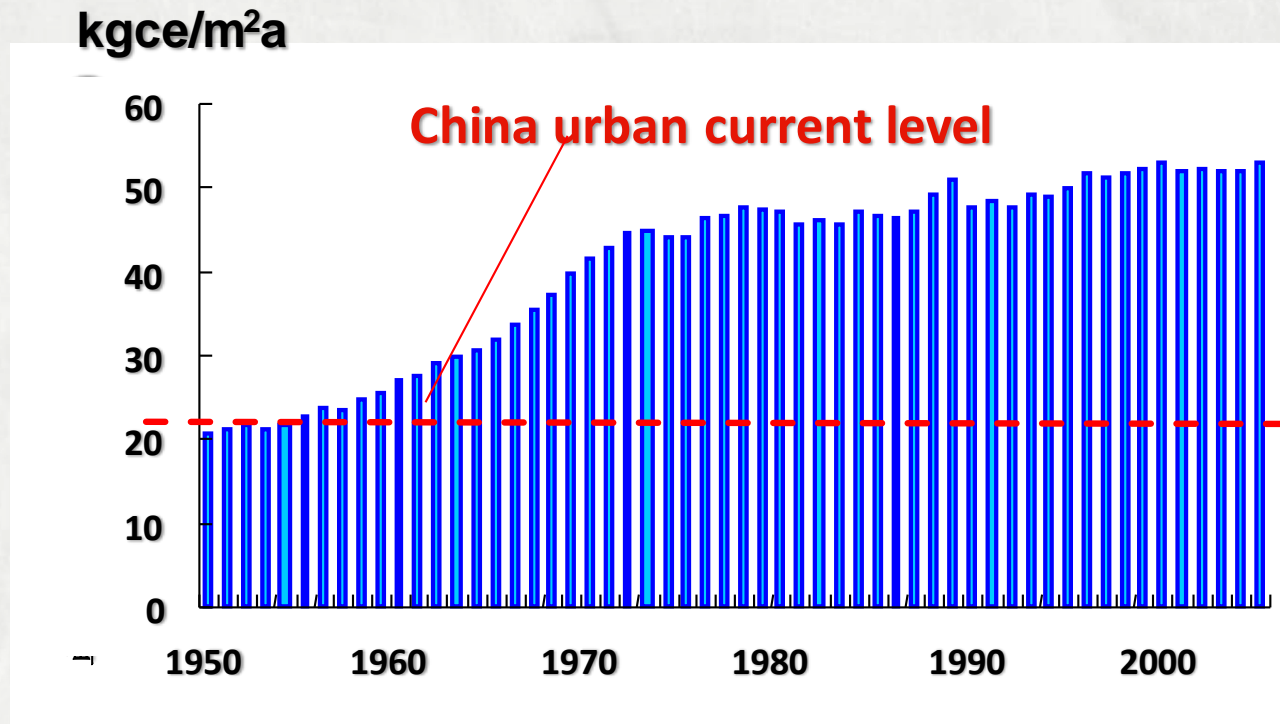
(1) *D&R International, Ltd. 2010 Buildings Energy Data Book*; (2) *Eurostat*;  
(3) *The Energy Data and Modeling Center, Handbook of Energy & Economic Statistics in Japan. 2011*



- \* Compared to OECD countries, building energy use intensity in China is still low, but the total amount is very significant.



# Energy Usage Density Comparison



**USA**



# Classification of building energy

## General Building Energy Consumption Model classification

Residential

Urban  
Rural

Commercial

**China  
Building  
Energy Usage**

## Model Classification Based on China situation

North Urban  
Space Heating

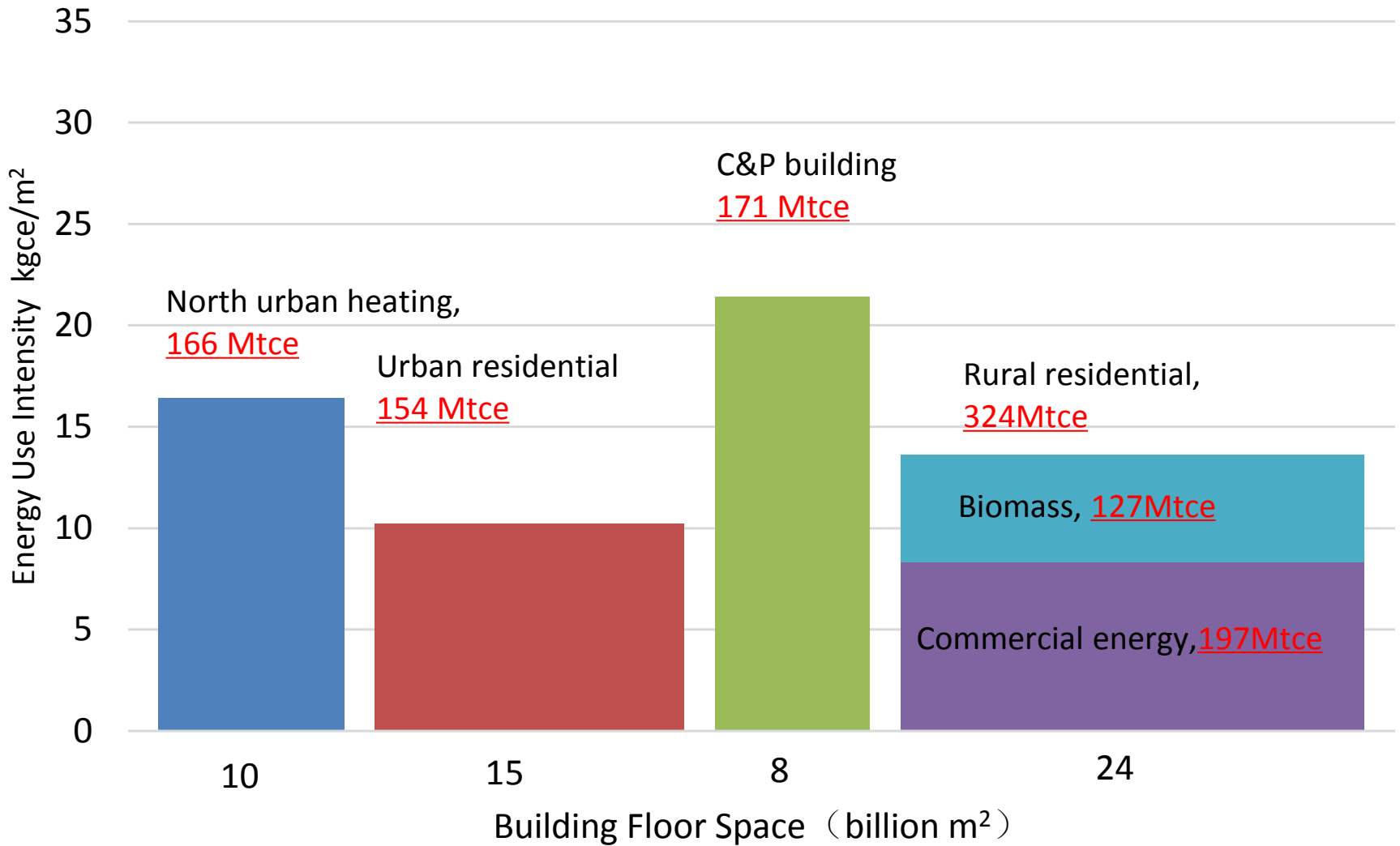
Urban Residential

Rural Residential

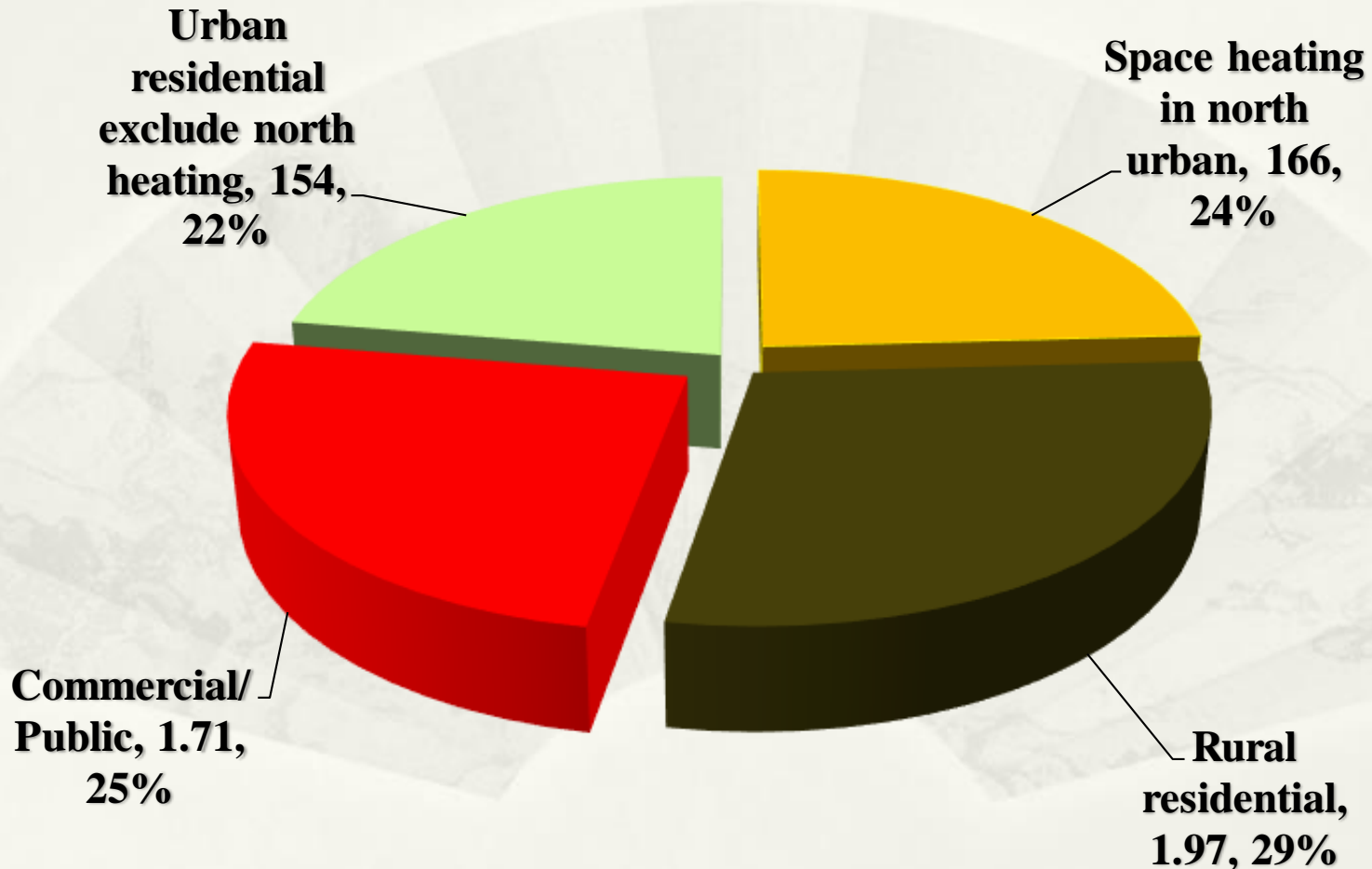
Commercial/Public



# Building Energy Break Down



# Building energy consumption in China (Mton coal/year)



# 1. North Urban Heating



District heating in North  
"Full Time, Full Space"  
 $T_{\text{room}} > 20^{\circ}\text{C}$



Individual heating in South  
"Partial Time, Partial Space"  
 $T_{\text{room}} < 15^{\circ}\text{C}$

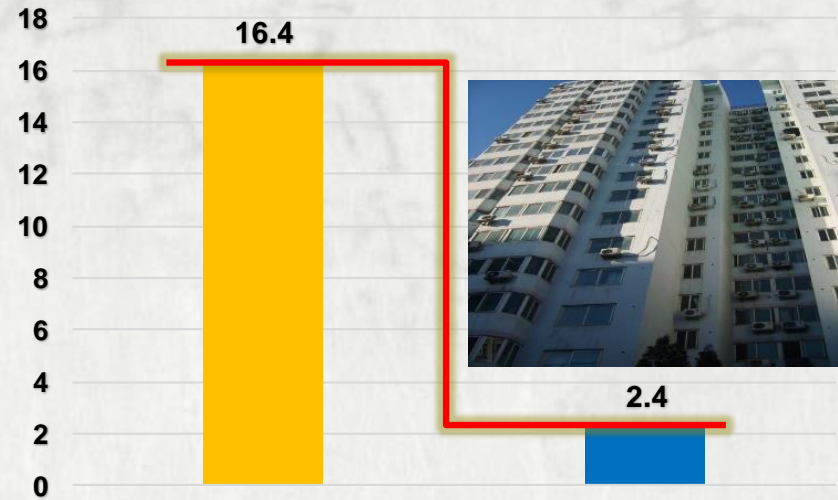




# Space Heating in Urban

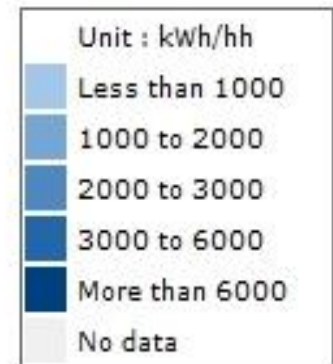
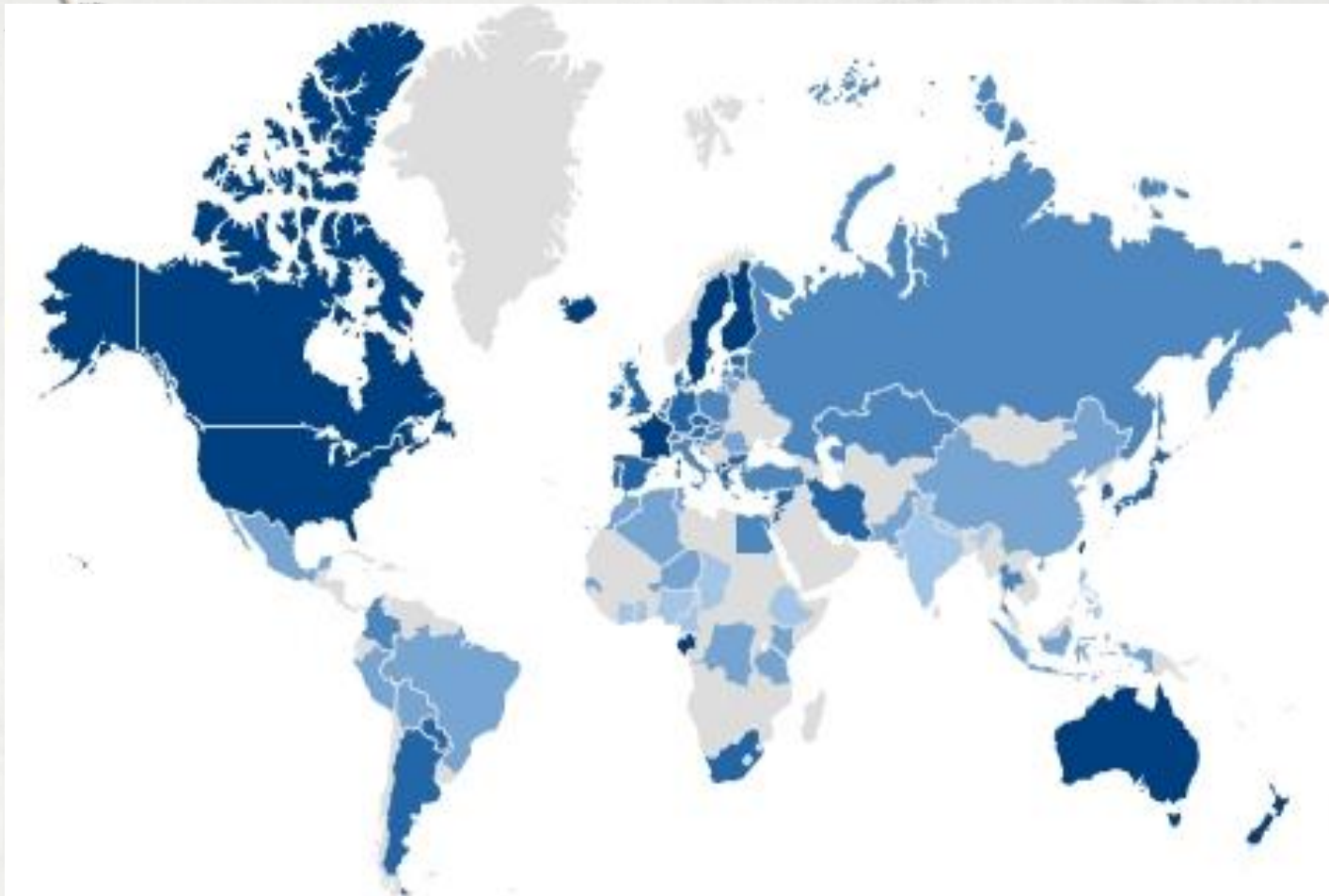


kgce/m<sup>2</sup>



North	South
District Heating System	Decentralize System
Coal & Gas	Electricity & Gas
Energy Density is similar	Energy Density is variable on Occupant behavior
Improve wall insulation, boiler & system efficiency	Improve thermal comfort, independent control

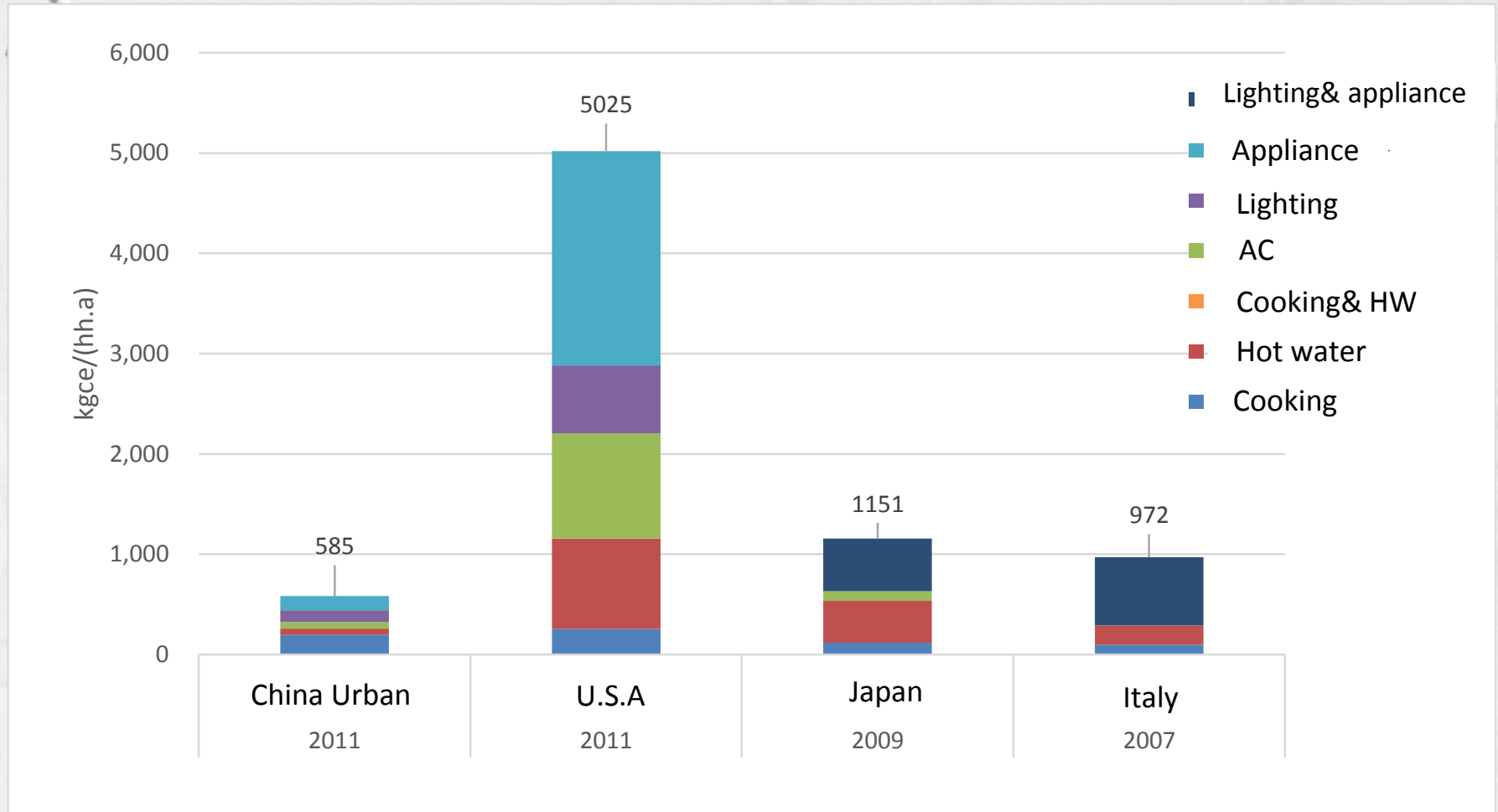
## 2. Urban residential buildings



<b>World</b>	3471
Canada	11879
US	11698
Australia	7227
France	6343
Japan	5513
UK	4648
SAfrica	4389
Korea	4215
German	3512
Italy	2777
Russia	2419
Brazil	1834
China	1349
India	900



## 2. Urban residential buildings



**Comparison of residential building energy consumption**

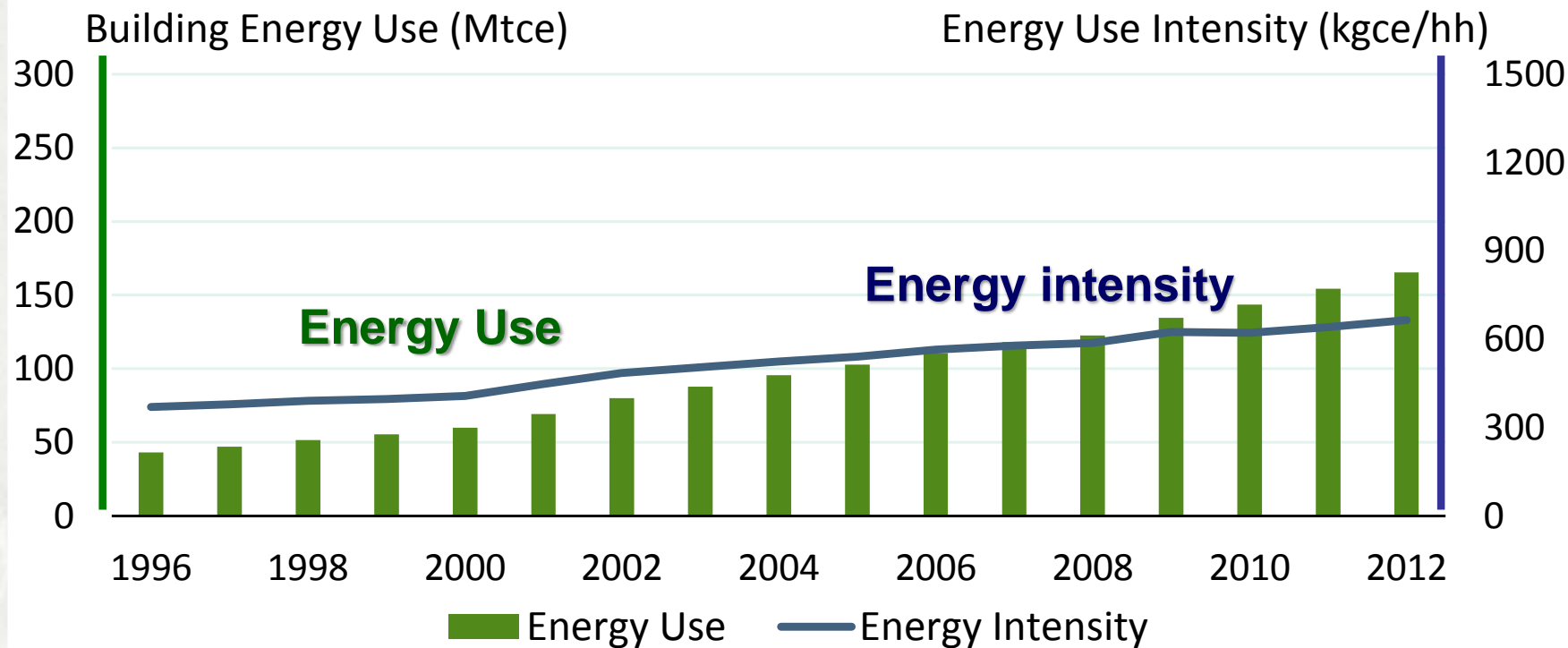
## 2. Urban residential buildings

	Total (kgce/m <sup>2</sup> a)	Cooking (kgce/m <sup>2</sup> a)	Hot water (kgce/m <sup>2</sup> a)	Lighting (kWh/m <sup>2</sup> a)	Air-cond. (kWh/m <sup>2</sup> a)	Ele. appliance (kWh/m <sup>2</sup> a)
<b>China</b>	<b>8.6</b>	<b>3.0</b>	<b>1.5</b>	<b>5.4</b>	<b>2.4</b>	<b>4.0</b>
<b>USA</b>	<b>26.8</b>	<b>1.7</b>	<b>4.7</b>	<b>12.0</b>	<b>13.4</b>	<b>32.0</b>
<b>Japan</b>	<b>22.6</b>	<b>1.4</b>	<b>6.4</b>	<b>5.7</b>	<b>4.5</b>	<b>31.6</b>
<b>Korea</b>	<b>19.5</b>	<b>1.4</b>	<b>1.9</b>	<b>25.5</b>	<b>6.0</b>	<b>14.5</b>
<b>Canada</b>	<b>26.5</b>	<b>7.6</b>		<b>11.9</b>	<b>6.8</b>	<b>34.8</b>

**Life style and occupants' behavior dependent**

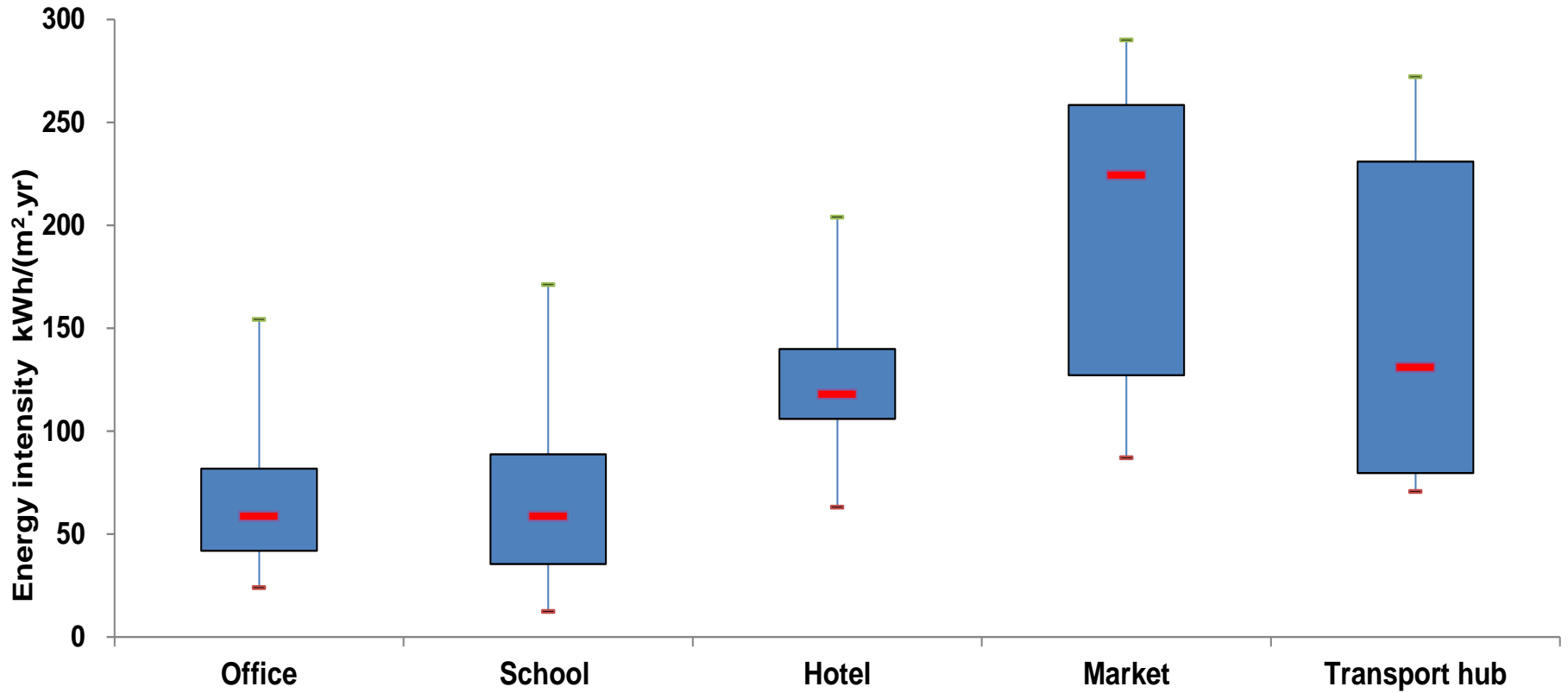


## 2. Urban residential buildings



- \* Total consumption increasing;
- \* Intensity increasing slightly.

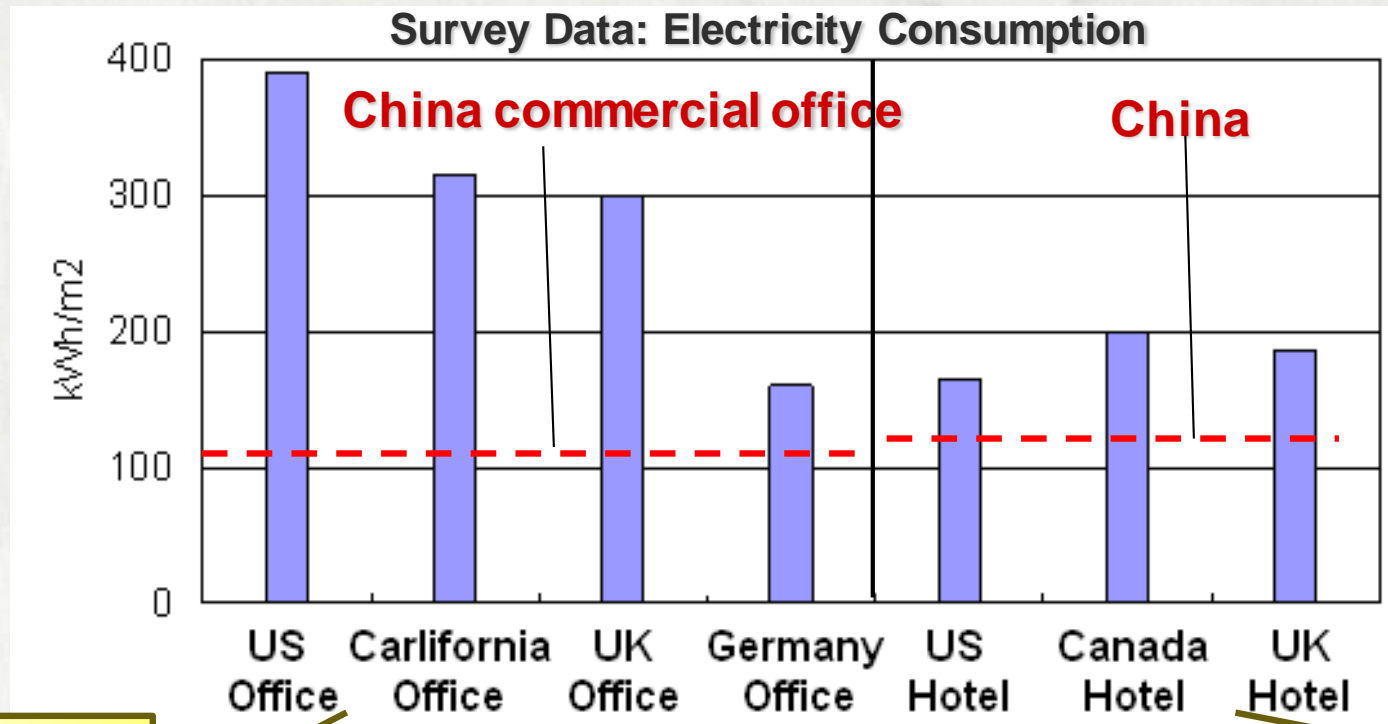
# 3. Commercial/Public Building



# 3. Commercial/Public Building

## Main AC systems used in China

- \* FCU+ outside air handling unit
- \* Split type / Multi- unit (VRF) of air-conditioners



Most are all-air system

Most are FCUs



# 4. Rural Residential

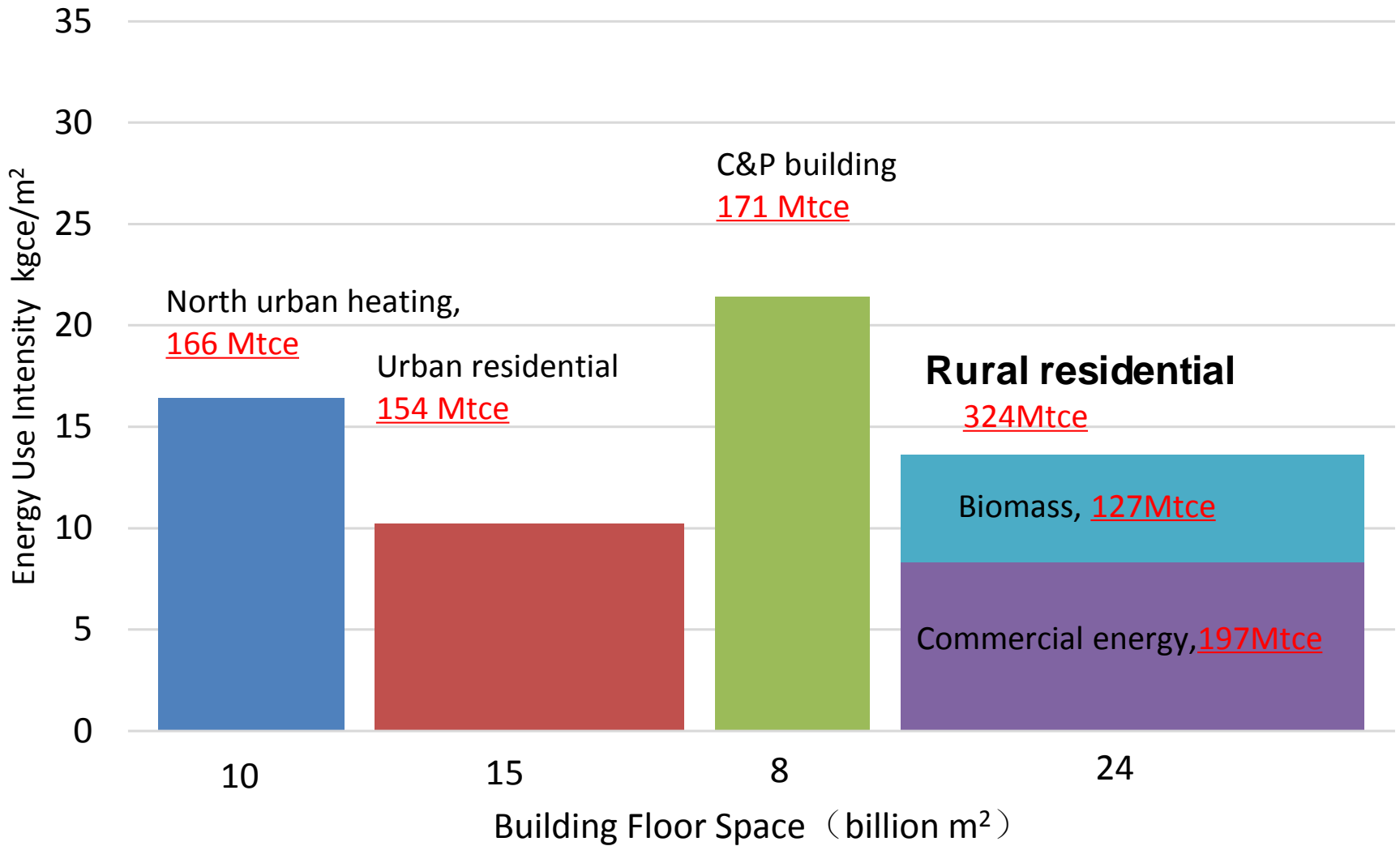
- \* Used both for Living and agriculture production
- \* Both biomass energy and fossil energy, passive way priority
- \* Energy intensity not very low, but indoor environment quality is not good, need economical and localized solution



	Urban residential	Rural residential
Building Type	Apartment building	Detached house

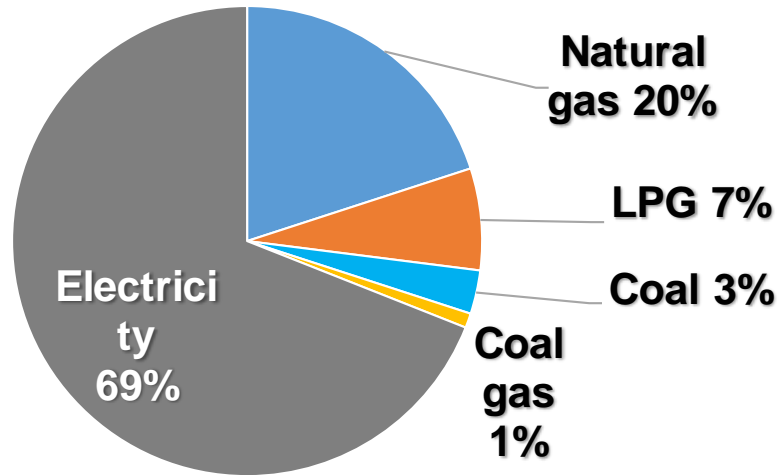


# Building Energy Break Down

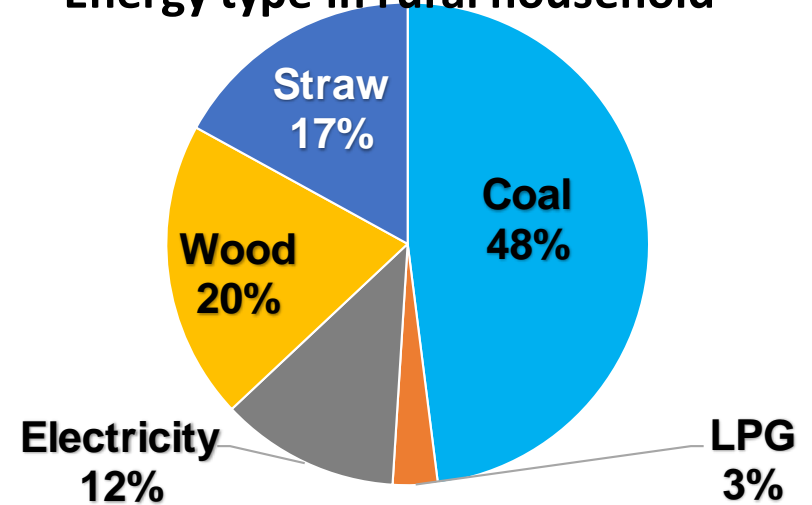


# Urban & Rural Residential

Energy type in urban household

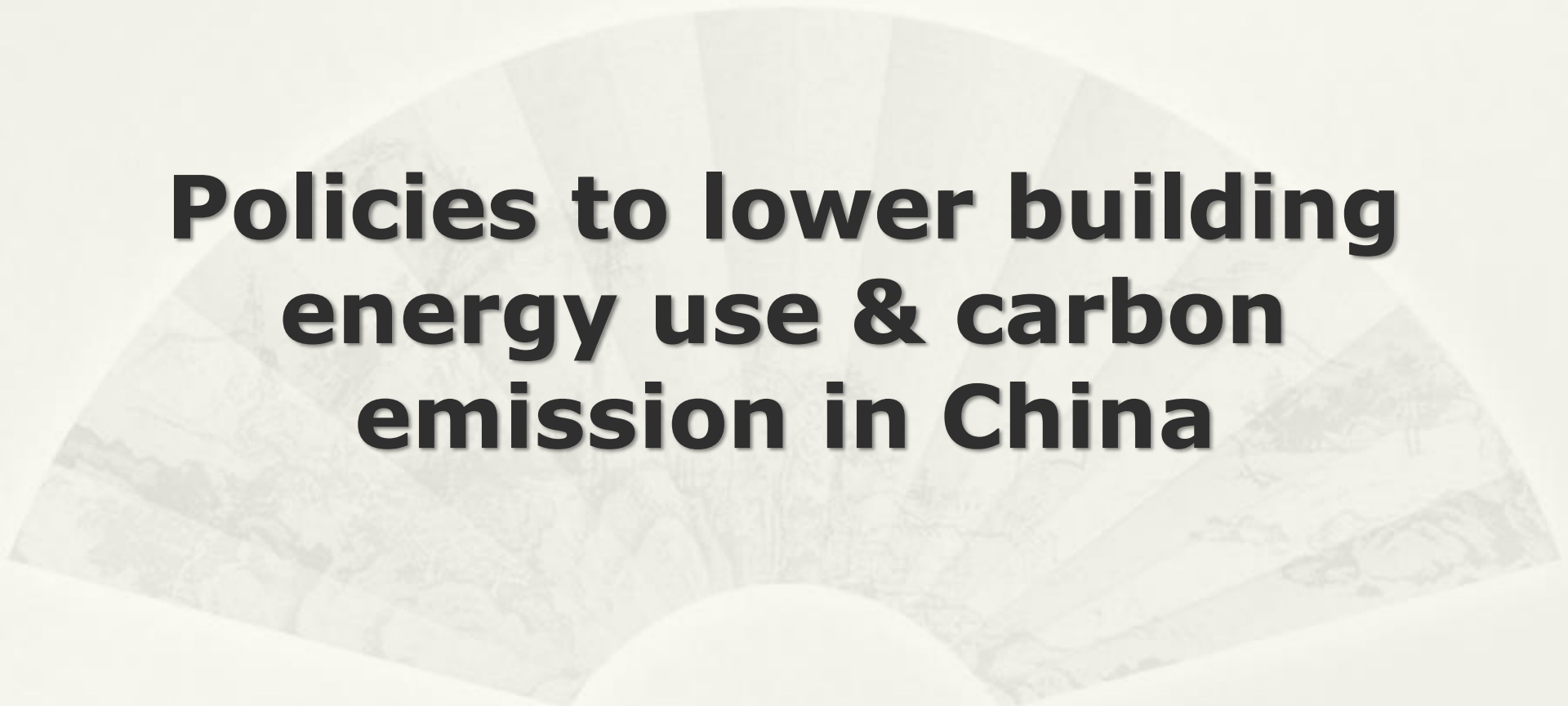


Energy type in rural household



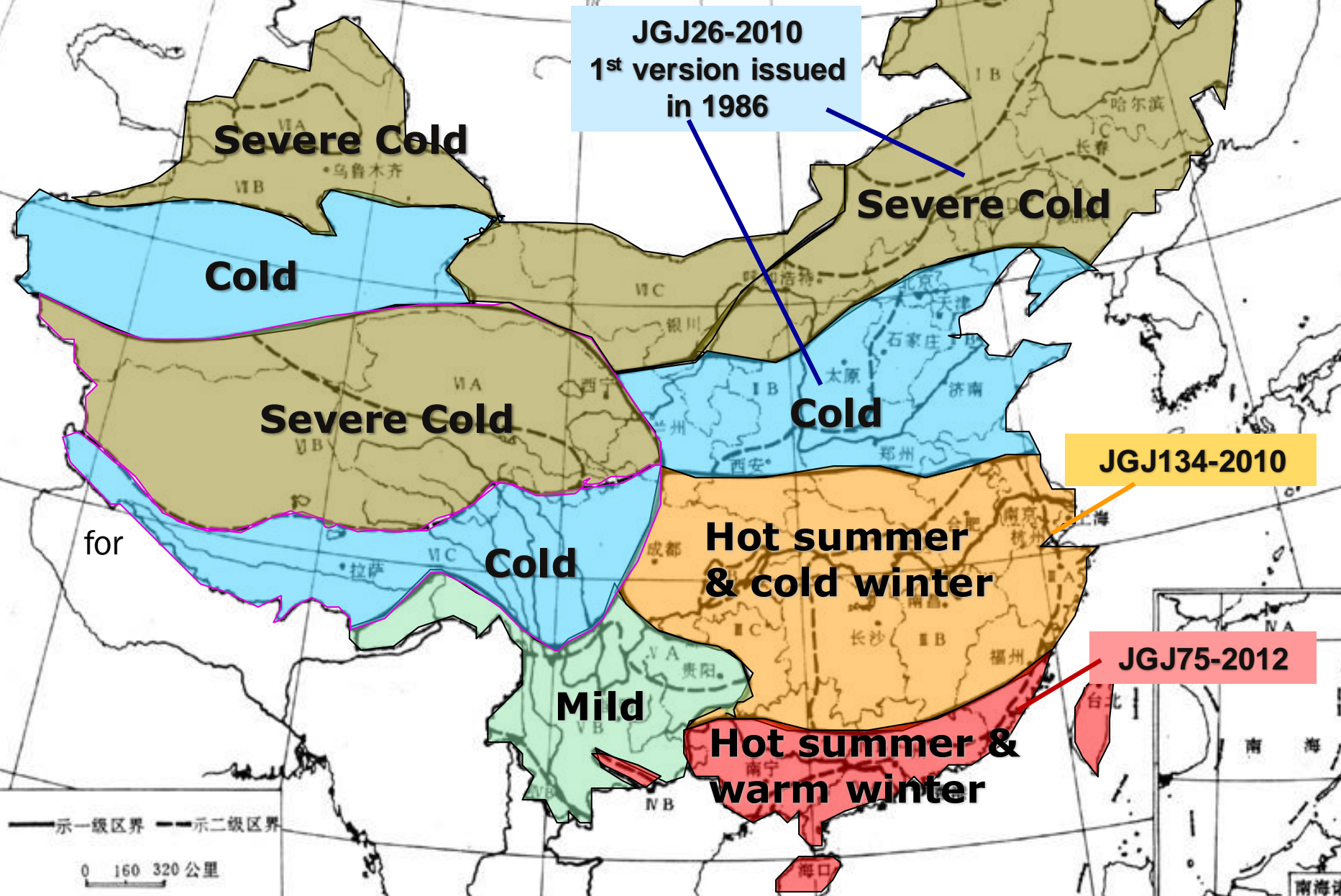
	Urban Residential	Rural Residential
Energy Type	Electricity, Gas, LPG	Biomass, Coal, Electricity

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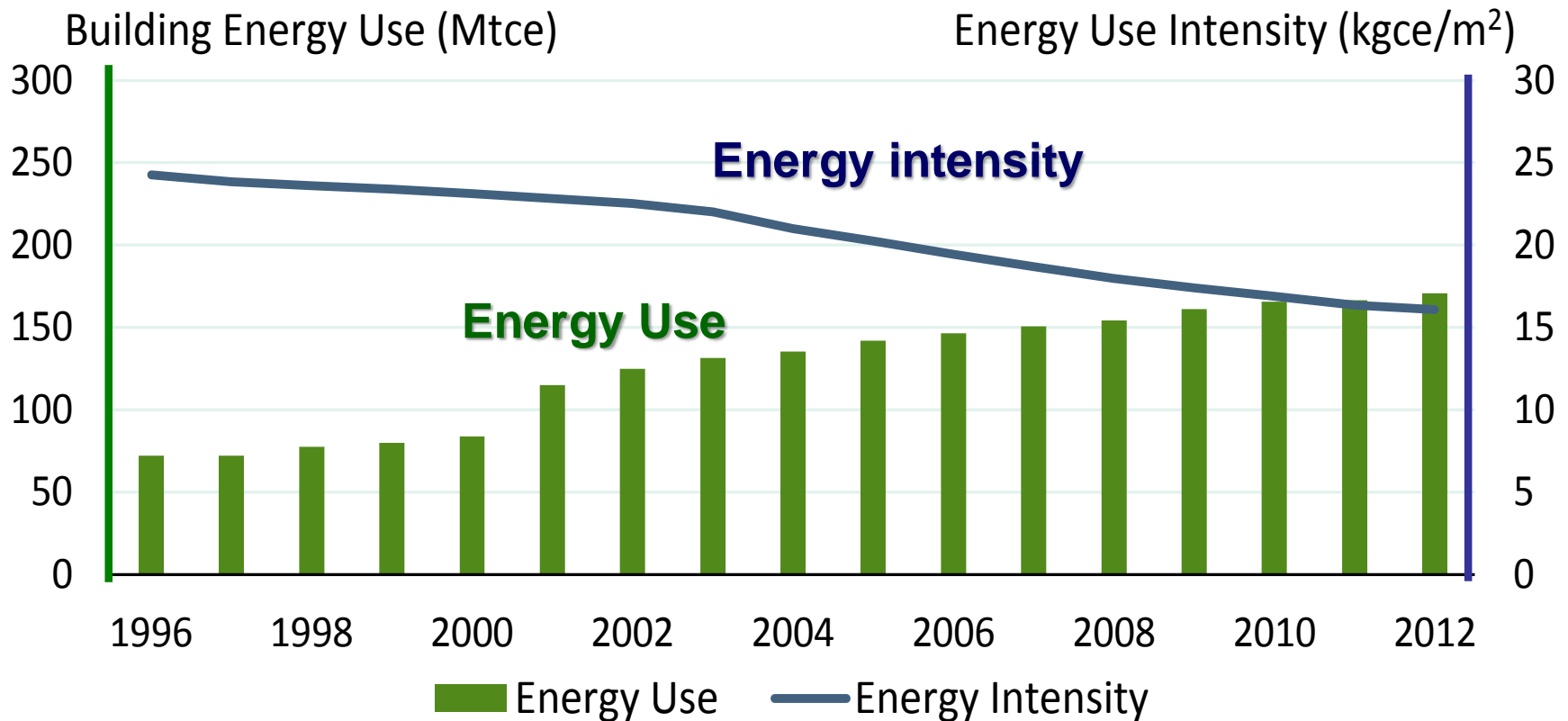
**Policies to lower building  
energy use & carbon  
emission in China**

# Chinese climate zones & energy standards for residential





# Trend of North Urban Heating Energy



**The earliest building energy saving standard in China is for space heating in north urban residential. It is effective in improving energy performance for space heating.**

# **National standard for commercial/public building**

- \* The original one is *Energy Saving Standard For Building Thermal Performance And Air-conditioning System In Hotel (GB 50189-93)*, issued in 1993
- \* From 2005, it changed into *Energy Saving Standard For Public Buildings (GB 50189)*, covers hotel, shopping center, office, school, hospital, airport, railway station, exhibition, theatre, cinema, arena, etc.



# New National Standard for Energy Consumption Index of Buildings

JDC

中华人民共和国国家标准

GB

P

GB\*\*\*\*—201\*

建筑能耗标准

Standard for Energy Consumption of Buildings

(征求意见稿)

201\*-xx-xx发布

201\*-xx-xx实施

中华人民共和国住房和城乡建设部

中华人民共和国国家质量监督检验检疫总局

联合发布

- \* Space heating energy index
- \* Public building energy index
- \* Residential building energy index
  
- \* Different climate zones: severe cold, cold, hot summer & cold winter, hot summer & warm winter
  
- \* Different building types: office buildings, hotels, shopping malls, etc.

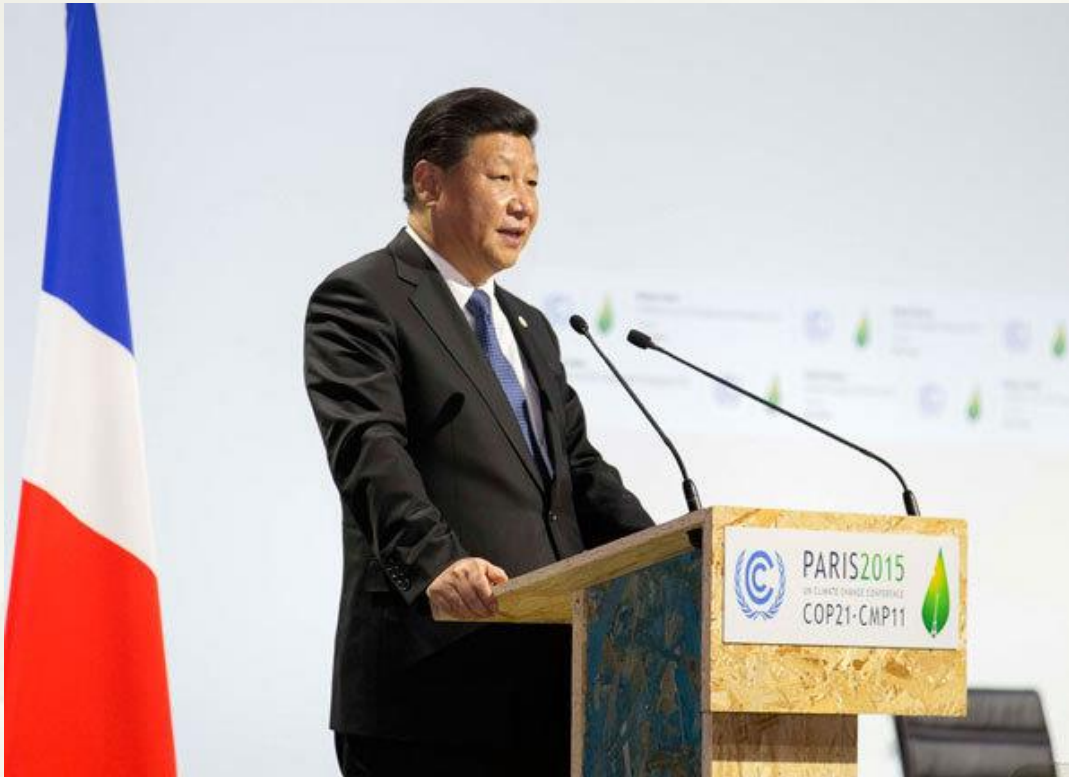
# E.g. Energy consumption index for office buildings

<b>Severe Cold / Cold climate zone</b>	<b>A</b>		<b>B</b>	
	<b>Constraint value (kWh/m<sup>2</sup>a)</b>	<b>Leading value (kWh/m<sup>2</sup>a)</b>	<b>Constraint value (kWh/m<sup>2</sup>a)</b>	<b>Leading value (kWh/m<sup>2</sup>a)</b>
<b>Governmental offices</b>	<b>45</b>	<b>30</b>	<b>70</b>	<b>50</b>
<b>Commercial offices</b>	<b>60</b>	<b>45</b>	<b>80</b>	<b>60</b>

<b>Cold Winter and Hot Summer</b>	<b>A</b>		<b>B</b>	
	<b>Constraint value (kWh/m<sup>2</sup>a)</b>	<b>Leading value (kWh/m<sup>2</sup>a)</b>	<b>Constraint value (kWh/m<sup>2</sup>a)</b>	<b>Leading value (kWh/m<sup>2</sup>a)</b>
<b>Governmental offices</b>	<b>60</b>	<b>45</b>	<b>90</b>	<b>65</b>
<b>Commercial offices</b>	<b>75</b>	<b>60</b>	<b>110</b>	<b>80</b>

<b>Warm Winter and Hot Summer</b>	<b>A</b>		<b>B</b>	
	<b>Constraint value (kWh/m<sup>2</sup>a)</b>	<b>Leading value (kWh/m<sup>2</sup>a)</b>	<b>Constraint value (kWh/m<sup>2</sup>a)</b>	<b>Leading value (kWh/m<sup>2</sup>a)</b>
<b>Governmental offices</b>	<b>55</b>	<b>40</b>	<b>80</b>	<b>55</b>
<b>Commercial offices</b>	<b>70</b>	<b>55</b>	<b>100</b>	<b>75</b>

# United Nations Conference on Climate Change 2015



“...China will, on the basis of technological and institutional innovation, adopt new policy measures to improve industrial mix, build low-carbon energy system, **develop green building** and low-carbon transportation, and build a nationwide carbon emission trading market so as to foster a new pattern of modernization featuring harmony between man and nature....”

*- President Xi Jinping*

Eco-housing rating system

中国生态住宅技术评估手册

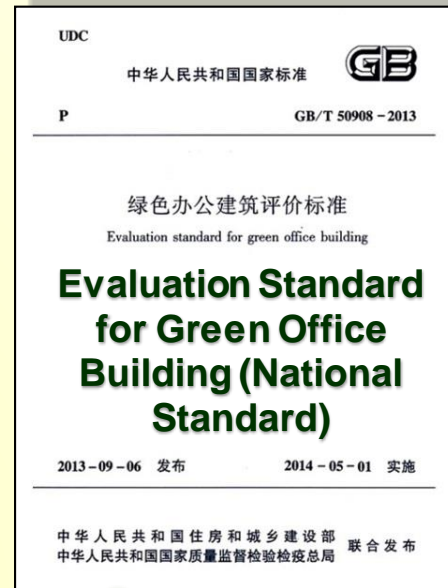


2001

2005

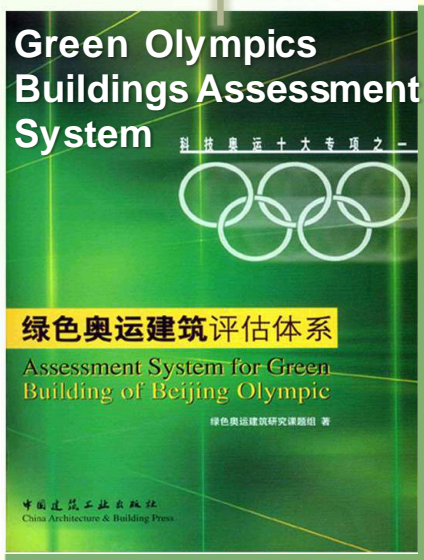


2011



2013

2003



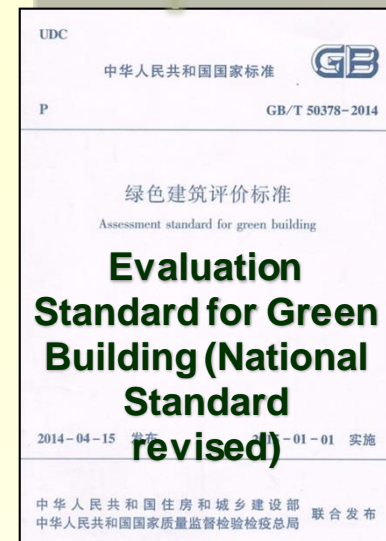
2006



2013



2014





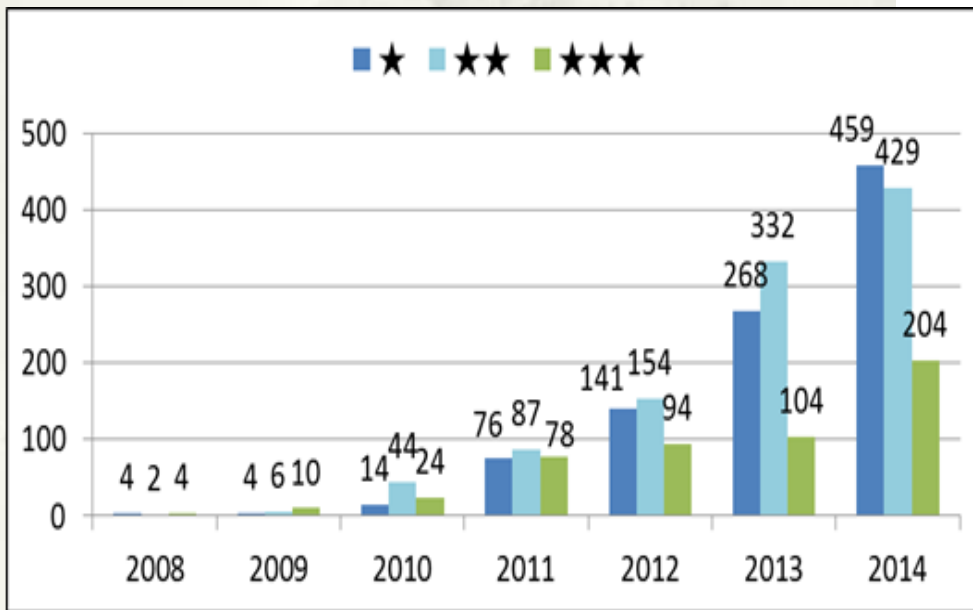
# **Green Building Action Plan**

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- \* Issued by China's State Council on Jan 1, 2013.**
  - \* Energy saving in new buildings**
  - \* Energy efficiency renovation of existing buildings**
  - \* Improvement of Urban heating system**
  - \* Promotion of renewable energy application in buildings**
  - \* Energy management of public buildings**
  - \* R&D of green building technologies**
  - \* Green building materials**
  - \* Building industrialization**

# Rapid Development of Green Building in China

- \* 2008~May 2015, there are 2800 certificated green buildings by 3-Star system in China, with a GFA of approximately 300 million m<sup>2</sup>.





# Some labeled buildings ——Low cost, low energy

Shenzhen Institute of Building Research

Electricity 60.2 kWh/m<sup>2</sup>a

Investment 4200 CNY/m<sup>2</sup>(2009)

Library of Shandong Transportation College

Electricity 30 kWh/m<sup>2</sup>a

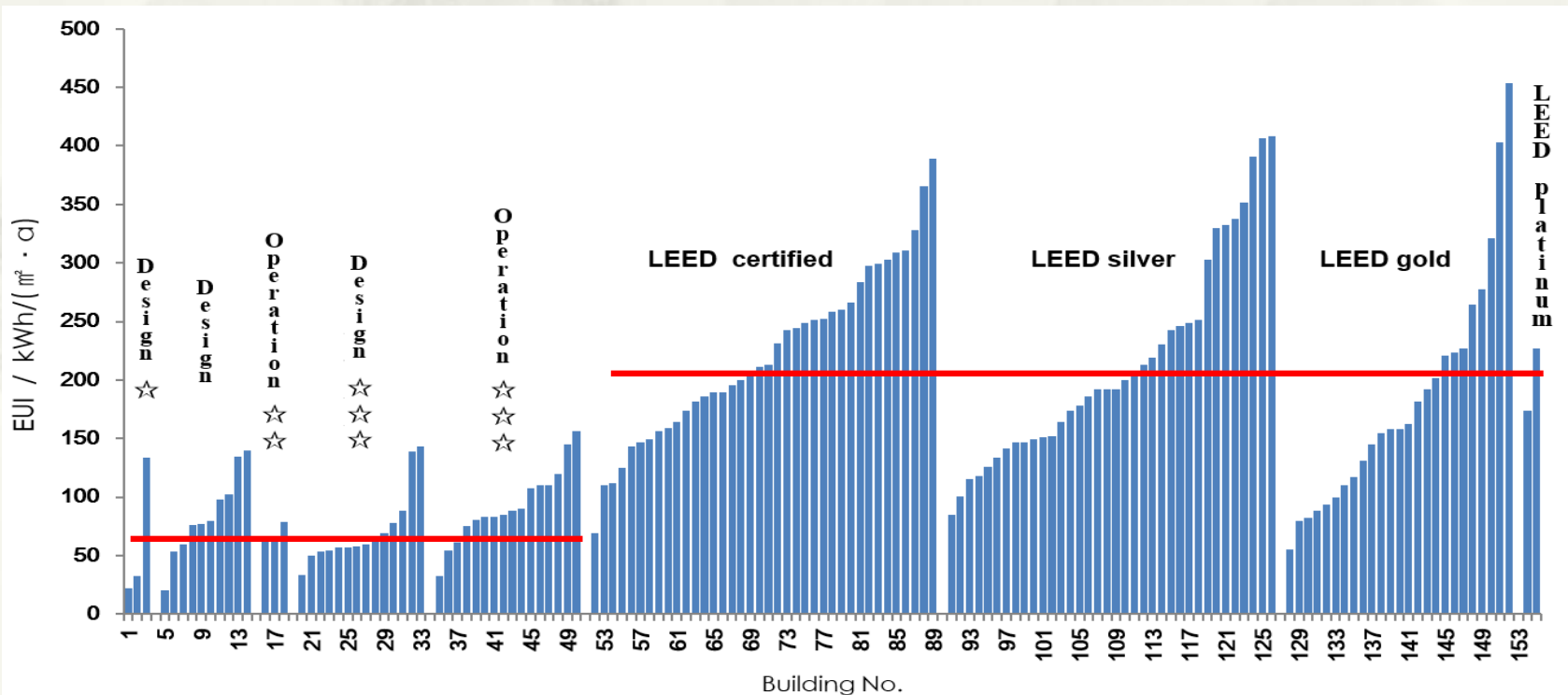
Space heating 63.4 kWh/m<sup>2</sup>

Investment 2150 CNY/m<sup>2</sup>(2003)



# Compared with buildings in US certified by LEED

- \* There is no correlation between energy consumption and green label in either China or US
- \* In general, the energy consumption of green buildings in China is about 1/3 of LEED labeled buildings in US



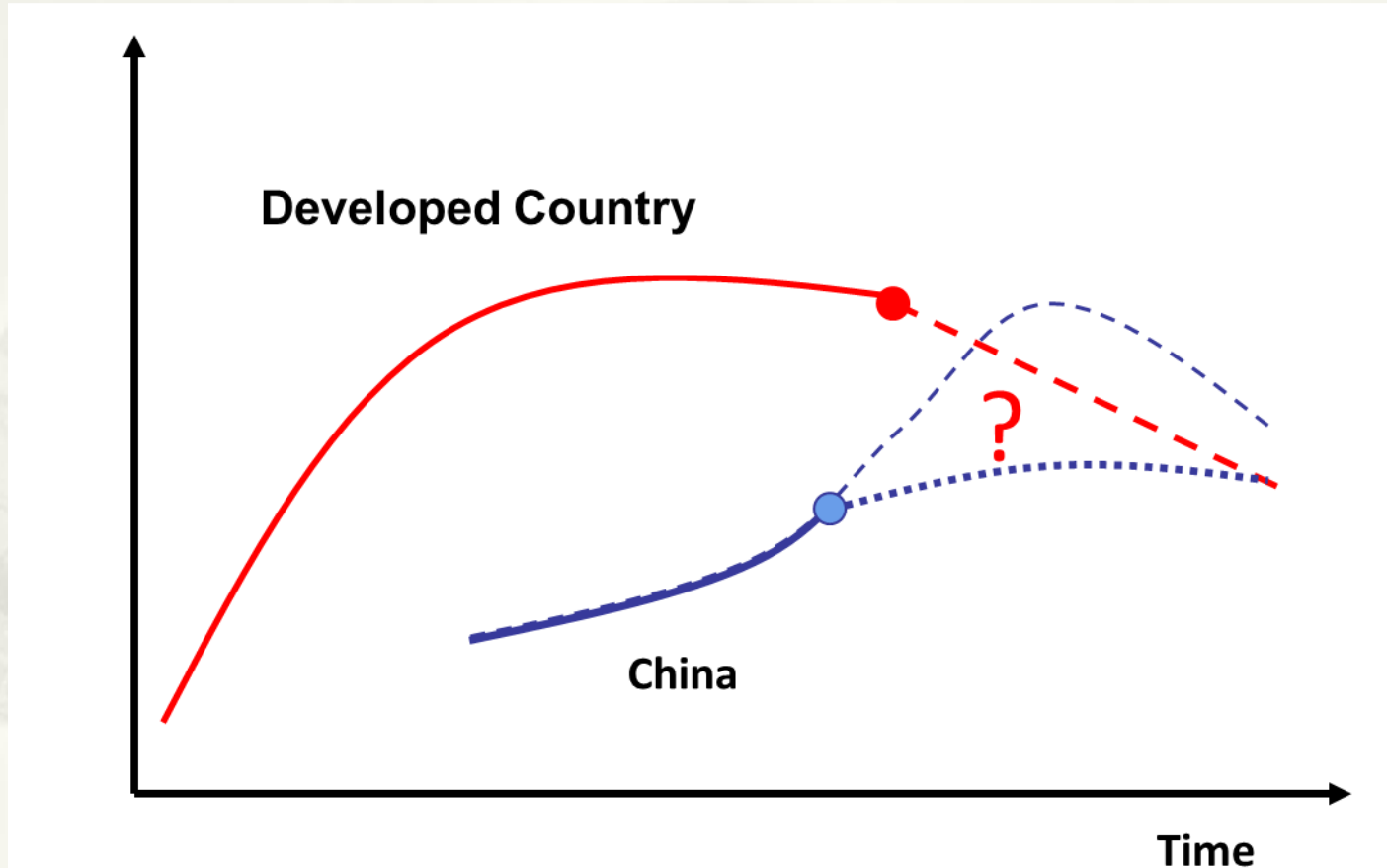
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# **Outlooks of building energy in China**

# Building energy policy

BEC





# Energy Ceiling for building sector

- \* It is estimated by 2030, available total energy for China will be 4000~4500 Mtce/year

Current Energy consumption and planned by sectors (Mtce)

	2011	Future
Industry	2510	2300~2700
Transportation	290	500~700
<b>Building</b>	<b>690</b>	<b>1000</b>
<b>Total</b>	<b>3480</b>	<b>4000</b>

**Ceiling value**



# Rural Residential

- \* **Target**

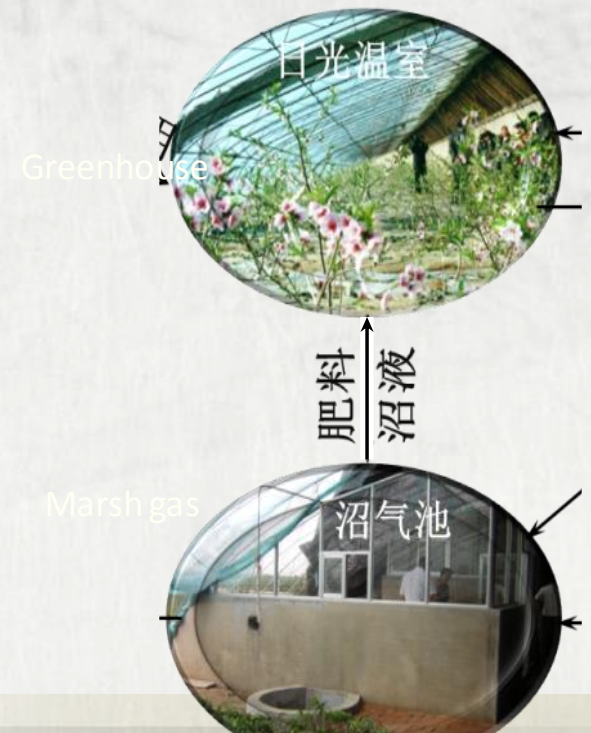
- \* **Free-coal village in North**
- \* **Eco village in south**

- \* **Technical Approach**

- \* **Biomass energy: Straw, Marsh gas(in South), Wood**
- \* **Renewable energy**
- \* **Passive design**



High efficiency stove for biomass



# Conclusion

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- \* **Building energy in China has quite different characteristic with developed countries**
- \* **For the rapid development and urbanization, building energy in China going green is more of a necessity than a choice**
- \* **A top down energy usage quota road map is essential for the transition from “Technical oriented” into “Energy Usage oriented”**
- \* **Occupant behavior together with appropriate innovative technology is critical to achieve the “tunnel approach”**