8th International Conference for Enhanced Building Operations
Oct. 20-22, 2008 Berlin, Germany

Building Energy in China: Forward to Low-Carbon Economy

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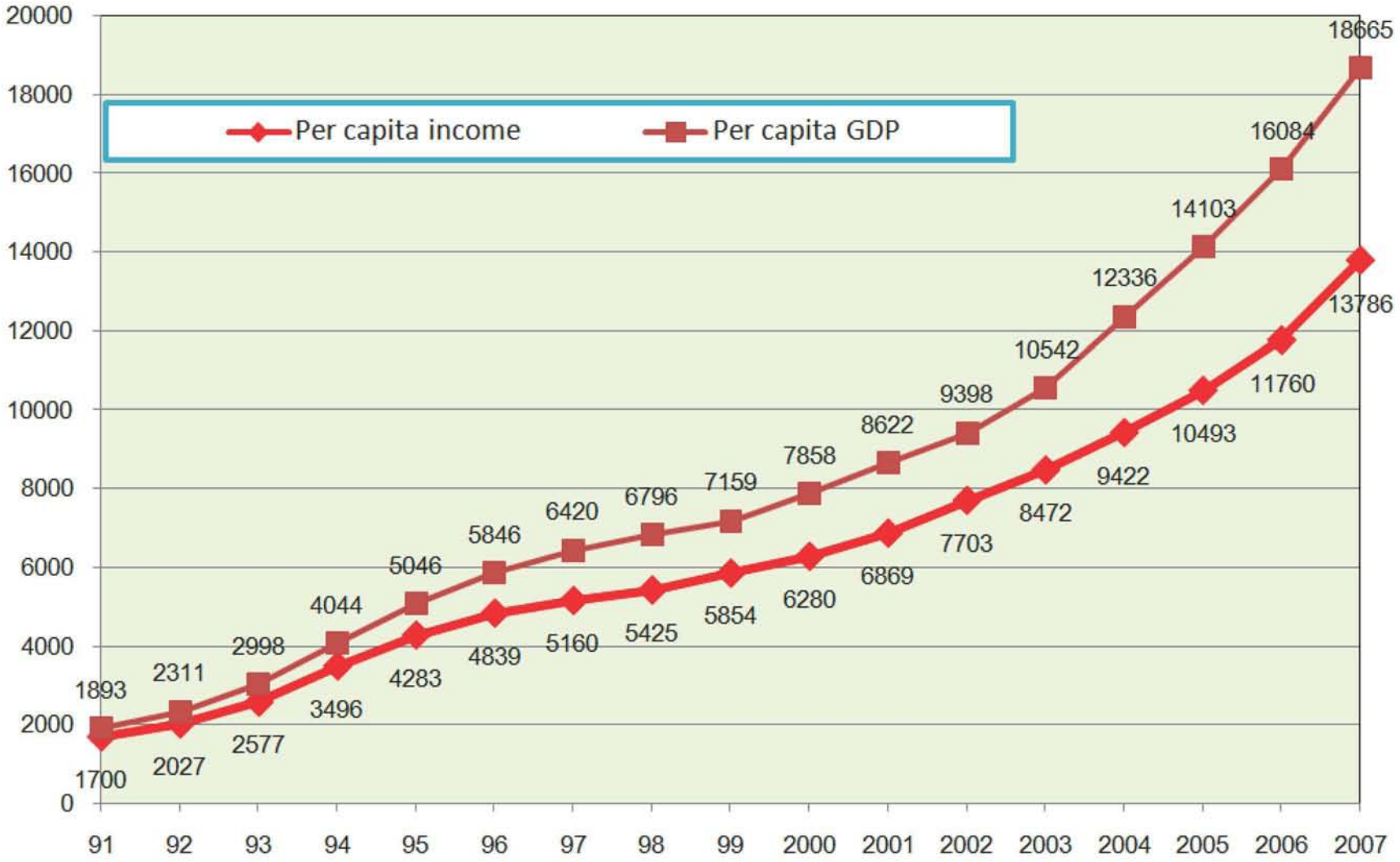
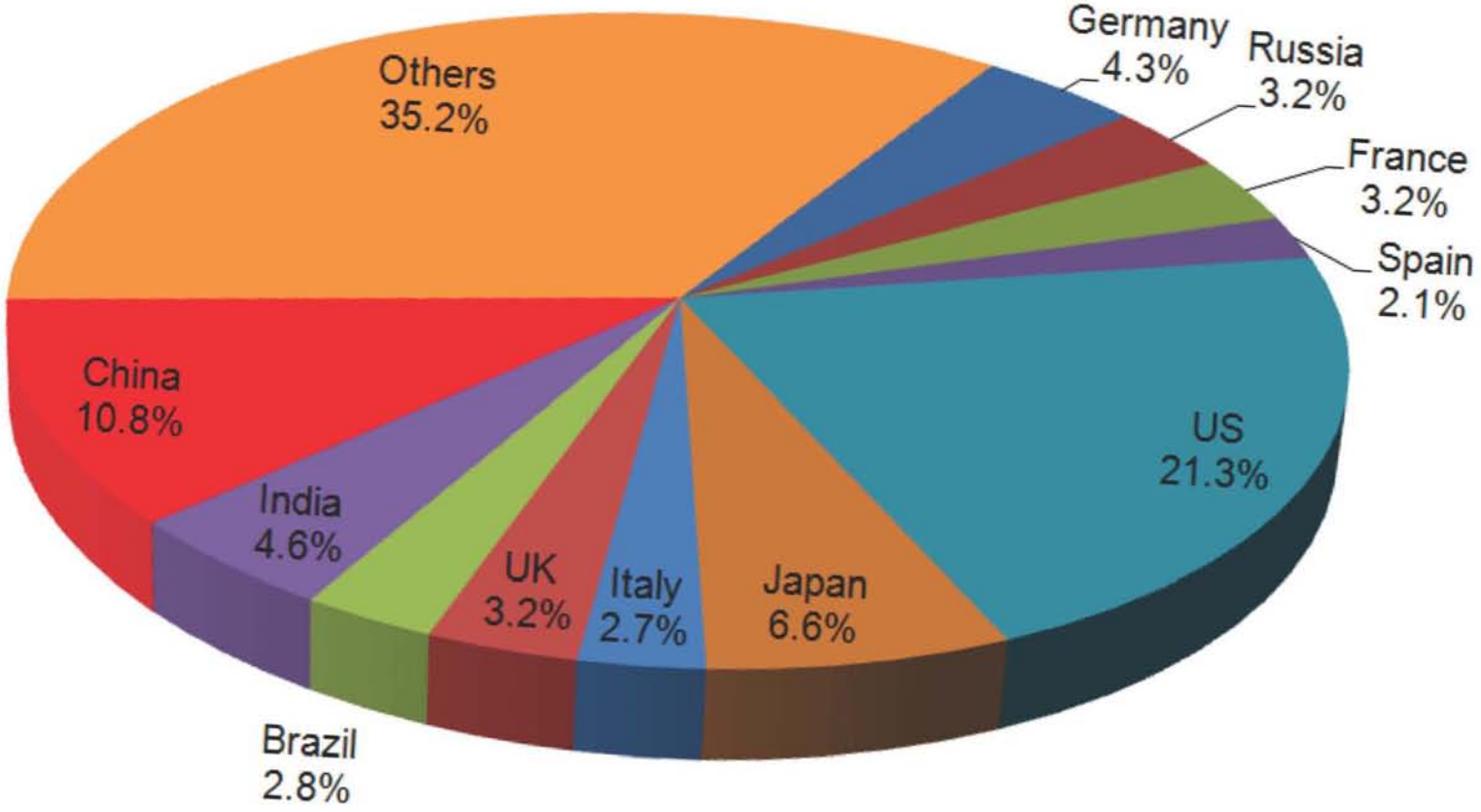
Growth of urbanization rate of China

Gross building floor area in cities & towns (bln.sq.m)

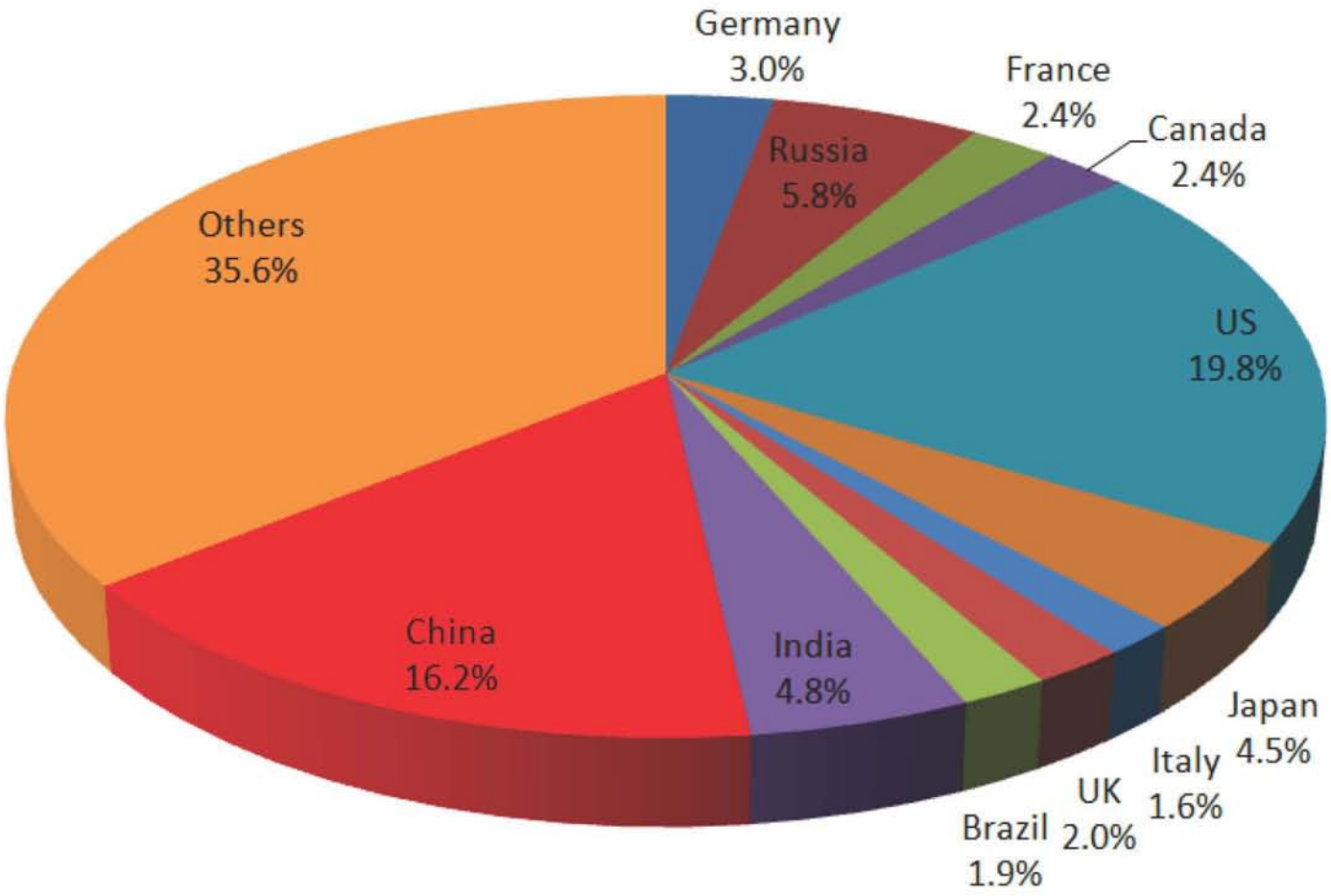
Per capita GDP and annual disposable income of urban households



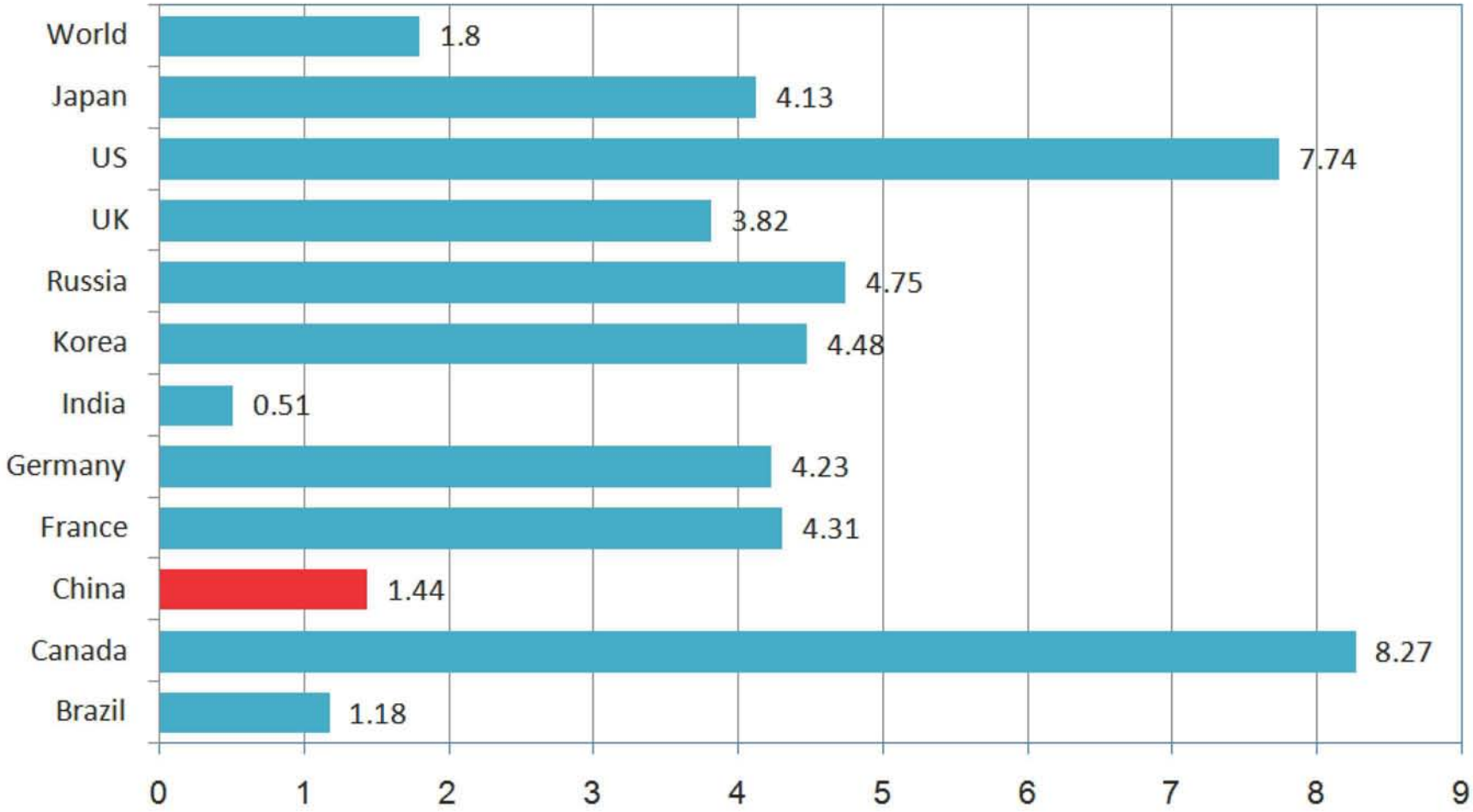
Shares of the World GDP (PPP) in 2007



China: ranking 2nd in the world of primary energy consumption in 2006



Per capita primary energy consumption in 2006 (toe)



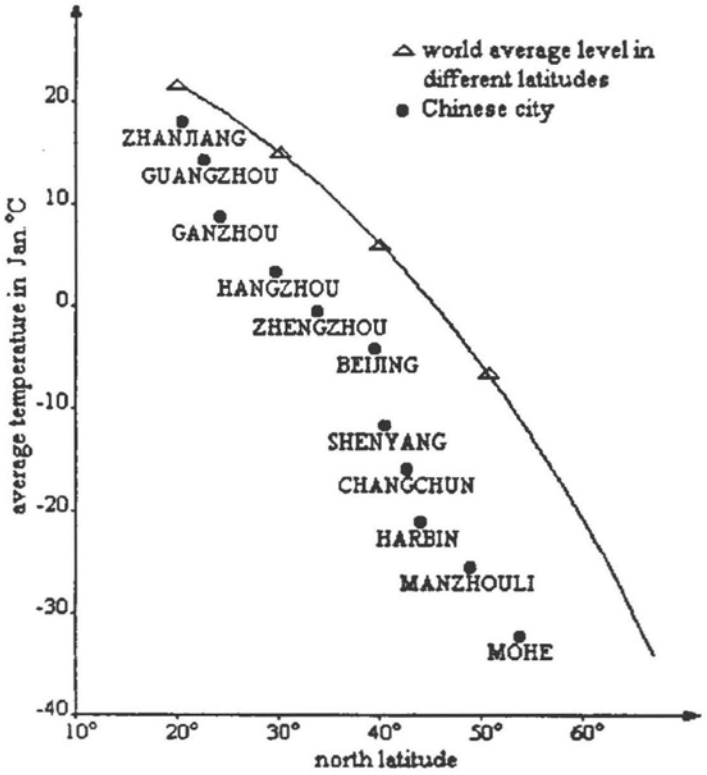
According to the World Bank: Two "Half's"

- By 2015 the World Bank predicts that half of the world's new building construction will take place in China.
- The World Bank estimates that more than one-half of China's urban residential and commercial building stock in 2015 will likely be constructed after the year 2000.
- A vast majority of these projects are very large, such as commercial office buildings between 1 to 1.5 million ft^2 and residential developments involving 5 million ft^2 of construction area.

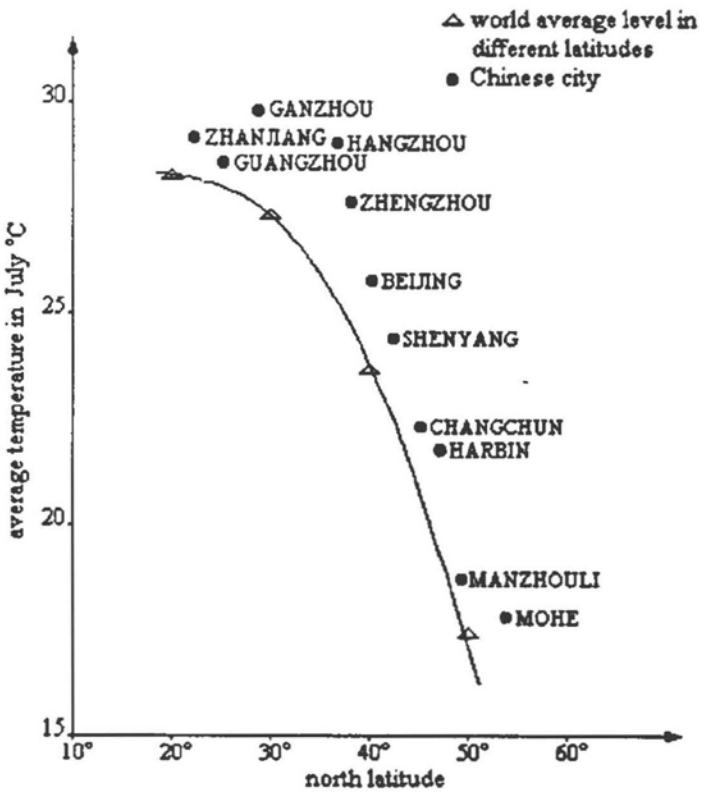
Comparison of heating and cooling demand

City	Latitude	HDD	Mean Temp. January	Mean Temp. July
Berlin	52	2540	-0.4 ° C	17.9 ° C
Hamburg	53~55	3073	0.5° C	16.8° C
Nürnberg	49~51	3010	-0.8° C	18.3° C
Munich	47~49	3061	-2.2° C	17.3° C
New York	40.77	2614	0° C	24° C
Seattle	47.53	2471	5° C	19° C
Rome	42	1570	1.9° C(Min)	31.2° C(Max)
London	51	2558	4° C	17° C
Vancouver	49.18	2820	3° C	17° C
Harbin	45	5032	-19.2° C	22.8° C
Beijing	40	2699	-4.3° C	25.9° C
Tokyo	35.7	1579	5.2° C	25.2° C
San Francisco	37.6	1675	9° C	17° C
Atlanta	33.7	1662	5.0° C	26.0° C
Los Angeles	34	1274	14.6° C	23.5° C
Davis	38.7	1527	7.3° C	24.0° C
Huston	29.7	1371	10° C	28° C
Shanghai	31	1691	3.7° C	27.8° C
Nanjing	32	1967	3.0° C	28.0° C
Hangzhou	30.2	1647	4.0° C	28.6° C

Weather of Chinese cities vs. World average level



The comparison of the temperature in Jan. between China and the areas in the same latitudes



The comparison of average temperature in July between China and the areas in the same latitudes

January

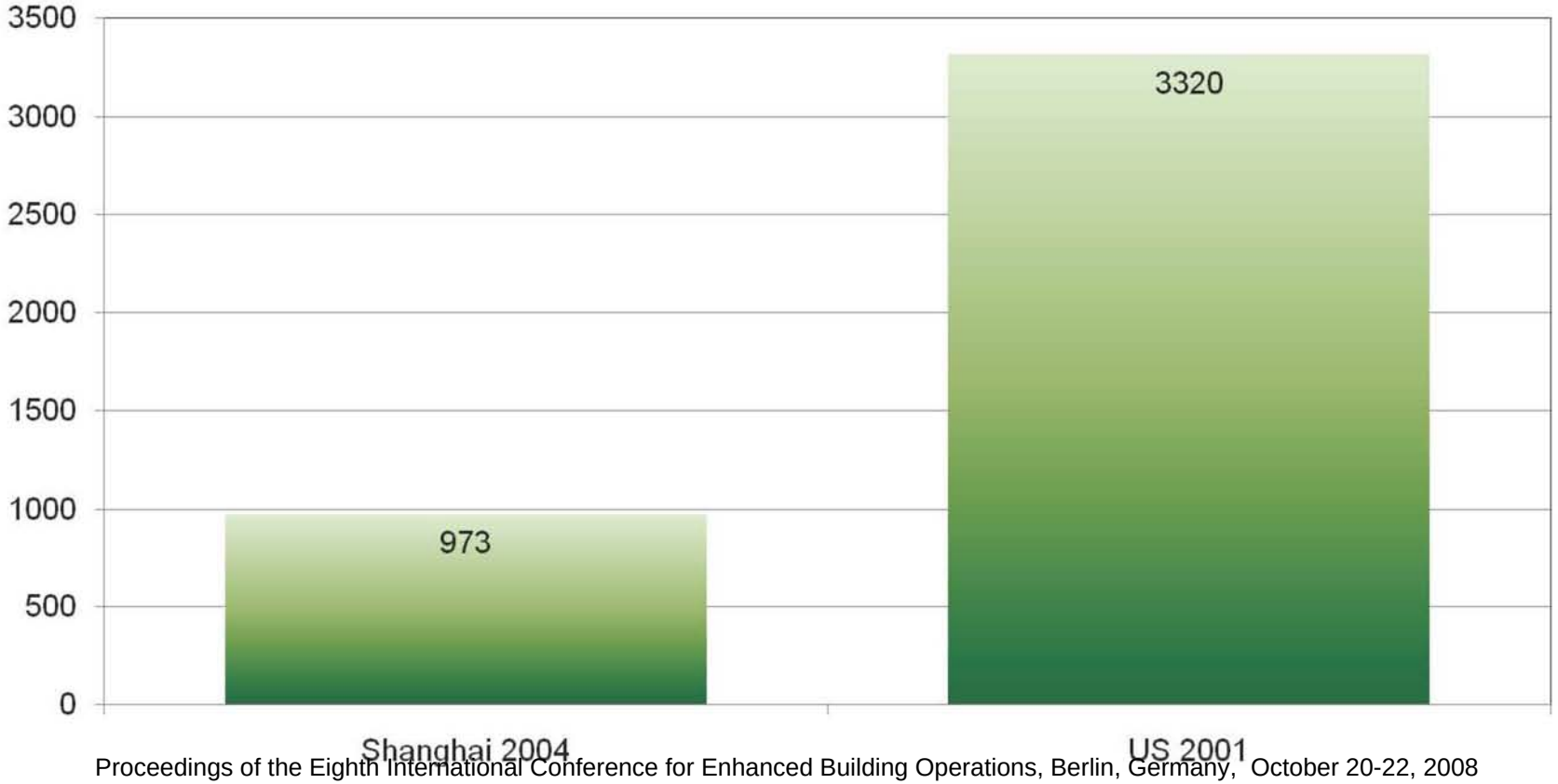
July

Comparison of household energy consumption between Shanghai and United States

	Shanghai (2004)	United States (2001)	Shanghai vs. US
The popularity rate of household room air conditioner	96.8%	75.5%	1.28/1
Household annual electricity consumption (kWh)	2,081	10,656	1/5.12
Household annual electricity consumption by RAC (kWh)	645	4058	1/6.3
Per capita annual disposable income	16,683RMB (2004)	28,180USD (2003)	1/11.2
Electric tariff for residential buildings (/kWh)	0.61RMB	0.086USD	1/1.13
Annual household electric charge	1,854RMB	1,493USD	1/6.6
Percentage of electric charge in the per capita income	11.1%	5.3%	—
Household electric cost for air conditioning	575RMB	197USD	1/9.6
Household heating cost		474USD	
Percentage of cooling & heating cost in the per capita income	2.4%	2.3%	—

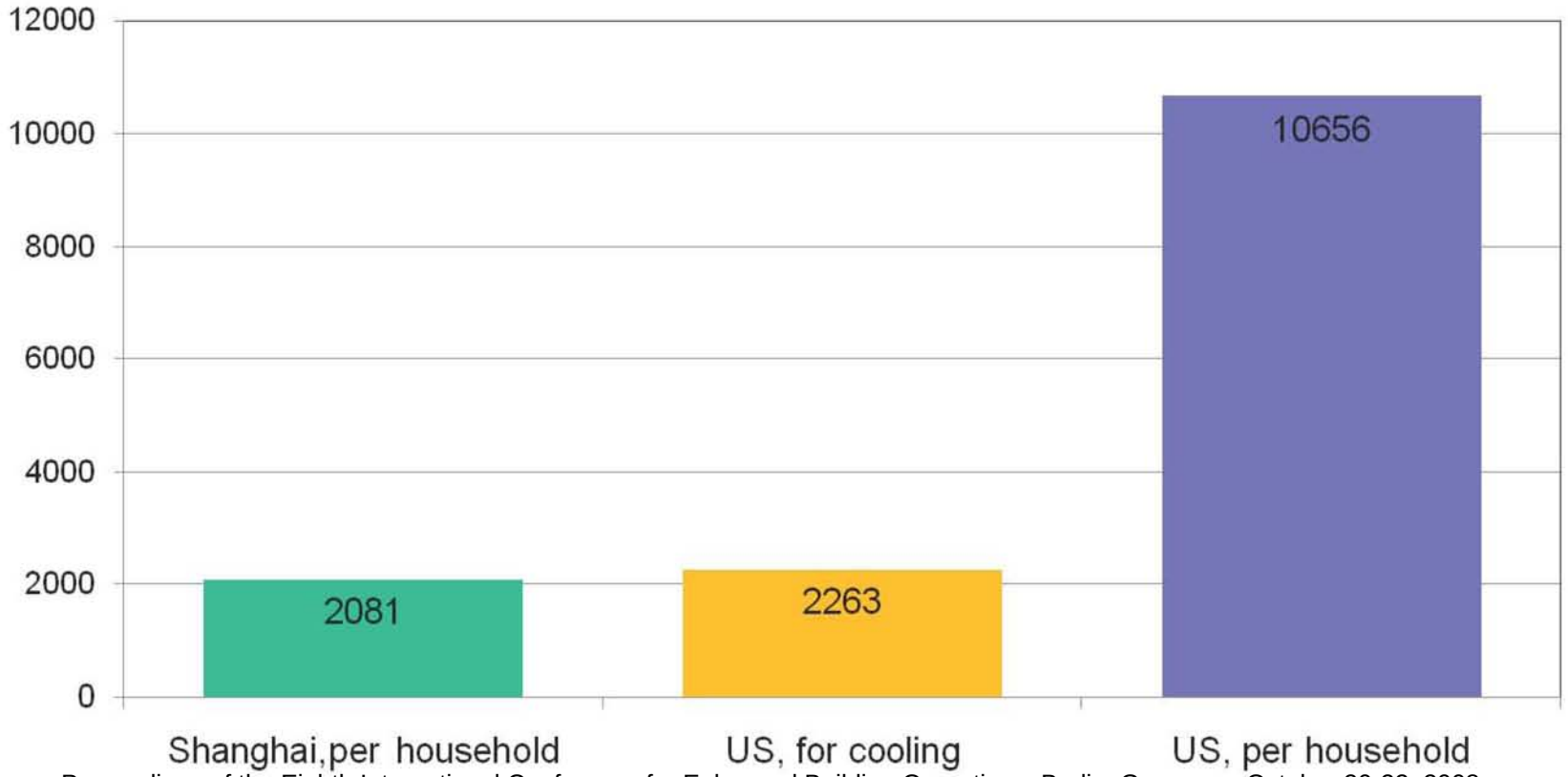
Lower energy consuming level in residential buildings

By surveying among ten thousand households of Shanghai in 2004, average annual primary energy consumption per household is only 973kgce(13.7 kgce/m2a), about one third to one fourth of mean level of US households (3320kgce) in 2001.

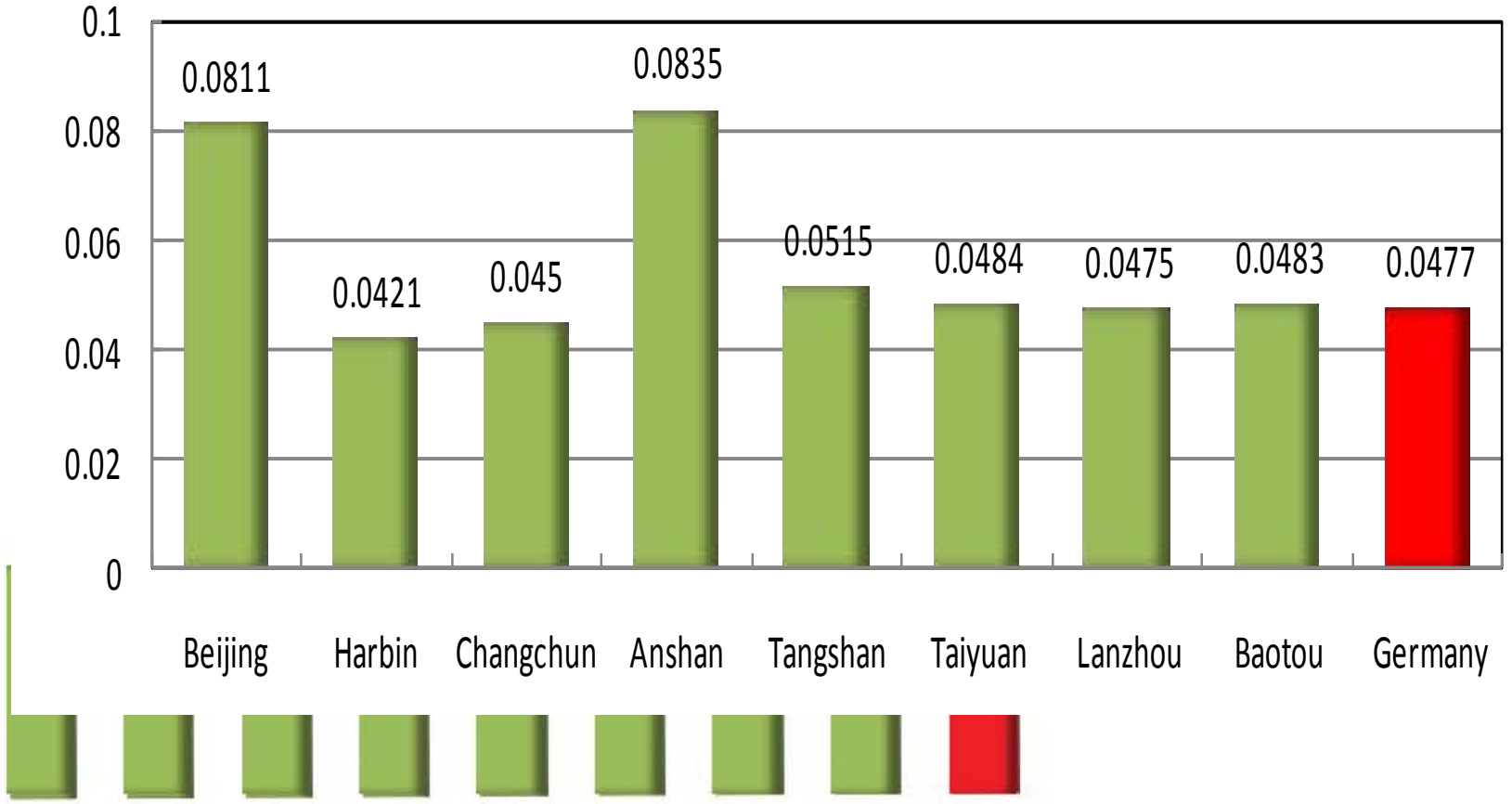


Lower energy consuming level in residential buildings

In 2004, average electricity usage per household in Shanghai is lower than average electricity usage per household of US for cooling, about one fifth of annual electricity consumption per household in US in 2001.



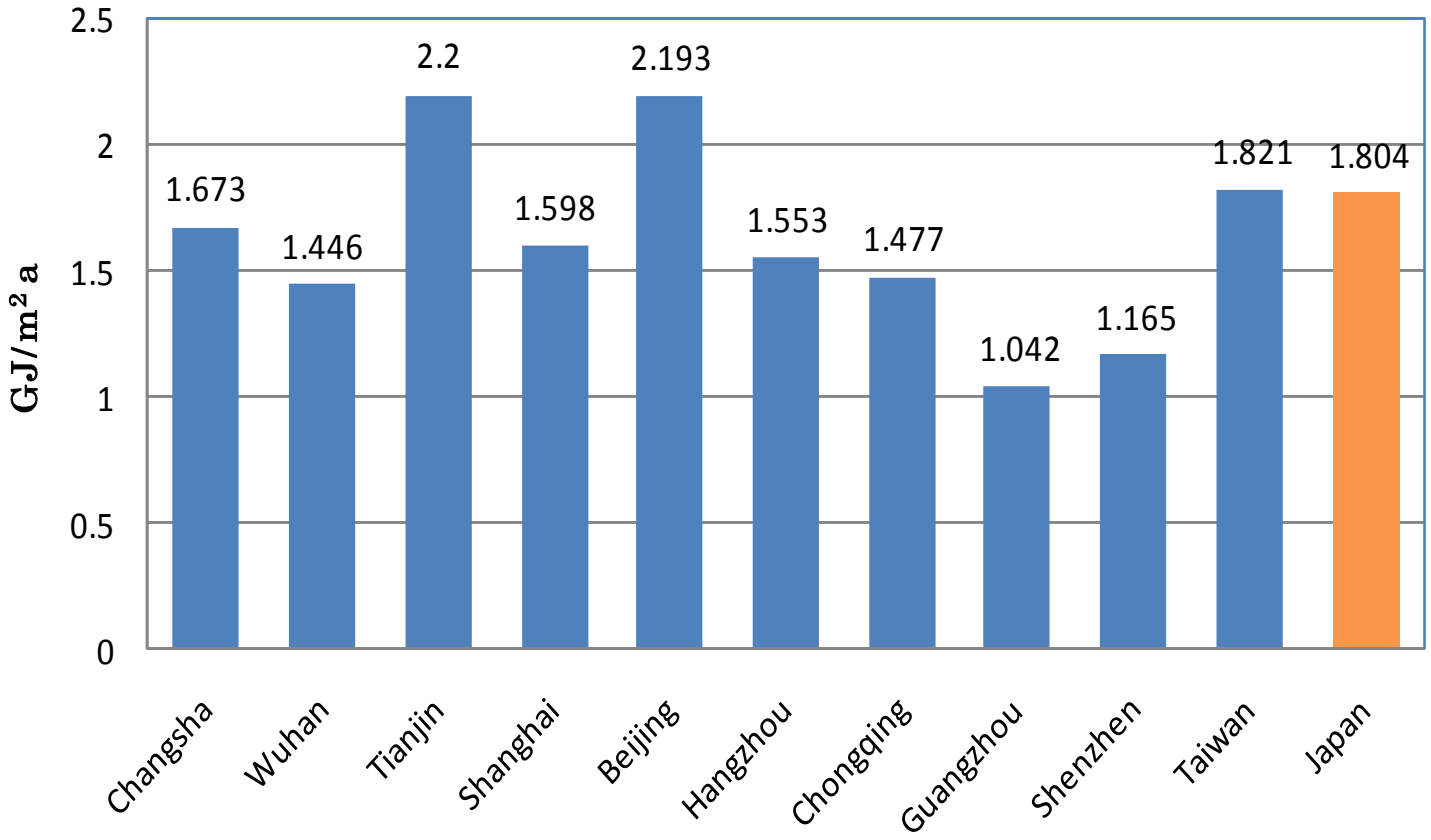
Comparing of energy consumption for heating in residential buildings (kWh/ m^2 HDD)



The people's livelihood problems

- Average annual energy charge paying for Shanghai's households is accounted for 26% of per capita disposable income in lower-income families.
- The room temperature in most households of Shanghai is lower than 14 ℃ in winter, due to poor insulation and intermittent operating of heat pump.
- Most households have turned on their RAC in summer only when the room temperature was higher then 29 ℃. We can learn from surveying data over 80% of housing rooms are out of ASHRAE comfort criteria zone.
- Most households have to suffer indoor humid surroundings higher than 70% during raining season in every June.
- In aged society (the proportion of the aged population in Shanghai is over 20.8% in 2007), non energy consumed measurers are helpless for IEQ improvement.

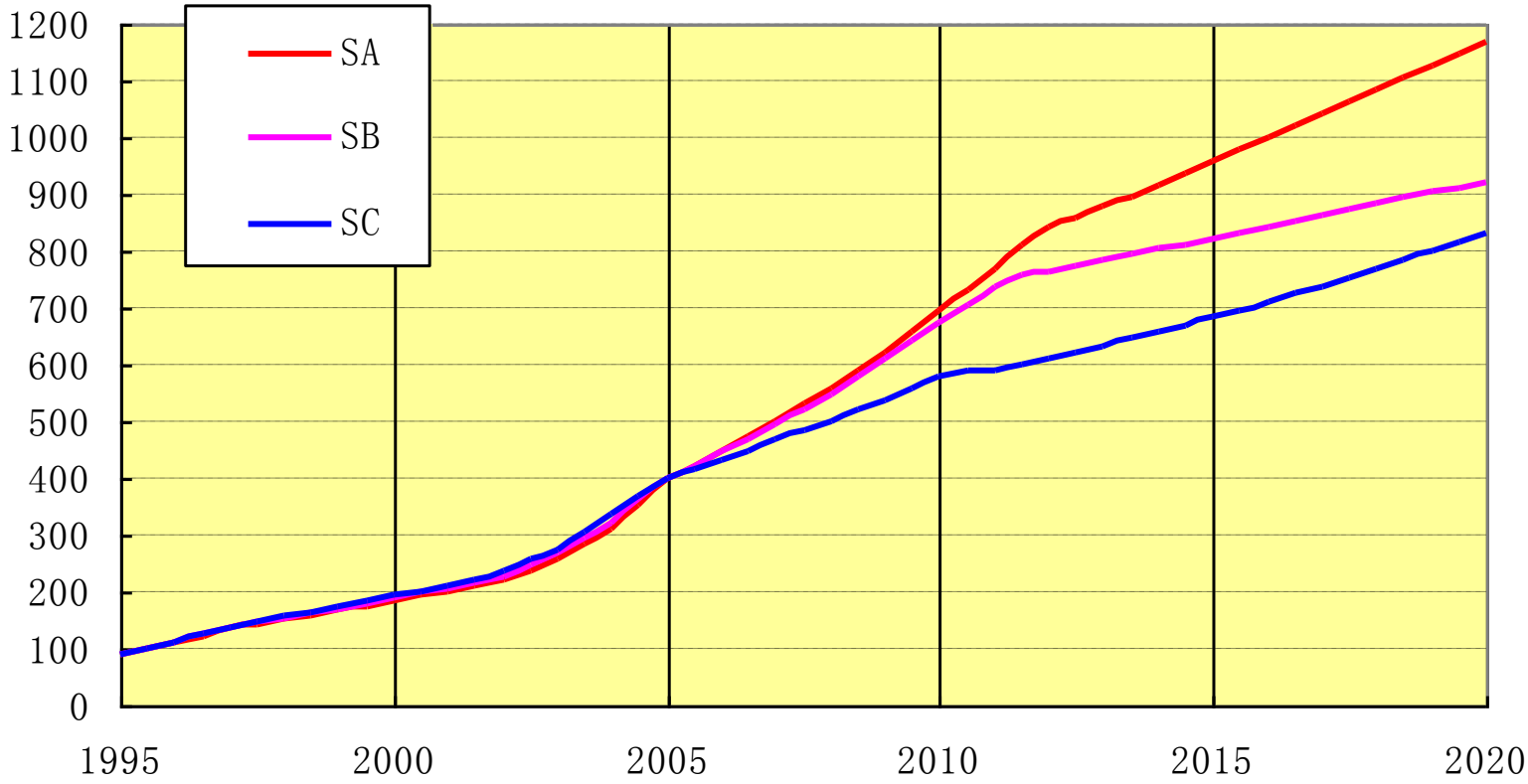
Comparing with the office building in Japan



Limitation of technologies due to weather diversity

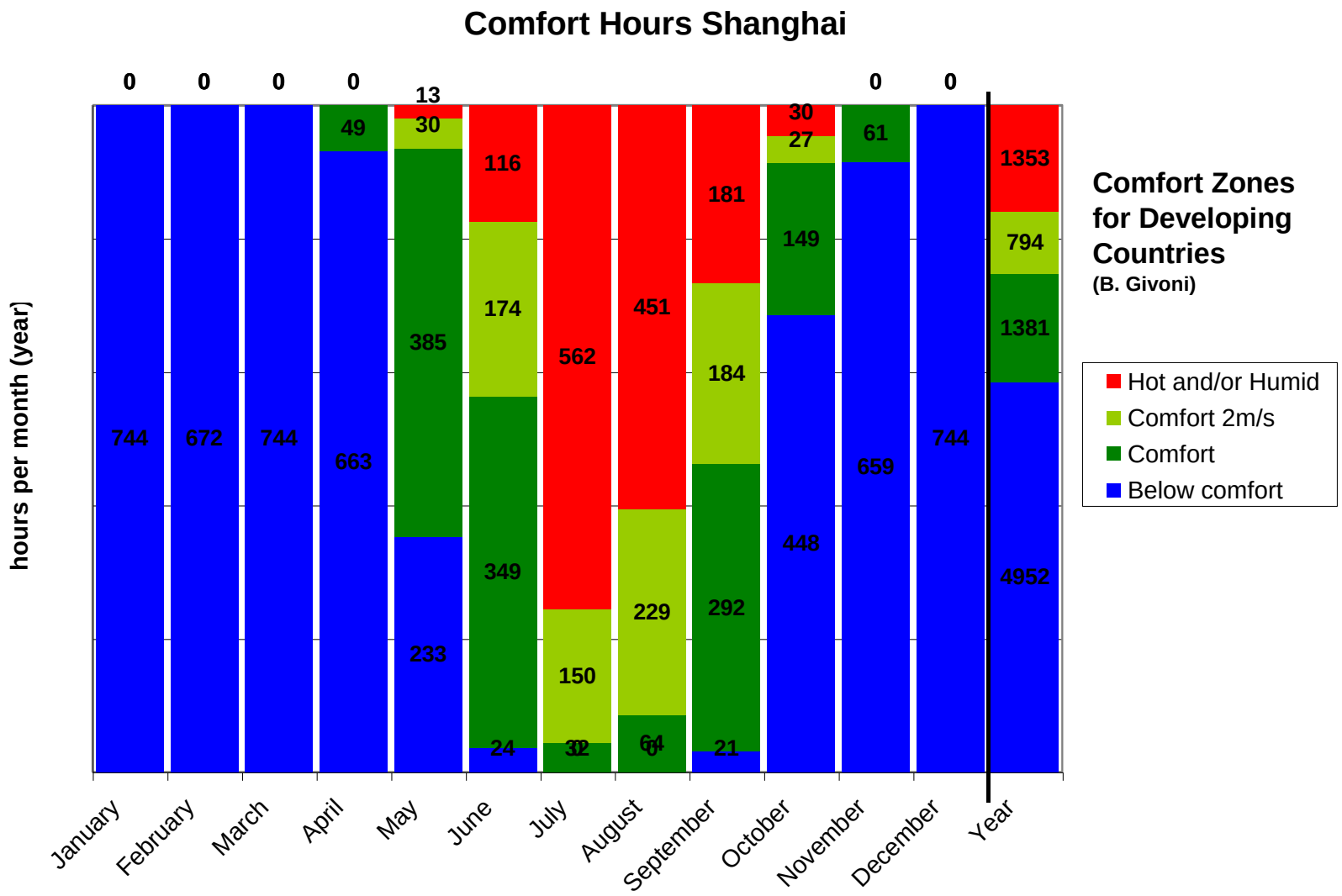
- Natural ventilation
- Solar energy (photovoltaic)
- Daylighting
- Ground source heat pump

Shanghai: energy expenditure prospects of residential buildings by scenario analysis (10^4tce)



SA: normal polices; SB: mild polices; SC: strict polices

Comfort hours with natural ventilation (source: MIT)



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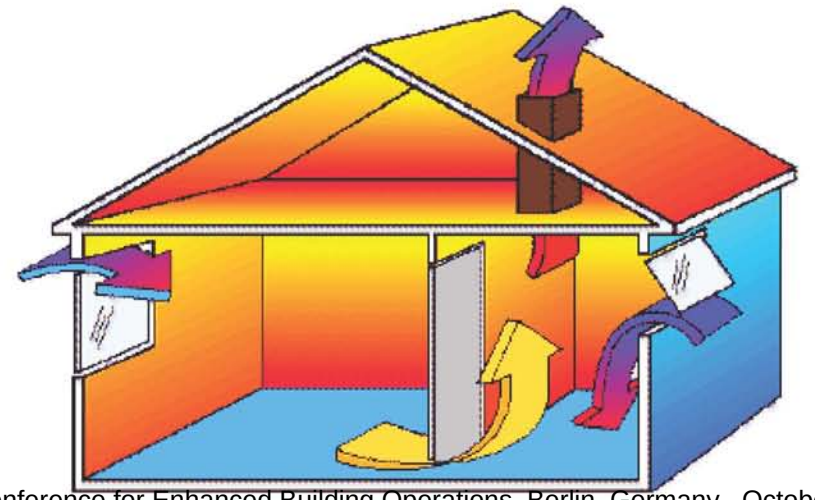
NV is not suitable for most times in Shanghai

- Introduce humid air for growth of mildew and microbe;
- Introduce air polluted by traffic exhaust in downtown;
- Security problems with opening widows in the night;
- Disturbing of strong air flow to dense high-rise buildings in downtown of the metropolises;
- The indoor air flow pattern is not so good organized and designed.



Photovoltaic: an expensive technology for demo

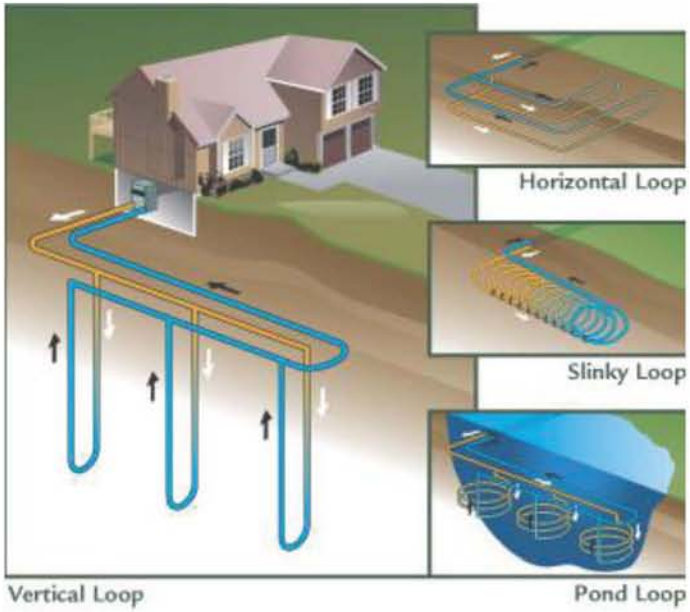
- Duration of equivalent full-load bright sunshine is only 980 hours in Shanghai;
- The cost of photovoltaic is 70,000RMB/kW;
- Electric tariff is about 1RMB/kWh for commercial buildings;
- Pay back period would be 70 years;
- No any benefits for normal investors;
- There are no policies for connecting to outer grid and purchasing (except to projects developed by utilities themselves)

Transparent roof with poor indoor thermal environment

- Transparent roof and/or vault would be with good daylighting but oppressive hot environment in summer.
- In atrium and dome there should be hybrid ventilation and underfloor air supply system.

Ground source heat pump: the heating and cooling load should be carefully balanced

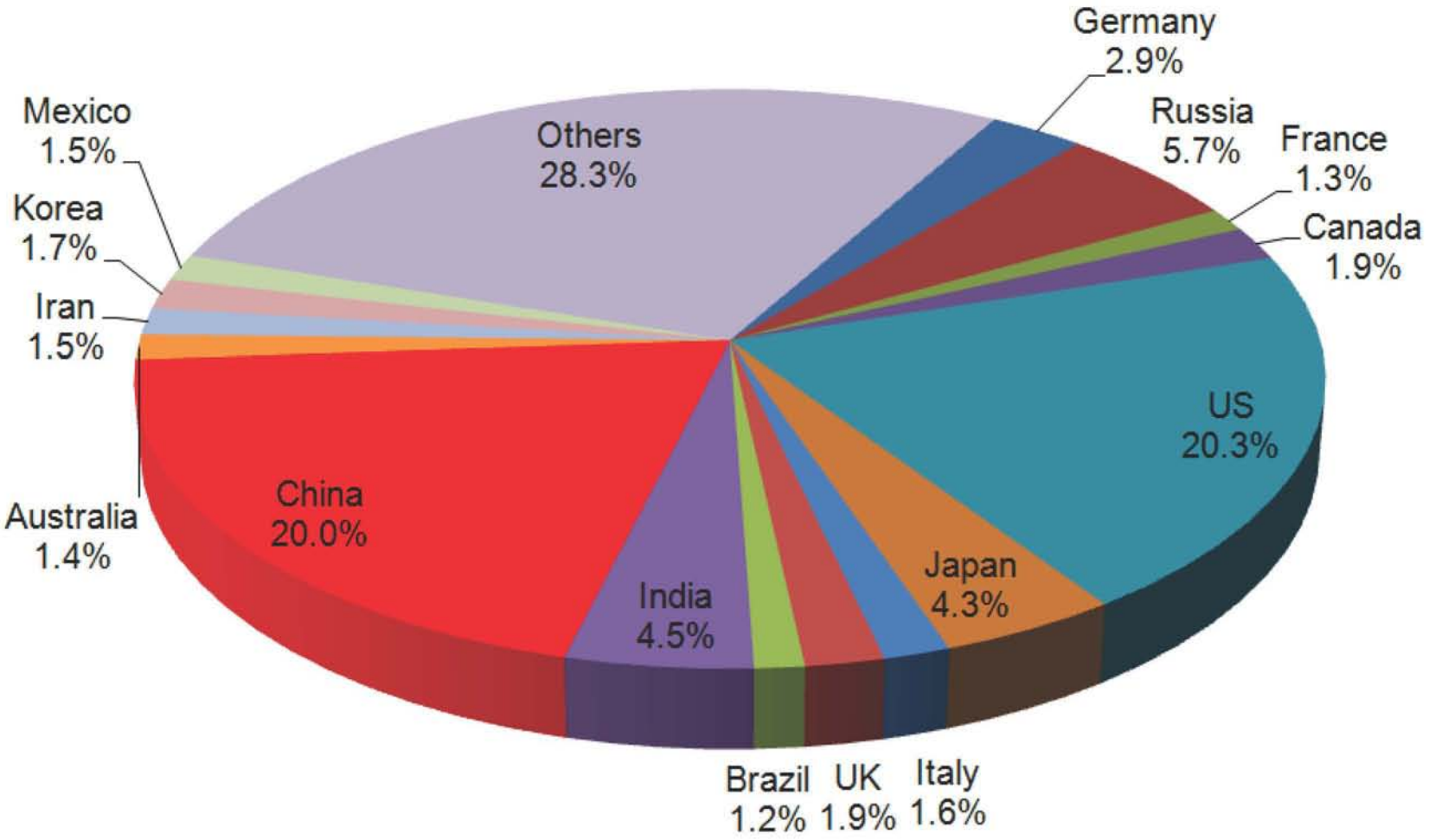
- In Shanghai the cooling load is far higher than heating load.
- The temperature of soil would raise after several years of the heat pump operating
- It is better to determine the size of GSHP according by heating load.
- To supplement in summer by normal chiller with higher efficiency (like centrifugal chiller).



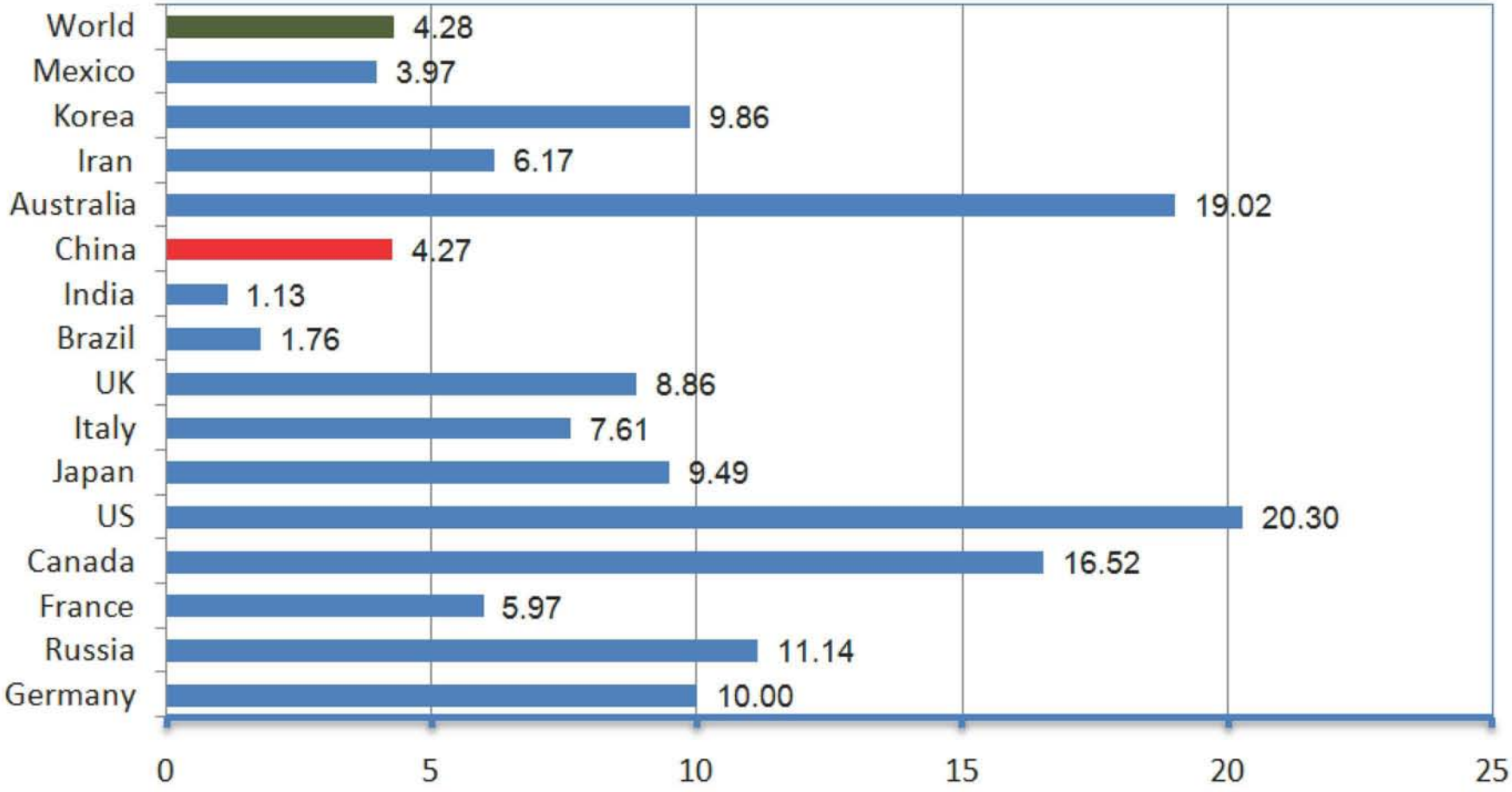
Ranking of the World GHG emissions in 2004

Country	MtCO2	Rank	% of World Total	Tons CO2 Per Person	Rank
United States of America	5,888.7	(1)	19.80%	20.1	(7)
China	5,204.8	(2)	17.50%	4.0	(73)
European Union (25)	4,017.1	(3)	13.51%	8.8	(37)
Russian Federation	1,575.3	(4)	5.30%	11.0	(24)
Japan	1,304.2	(5)	4.39%	10.2	(28)
India	1,199.0	(6)	4.03%	1.1	(122)
Germany	856.6	(7)	2.88%	10.4	(27)
United Kingdom	551.3	(8)	1.85%	9.2	(35)
Canada	549.1	(9)	1.85%	17.2	(10)
Korea (South)	507.0	(10)	1.71%	10.5	(26)

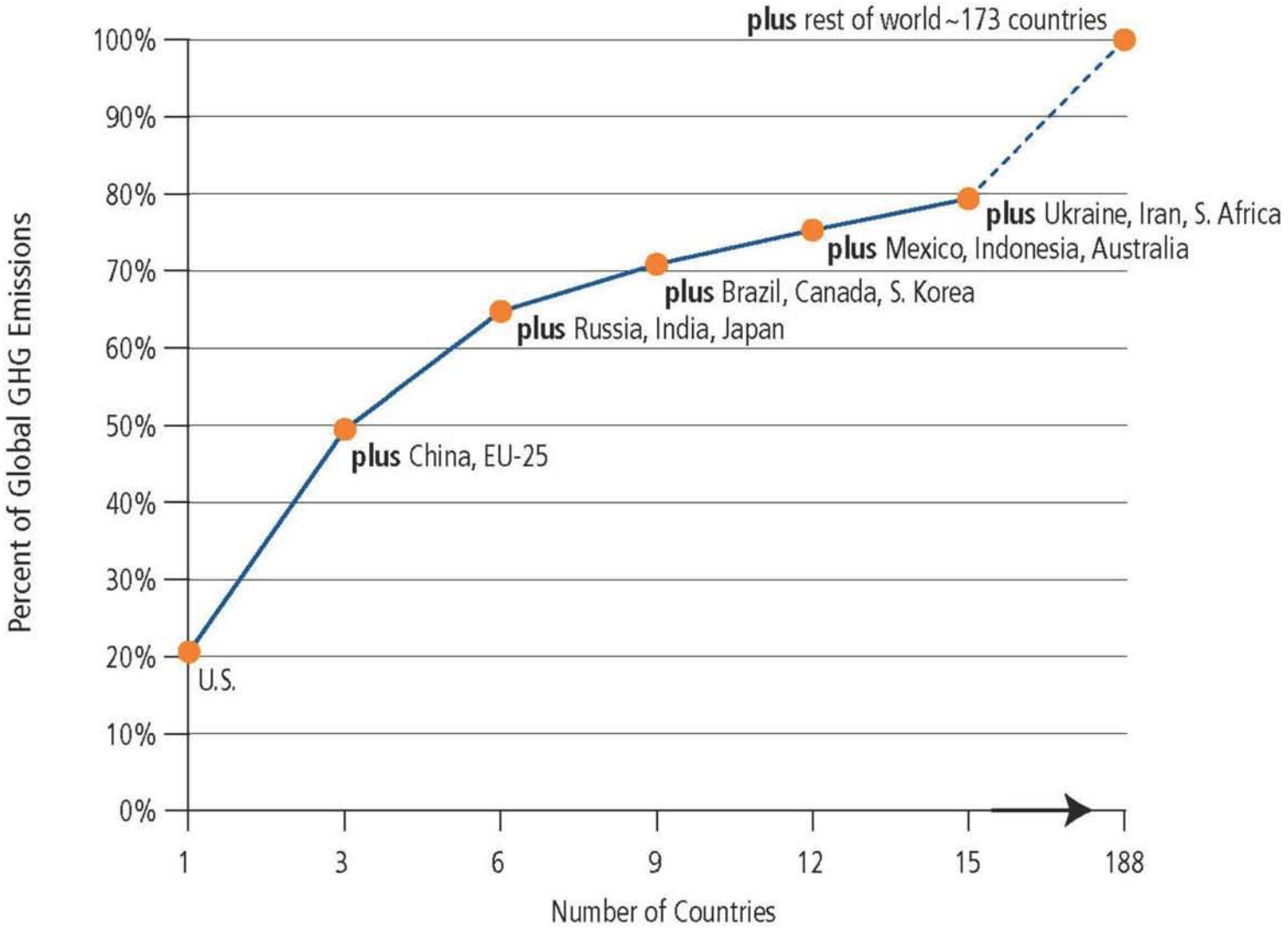
Shares of the World CO_2 emission in 2006



Per capita CO_2 emission (t CO_2/capita) in 2006



The contribution rate for GHG emission



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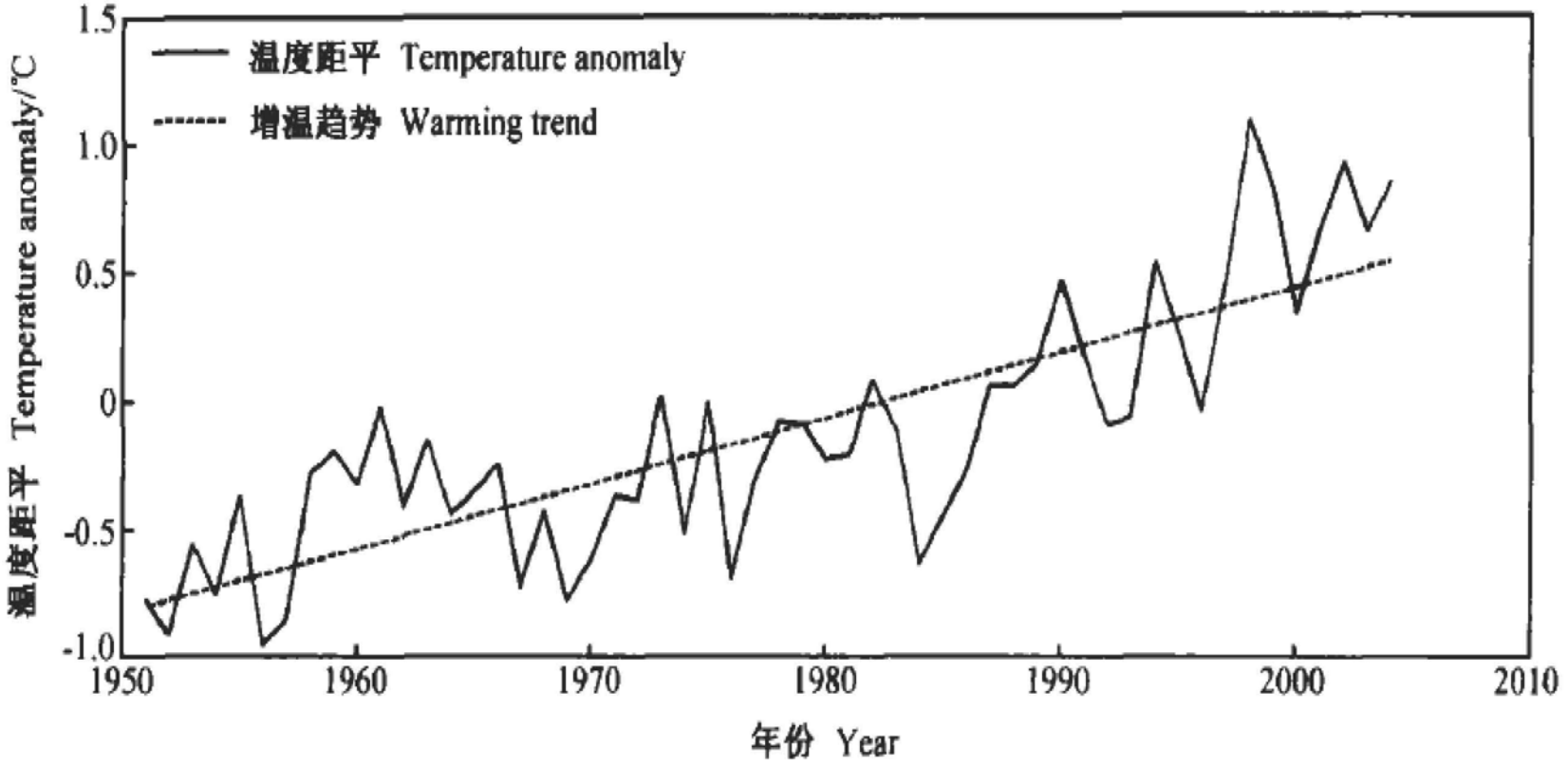
Appalling news

- IEA World Energy Outlook 2007: *China is by far the biggest contributor to incremental emissions (of CO2), overtaking the United States as the world's biggest emitter in 2007.*
- The Netherlands Environmental Assessment Agency (MNP): *With approximately 8% higher emissions than those of the USA, China now tops the list of CO2 emitting countries.*
- By Maximilian Auffhammera and Richard T. Carson from University of California, San Diego, USA: *The size of the increase in emissions of China till 2010 in sharp perspective, it is significantly larger than the decrease in emissions embodied in the Kyoto protocol.*

Climate change of China's mainland during the past 54 years



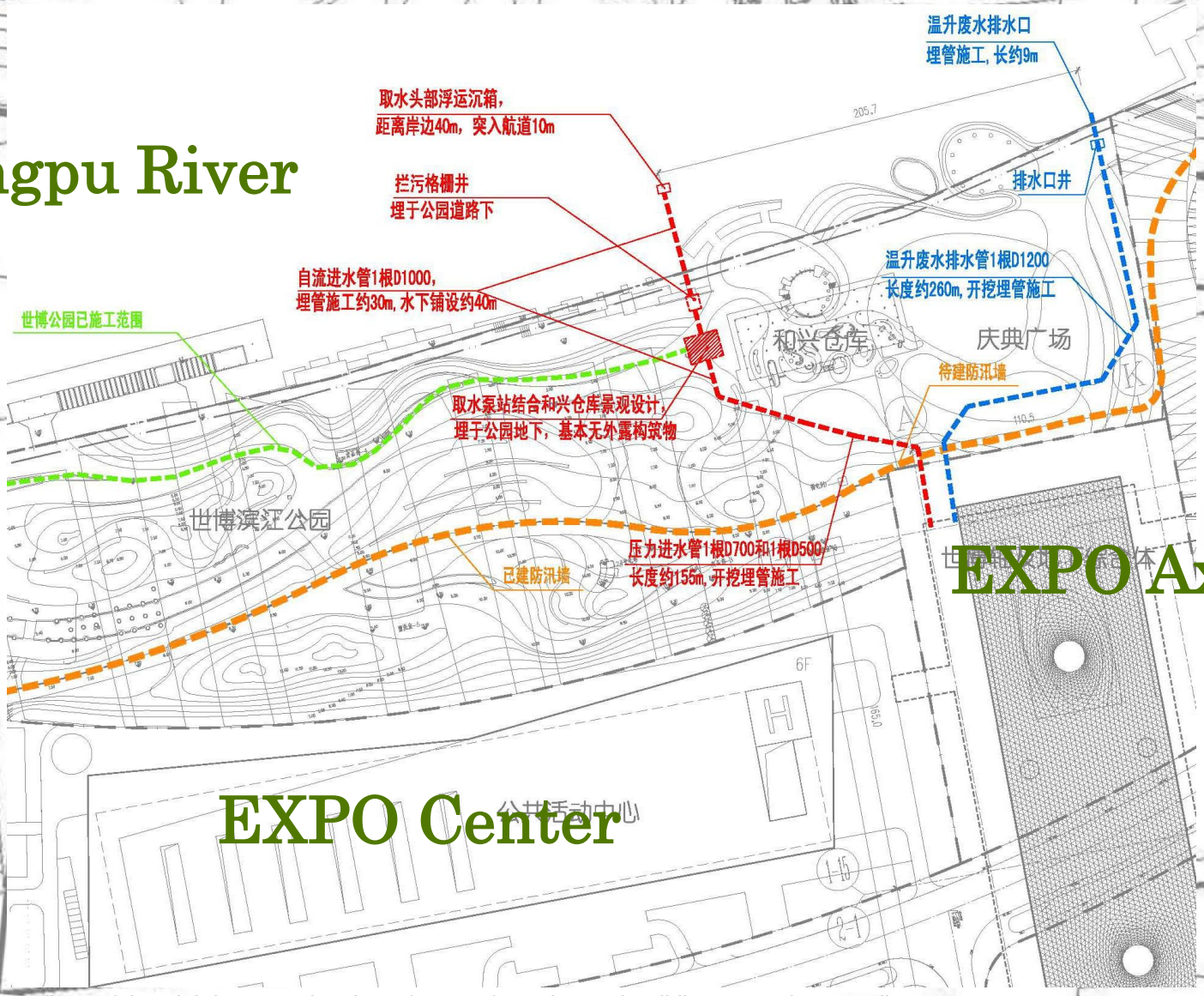
Documents and Statements

- China National Plan for Coping with Climate Change;
- National Assessment Report on Climate Change;
- "*We should ensure that both production and consumption are compatible with sustainable development. We should optimize the energy structure, promote industrial upgrading, develop low-carbon economy, build a resources-conserving and environment-friendly society and thus address the root cause of climate change*," said the Chinese president Hu at APEC meeting 2007.

Projects

- Energy system in Shanghai 2010 Expo Park
- Low carbon economy demonstration zone in Chongming Island
- Guide for low carbon community energy planning
- Collaborative projects with Siemens

River water source distribution system for heat pump

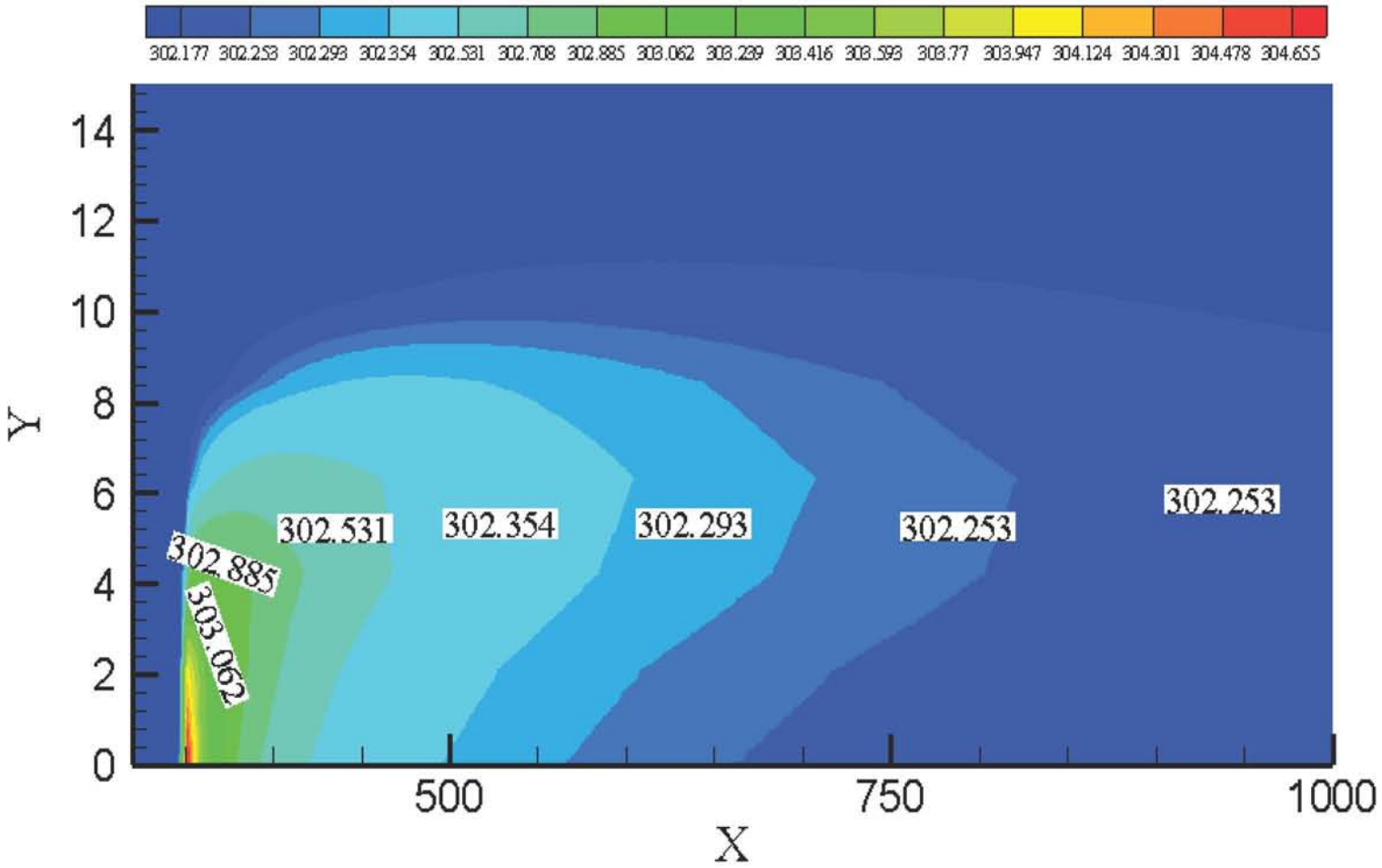


Huangpu River

EXPO Axis

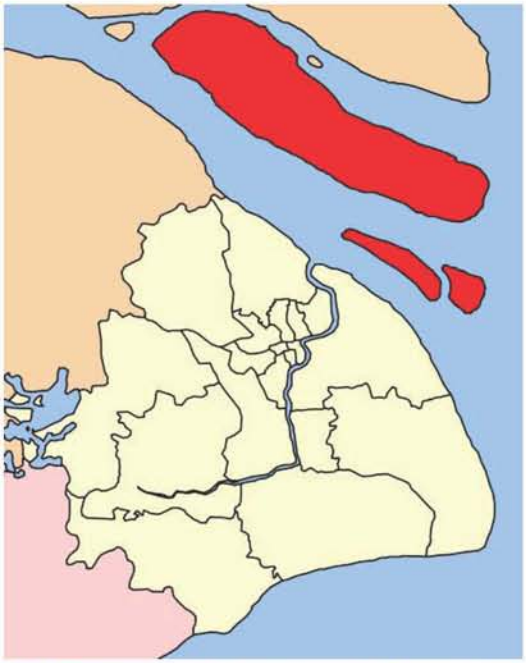
EXPO Center

Impact of condensing water outlet to the river



Shanghai EXPO Axis and EXPO Center

Low carbon demonstration zone: Chongming Island



The project

- Title: *Research on industry developing, application of know-how integrated technologies and demonstration in Chongming low-carbon economy demonstration zone*
- From Ministry of Science & Technology (MST)
- Would be one of the national major key projects
- Duration would be 3 years (till 2011)
- Budget would be several decades million RMB
- Should give demonstrations
- Tongji would be major or exclusive institution to undertake and implement the project
- Status:
  - The feasibility analysis report has been finished;
  - The project will be decided before end of this year.

Project structure and contents

Low carbon economy

Demonstration in Chongming Island

Subprojects: Energy

- Methodology of IRP (Integrated Resources Planning) using in community energy planning for low-carbon park in Chongming Island.
- Community-oriented system technologies integrating renewable energy & unused energy.
- Demonstration of integrated energy system (trigeneration) based on biomass energy.

Principal of community energy planning: Energy efficiency as a resource

Virtual resources

EPSRC Dongtan Sustainable City Networks

- The UK Engineering and Physical Sciences Research Council.
- UK universities
- China universities
- ARUP

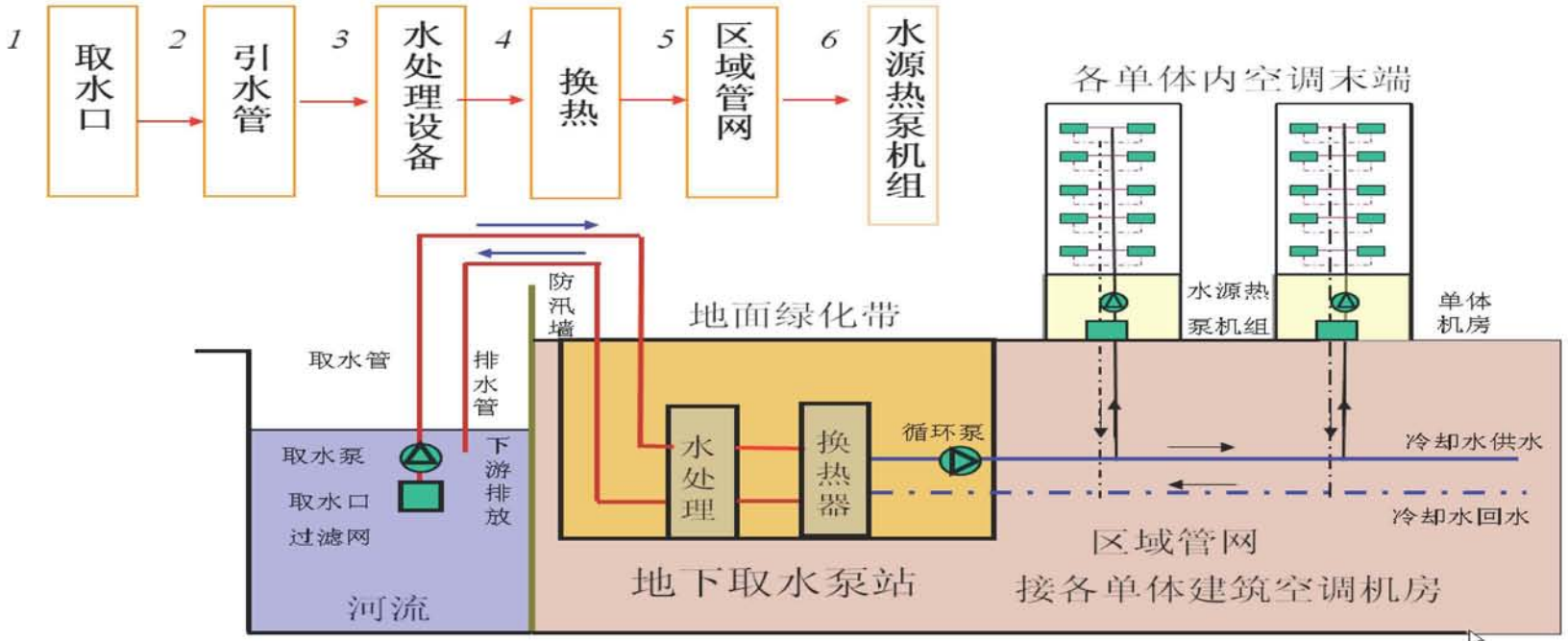
Research Area	Network
Governance, culture and space	CHaMSpaM (City History and Multi-scale Spatial Master-planning)
Economics, environment and regional context	ECOCIT (Sustainable Economic and Ecological Models for Peripheral Urban Functional Units)
Sustainable infrastructure and behaviour adaptation	SUSTAIN (Sustainable Urban Systems to Transfer Achievable Implementation)

Collaborative project with SIEMENS: Qingdao ecological community

- Siemens/Tongji/Government of Qingdao/ARUP
- 3.5 hectares
- 60,000 m2 floor space residential
- 6,000 m2 floor space commercial
- Self-sufficient
- Zero-waste

Low carbon technologies: should be studied

- Temperature difference: solar collector vs. thermal cooling
- Concentrated usage mode of low exergy & renewable energy
- Micro grid for distributed & multipoint energy sources
- DCHP (district cooling/heating/power): load matching & system optimization
- DCW (distributed condensing water) or Energy Bus system
- Baseline of CO2 emission from buildings

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