


# Sustainability of Building Energy in China by Professor Long Weiding

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## Sustainability of Building Energy in China



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- ◆ China: Dramatic Growth of Building Construction Industry
- ◆ China: Energy Status in Building Sector

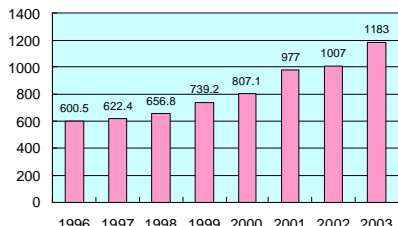
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## Urbanization

- ◆ Rate of population lived in cities and towns in 2003: 40.53%;
- ◆ It would be reached to 60% in 2020;
- ◆ 660 cities and 19 thousands towns by the end of 2002;
- ◆ 33 metropolises with population above 2 million for each.

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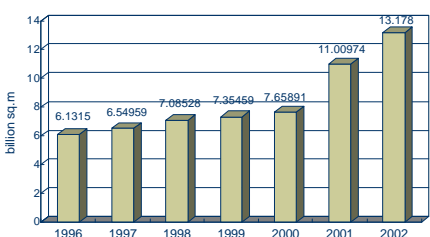
## Large scale of building construction in cities & towns



**Floor space of new buildings completed each year (million m<sup>2</sup>)**

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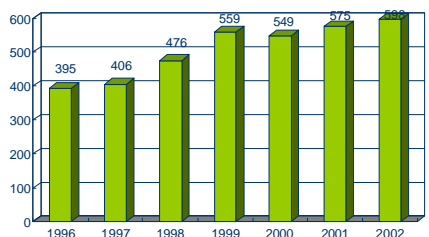
## Total floor space of buildings in cities & towns



**billion sq.m**

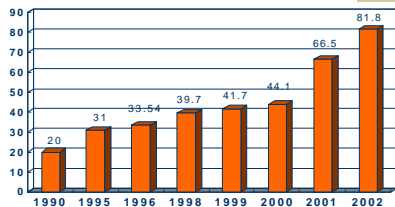
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## Floor space of new residential buildings in urban area (million m<sup>2</sup>)



**million m<sup>2</sup>**

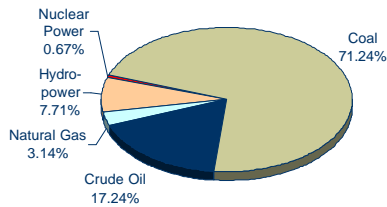
Total floor space of residential buildings in cities & towns ( $10^8\text{m}^2$ )



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.**
- A vast majority of these projects are very large, such as commercial office buildings between 1 to 1.5 million ft<sup>2</sup> and residential developments involving 5 million ft<sup>2</sup> of construction area.
- 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.**

Percentage of total energy consumption (2002)



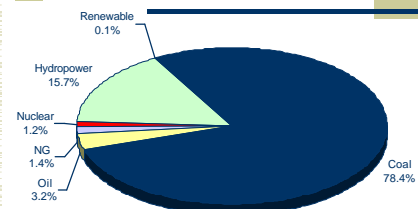
China: electric industry

- 2002:**
  - Generation capacity 353 GW
  - Power supply 1640 TWh
- 2003:**
  - Generation capacity 386 GW
  - Power supply 1910.8TWh
- Growth rate of power consumption was 16.5%; but growth rate of GDP was only 9.1%**

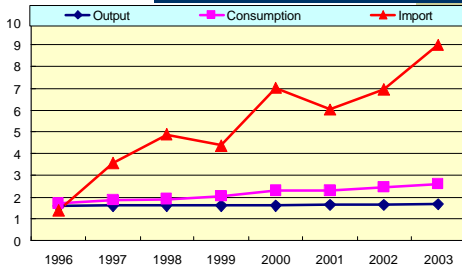
Per capita electric consumption

- Only half of mean level of the World**
- 2001: World 2316kWh vs. China 1094kWh**
- By the end of 2003, there are still about 29,000 villages with about 7 million rural households (about 3.55% of the total population) which are not connected to the grid.**

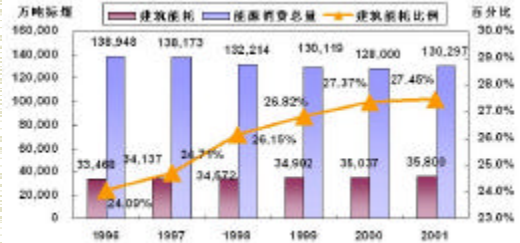
Fuel structure of electricity generation in 2001



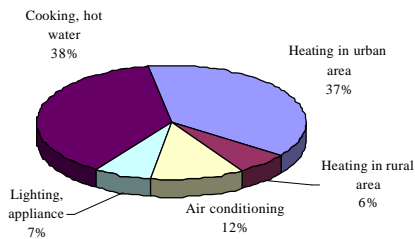
### Oil: Output (10<sup>8</sup>t), Consumption (10<sup>8</sup>t) and Import (10<sup>7</sup>t)



### Percentage of building energy consumption in total energy consumption



### Proportion of building energy consumption in 2001



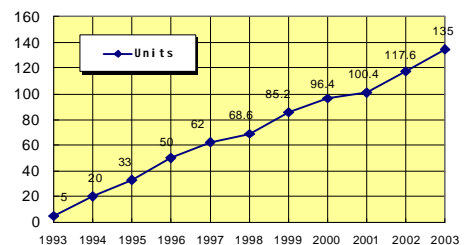
### Serious crisis of electric shortage in coming summer

- ◆ From January to April, the growth rate of electric consumption is 16.7% comparing with the same period last year.
- ◆ The power plants, transformer substations and grids are all top loading.
- ◆ It is estimated the shortage would be 30GW.
- ◆ In most metropolises, 40% of peak load is for air conditioning.

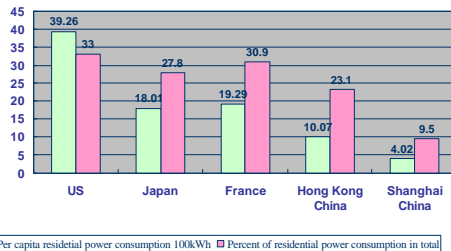
### Possession of air conditioners per hundred families (2002)

Province/City	Per capita annual disposable income	Units of RAC
Guangdong	11137.20	125.54
Shanghai	13249.80	113.87
Chongqing	7238.04	106.89
Beijing	12463.92	106.46
Zhejiang	11715.60	81.64
Tianjin	9337.56	76.78
Fujian	9189.36	74.45
Hubei	6788.52	70.52
Jiangsu	8177.64	67.40
Anhui	6032.40	50.65
Average nationwide	7702.80	51.10

### Growth of RAC possession per hundred families (Shanghai)



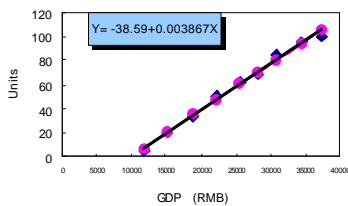
### Comparison of residential power consumption



### Pollution caused by household RAC

- ♦ Possession of household RAC in Shanghai: 85.2 units per hundred families in 1999 (4.5 million families);
- ♦ Assume 1,000 full-load operating hours per units per year in average;
- ♦ 30,000 tons SO<sub>2</sub> emission, almost equal to two times of total emission amount in Hainan Province in 1997;
- ♦ 5.1 million tons CO<sub>2</sub> emission, almost equal to total emission amount emitted by the whole nation of Georgia or Bosnia in 1998.

### Relation between possession of RAC per hundred families and increment of GDP



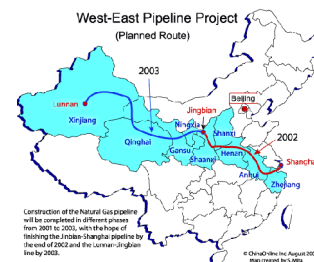
### Impact on Environment

- ♦ Possession of household RAC in Shanghai: 85.2 units per hundred families in 1999 (4.5 million families);
- ♦ Assume 1,000 full-load operating hours per units per year in average;
- ♦ 30,000 tons SO<sub>2</sub> emission, almost equal to two times of total emission amount in Hainan Province in 1997;
- ♦ 5.1 million tons CO<sub>2</sub> emission, almost equal to total emission amount emitted by the whole nation of Georgia or Bosnia in 1998.

### Open Coastal Cities and Special Economic Zones

- ♦ If the Possession of household RAC reached to 1 unit per family in Open Coastal Cities and Special Economic Zones, it could be estimated that the electric demand will be 25GW.
- ♦ Also assume 1,000 full-load operating hours per units per year in average, CO<sub>2</sub> emission would be 35million tons.
- ♦ Higher than the total amount emitted by the whole nation of Vietnam in 1998.

### West-East Natural Gas Transportation Pipeline



## Natural Gas Plan



## Building Energy Trends (1): Natural Gas

- ◆ B CHP (Building Cooling Heating Power) and D CHP (District Cooling Heating Power)
- ◆ DER (Distributed Energy Resources) using natural gas
- ◆ Gas cooling

## Potential of Renewable Energy Resources

- ◆ Hydraulic: 378million kW
- ◆ Solar Energy:
  - Radiant intensity in 2/3 area: 0.6MJ/cm<sup>2</sup>
  - Energy equivalent: 17 Trillion tons of standard coal
- ◆ Wind Energy: 1.6TW
- ◆ Geothermal Energy Reserves: 1.3711T tons see

## Building Energy Trends (2): Renewable Energy

- ◆ Solar water heater:
  - 15million m<sup>2</sup> totally;
  - Would be reached to one hundred million m<sup>2</sup>
- ◆ Solar energy absorption and adsorption chiller; solar energy aided heat pump chiller
- ◆ Photovoltaic
- ◆ Biomass energy absorption chiller
- ◆ Geothermal heating and ground source heat pump

## Building Energy Trends: Energy Efficiency

- ◆ Residential and public building design standard for energy efficiency
  - Residential: cold, hot summer and cold winter, hot summer and warmer winter climate zones respectively
  - Public: will be published by the end of this year
- ◆ Grading of chiller and RAC energy efficiency standard

Comparison of envelop heat transfer coefficients between China and other countries

Country			Roof	Wall	Window
China	Beijing	Original	0.91	1.28	6.40
		New	0.60	0.82	4.00
	Harbin	Original	0.64	0.73	3.26
		New	0.30	0.40	2.50
Sweden			0.12	0.17	2.00
Canada			0.31	0.27	2.22
			0.40	0.38	2.86
Denmark			0.20	0.35	2.90
UK			0.45	0.45	--
Japan	Hokkaido		0.23	0.42	2.33
	Tokyo		0.66	0.87	6.51
Germany			0.22	0.50	1.50

National Standard  
— grading of chiller energy efficiency

Type	Rating cooling capacity (CC) kW	Grade of energy efficiency (EER, W/W)				
		1	2	3	4	5
Air source /evaporative cooling	CC= 50	3.2	3.0	2.8	2.6	2.4
	50<CC	3.4	3.2	3.0	2.8	2.6
Water source	CC= 528	5.0	4.7	4.4	4.1	3.8
	528<CC= 1163	5.5	5.1	4.7	4.3	4.0
	1163<CC	6.1	5.6	5.1	4.6	4.2

National Standard  
— grading of RAC energy efficiency

Type	Cooling Capacity (W)	Grade of Energy Efficiency				
		5	4	3	2	1
Window		2.3	2.5	2.7	2.9	3.1
	≤4500	2.6	2.8	3.0	3.2	3.4
Split	4500~ 7100	2.5	2.7	2.9	3.1	3.3
	7100~ 14000	2.4	2.6	2.8	3.0	3.2

Green Building Technology

- ◆ Assessment handbook for ecological residential building technology (referenced to LEED)
- ◆ Assessment system for green building of Beijing Olympic (referenced to CASBEE)



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