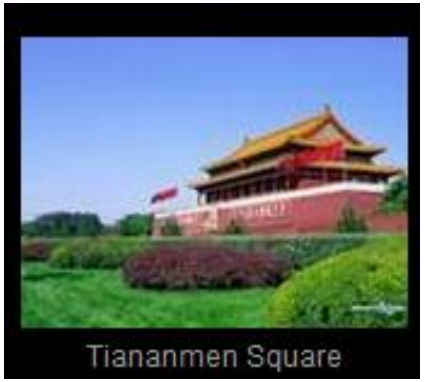
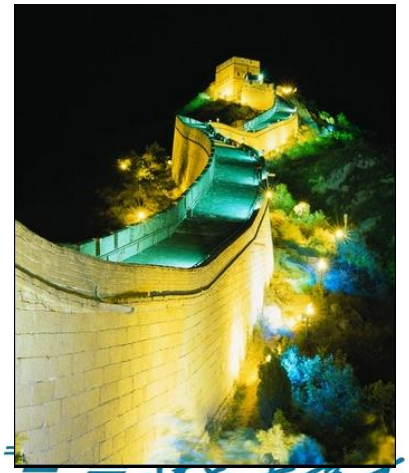
Solid waste management in China & Community Carbon Emissions in Beijing

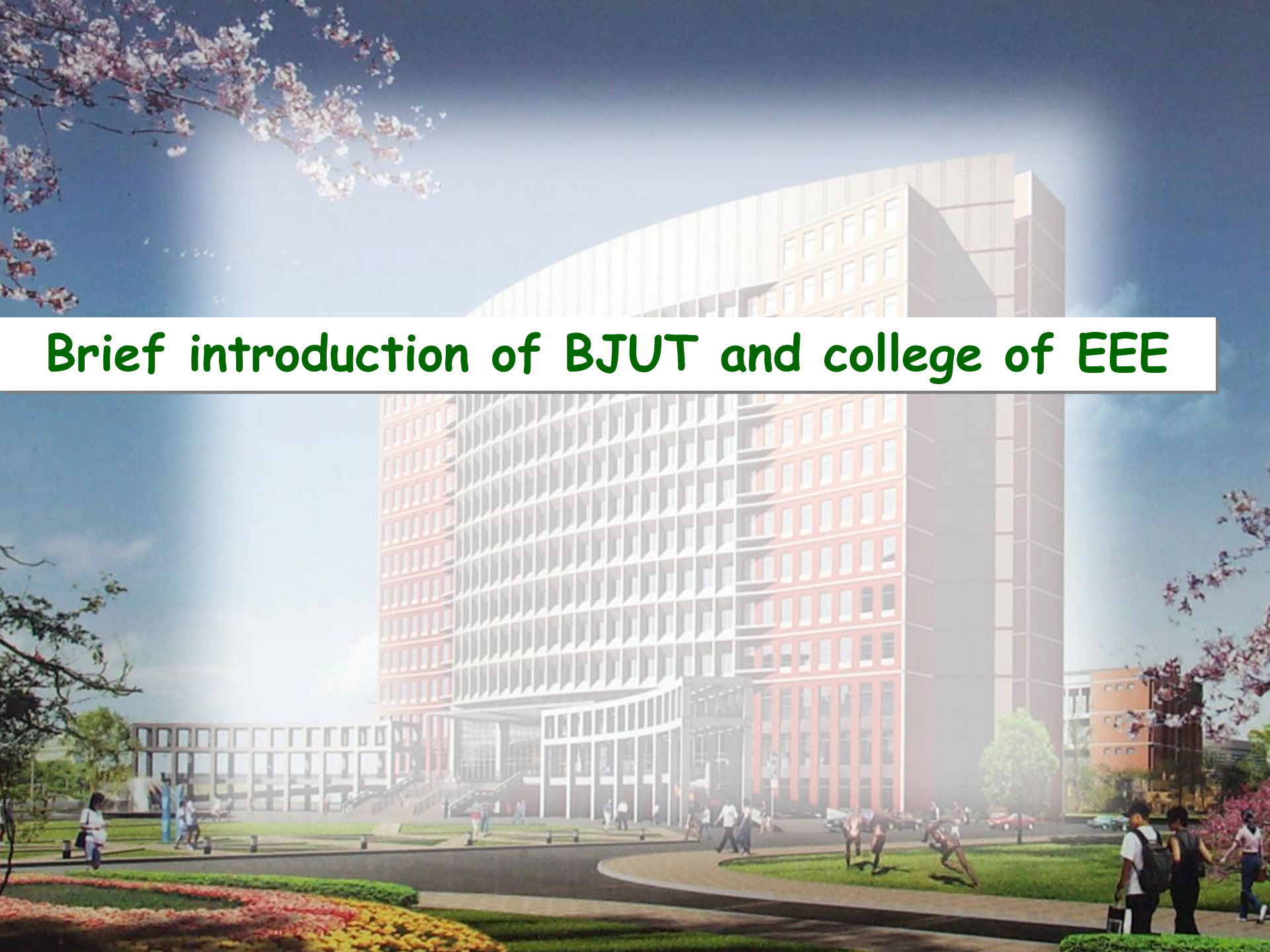
Chen Sha

Spring.21.2014

- **Brief** introduction of BJUT and college of EEE
- **Municipal Solid waste management in China**
- **Community Carbon Emissions in Beijing**







Brief introduction of BJUT and college of EEE

About BJUT

Beijing

- 3,000 years history

Population: more than 21 million

Areas:16,808 km^2

Center of national politics and culture

Center of international communication

Center of technology innovation

About BJUT

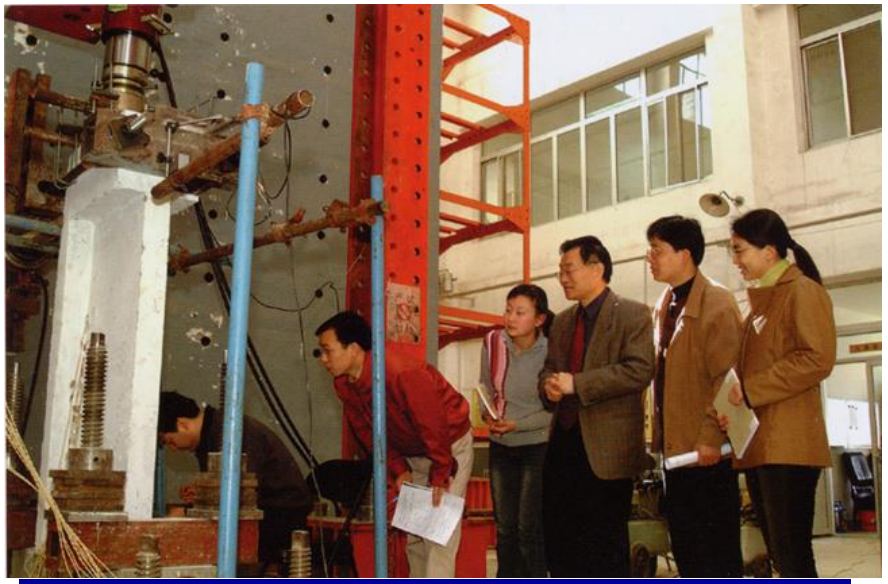
- Founded in 1960
- 21 schools or colleges
  - Electromechanical Engineering
  - Electronics and Information
  - Computer Science and Technology
  - Building and Civil Engineering
  - Environmental and Energy Engineering
  - ……
- More than 16,000 Bs students and 5,000 Ms PhDs

北京工業大學
BEIJING UNIVERSITY OF TECHNOLOGY

BSL－3（Bio-safety）lab

Laser technology research center

Key lab of new functional materials



Anti-seismic lab

About EEE College

- College of Environmental & Energy Engineering
  - Founded in 1999
  - 6 departments and 1 Experiment Centre
    - Environment Engineering
    - Environmental Science
    - Chemistry & Chemical Engineering
    - Cryogenic & Refrigeration Engineering
    - Internal Combustion Engine and Vehicle Engineering
    - Environmental Energy Engineering Institute
    - Chemistry Experiment Centre

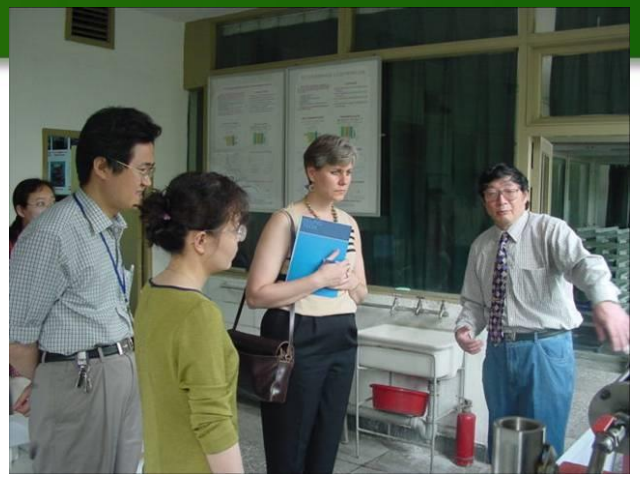
About EEE College

- Covers chemistry, environment and energy
- About 120 stuff
  - 75 faculty members
  - 700 undergraduates
  - 400 graduates
  - Annual research funding: RMB 40 million(2013)

About EEE College

- 4 PhD programs
  - Environmental Engineering
  - Environmental Science
  - Thermal Engineering
  - Applied Chemistry

About EEE College



- 6 master programs
  - Environmental Engineering
  - Environmental Science
  - Thermal Engineering
  - Cryogenic and Refrigeration Engineering
  - Chemical Engineering and Technology
  - Physical Chemistry

About EEE College

- 4 bachelor programs:
  - Environmental Engineering
  - Environmental Science
  - Applied Chemistry
  - Thermal Power Engineering
    - Refrigeration and Cryogenic Engineering
    - Vehicle Engineering
    - Renewable Energy Technology

北京工業大學
BEIJING UNIVERSITY OF TECHNOLOGY

MSW management and recycling in China

The characteristics of MSW in China

The largest amount of municipal waste generation in the world, but the development of disposal and treatment of MSW is relatively backward.

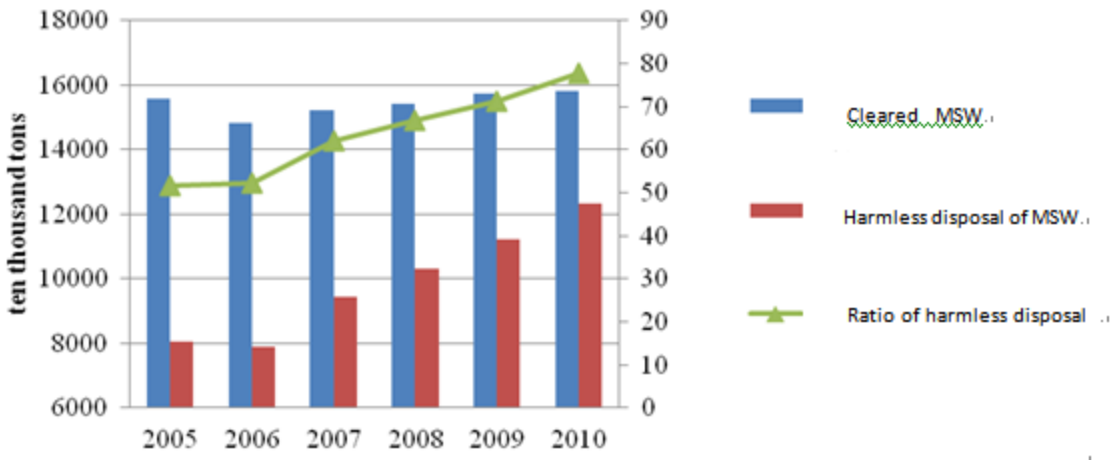


Figure 1. The Amount of Cleared MSW and Harmless Disposal from 2005 to 2010

Resource： National Bureau of Statistics of China(2005-2010). Index Statistics of the national Household Garbage.

In 2010, cleared MSW was 158 million tons while the counties and town's garbage was more than 7million tons, which increased at 8%-10% rate per year and by 2030 this amount is projected to be at least 585 million tons.

Before the waste is collected and transported by the sanitation sector, some of the higher value waste is diverted through two ways:

1.Collected and sold by units and residents ,such as some package waste, waste paper and books.

2. Scavengers collect valuable wastes from the garbage bins or packaging centers.

It was estimated that recyclable wastes accounted for 10–15% of the total amount of cleared MSW.

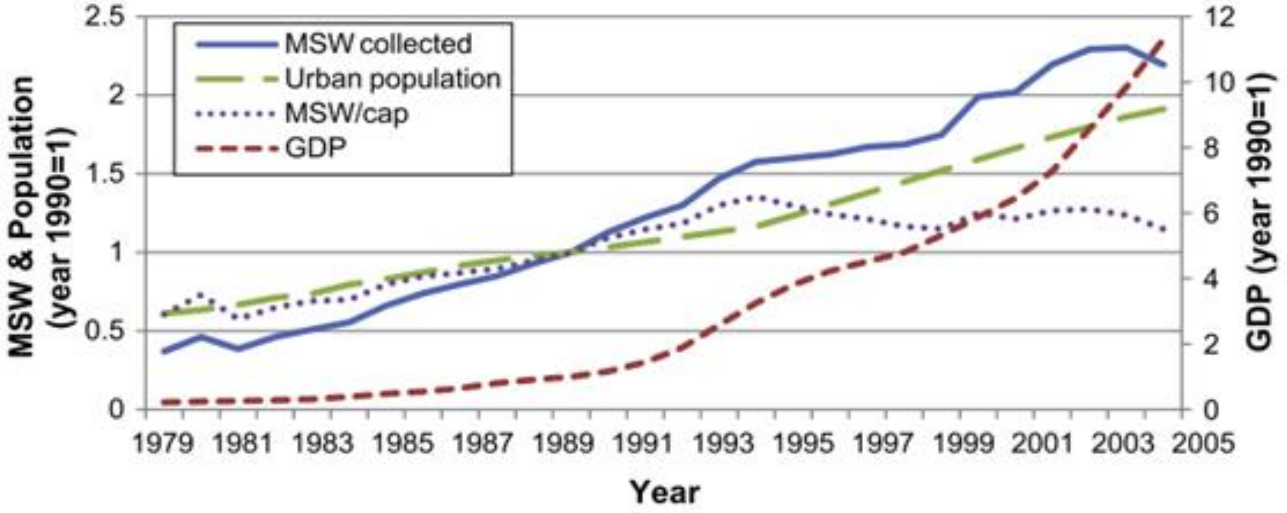


Fig2. Relation of collection of MSW with the population growth and GDP[]

Waste Management. 30. pp. 716-724

After 1990, the impact of the population on MSW is far greater than the impact of GDP, which is mainly a result of increasing municipal waste recyclable.

The average MSW generation in big cities in China is about 1.0-1.5kg per capital per day.

- **This unprecedented increase in waste generation is also adding a significant financial burden to cities' budgets. Based on current solid waste plans, China faces a potential 10-fold increase in its countrywide waste management budget by 2030, going from a currently estimated RMB 50 billion to about RMB 500 billion.**
- **In 2030, if China were to provide waste management services comparable to those in Organization for Economic Co-operation and Development (OECD) countries, annual estimated costs would be approximately US$77 billion, of which half would be used for collection and half for disposal.**

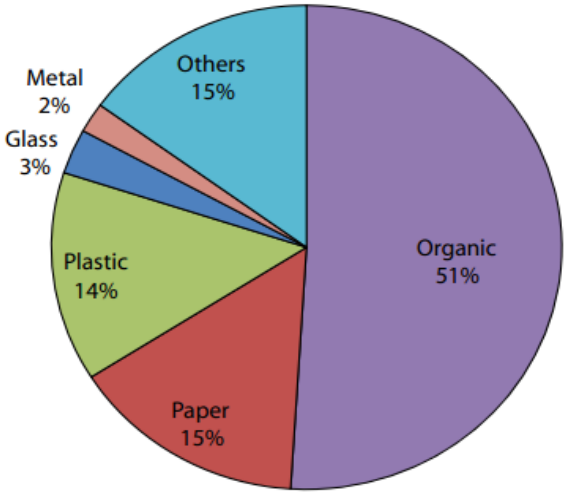


Fig. Projected MSW Composition in Urban Areas of China, 2030 (585 million tons)

Source: World Bank 2005.

The amount of new types of solid waste is dramatically increasing, but lack of efficient treatment and management system.

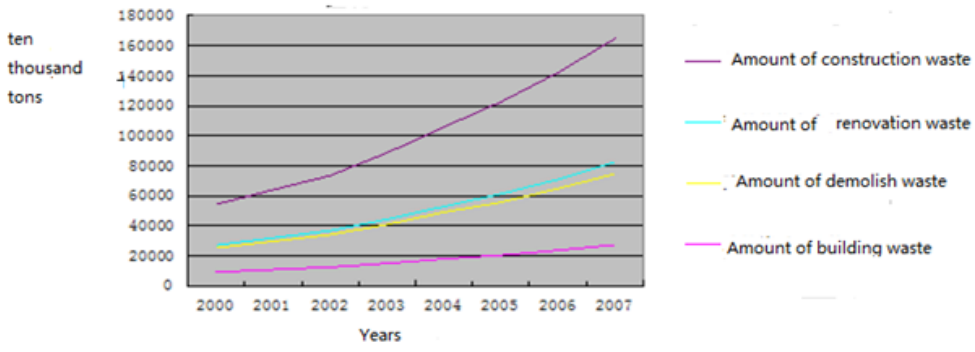


Fig.6 The increase of construction and demolish waste in China from 2000 to 2007

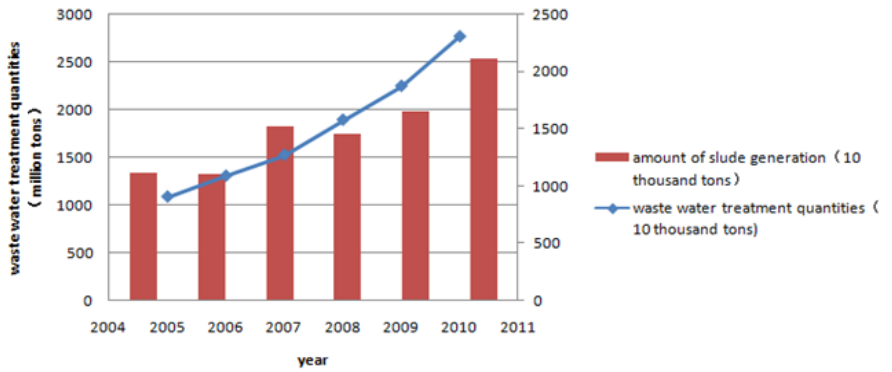


Fig.5: The Treatment Quantity of wastewater and amount of sludge generation from 2004 to 2011

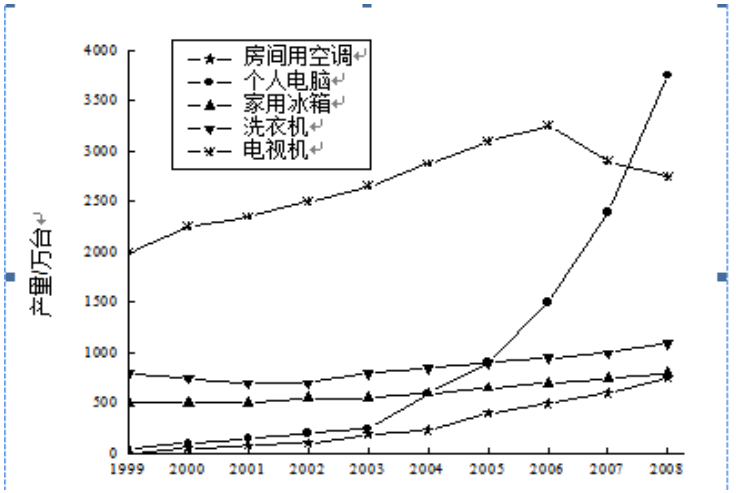
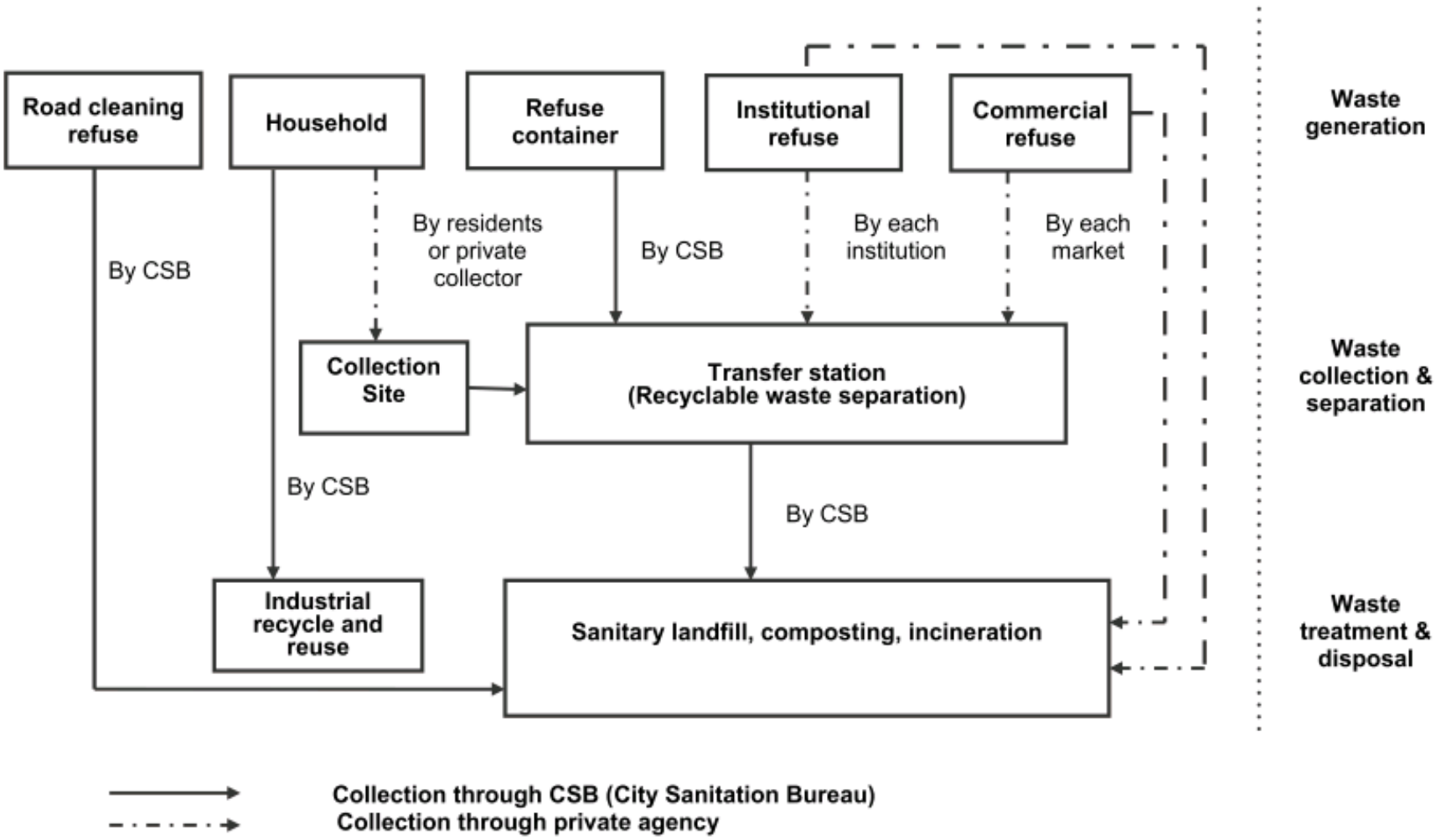


Fig.3 The amount of waste electrical and electronic equipments

北京工業大學 BEIJING UNIVERSITY OF TECHNOLOGY

The disposals of MSW in China

- Urban waste disposal methods are divided into three kinds：
  - landfill
  - Composting
  - Incineration
- Except counties, two thirds of the cities among more than 600 cities are surrounded by garbage, and a quarter of them has no suitable place to stack waste.
- Till 2010，urban garbage treatment rate has reached 71.6%，but garbage in second- or third-tier cities, its treatment rate is estimated about 40% ,lower 40-50% than first- tier cities.
- Statistics according to garbage treatment volume, landfill, composting and incineration accounted for 81.7%, 2.7% and 15.6% respectively；according to garbage removal volume，landfill, composting and incineration rates were 50.4%, 1.6% and 9.6% respectively.



The general process of MSWM in China

Table : The Quantities of Landfill Sites, Plants of Compost and Incineration from 2003 to 2010

Year	2003	2004	2005	2006	2007	2008	2009	2010
Landfill Site	457	444	356	324	366	407	447	498
Compost Plant	70	61	46	20	17	14	16	11
Incineration Plant	47	54	67	69	66	74	93	104
total	575	559	471	419	460	509	567	628

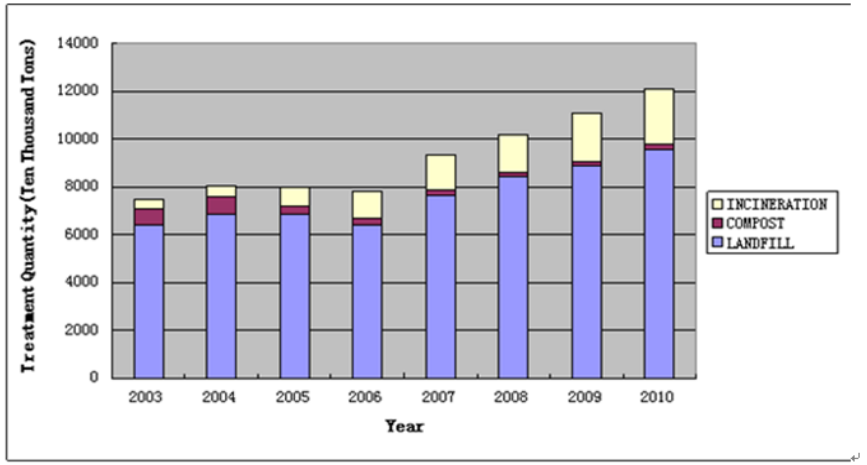


Fig.3: The Treatment Quantity of MSW from 2003 to 2010.

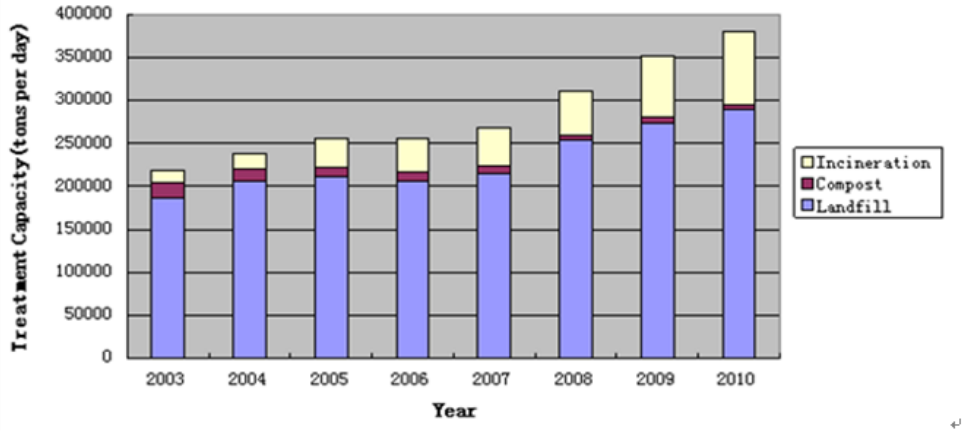
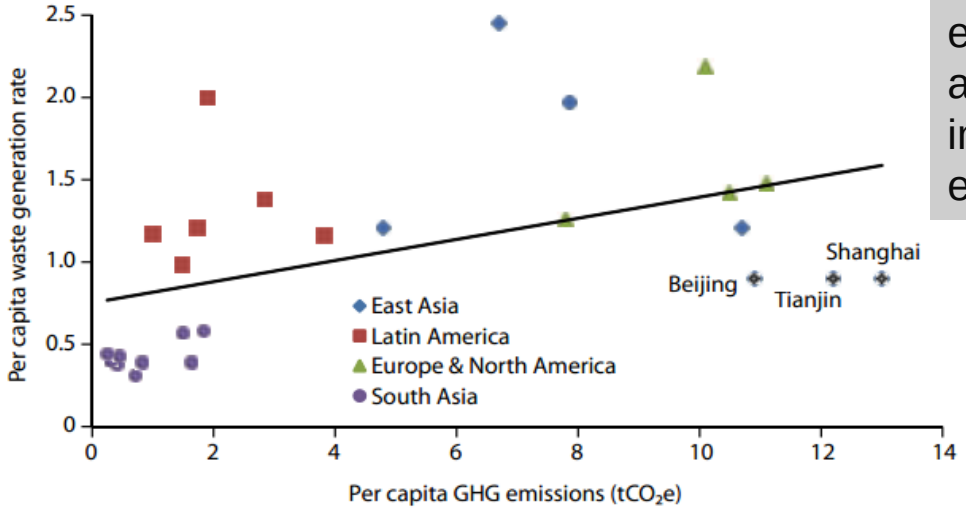


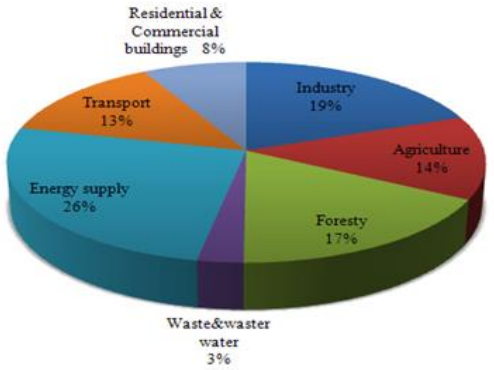
Fig.4: The Capacity of MSW Treatment from 2003 to 2010

Global estimates suggest that solid waste accounts for 5% to 10% percent of carbon emissions generated within a city boundary, and embodied emissions—or “up-stream” impacts—associated with solid waste are even more significant.



Source: Based on data from World Bank 2005.
Note: tCO_2e = tonnes of carbon dioxide equivalent.

Fig. Per Capita Waste Generation Rate and GHG Emissions



Source: IPCC, 2007, Climate Change 2007: Mitigation of Climate Change, 2007

Fig. Greenhouse Gas Emission by Sectors

E-waste management & recycling in China

- Definition and generation of E-waste in China
- E-waste recycling and disposal processes in China
- Challenge of E-waste management in China

E-waste categories in EU

No.	Category	Label
1	Large household appliances	Large HH
2	Small household appliances	Small HH
3	IT & telecommunications equipment	ICT
4	Consumer equipment	CE
5	Lighting equipment	Lighting
6	Electrical and electronic tools (with the exception of large scale stationary industrial tools)	E&E tools
7	Toys, leisure and sports equipment	Toys
8	Medical devices (with the exception of all implanted and infected products)	Medical equipment
9	Monitoring and control instrument	M&C

E-waste categories in China

Clear categories list is unavailable

---Home appliances

---Personal computers and mobile devices

---Business electric and electronics

---Industrial electric and electronic equipment

---others

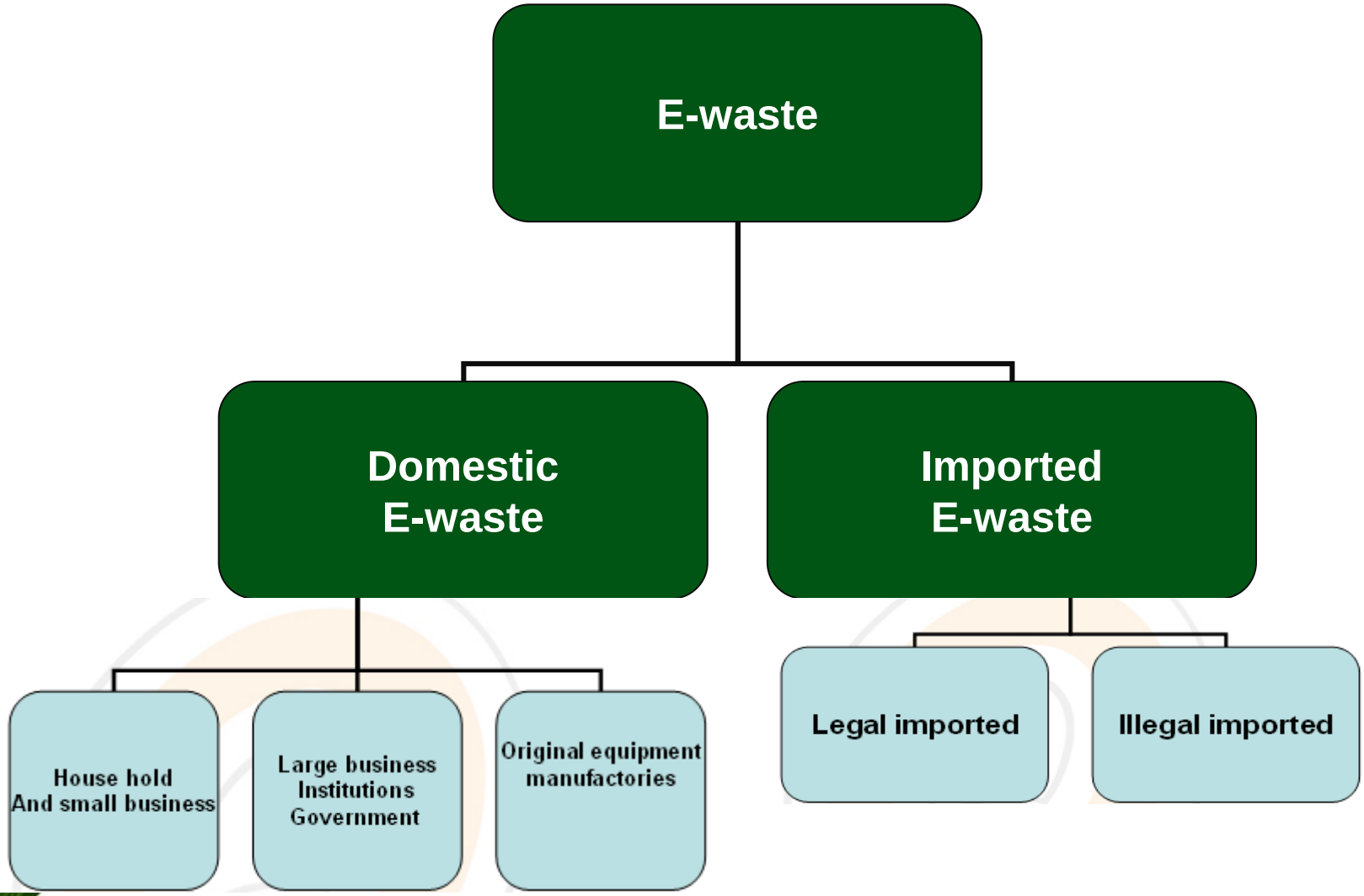
Current policies focus on home appliances and PCs

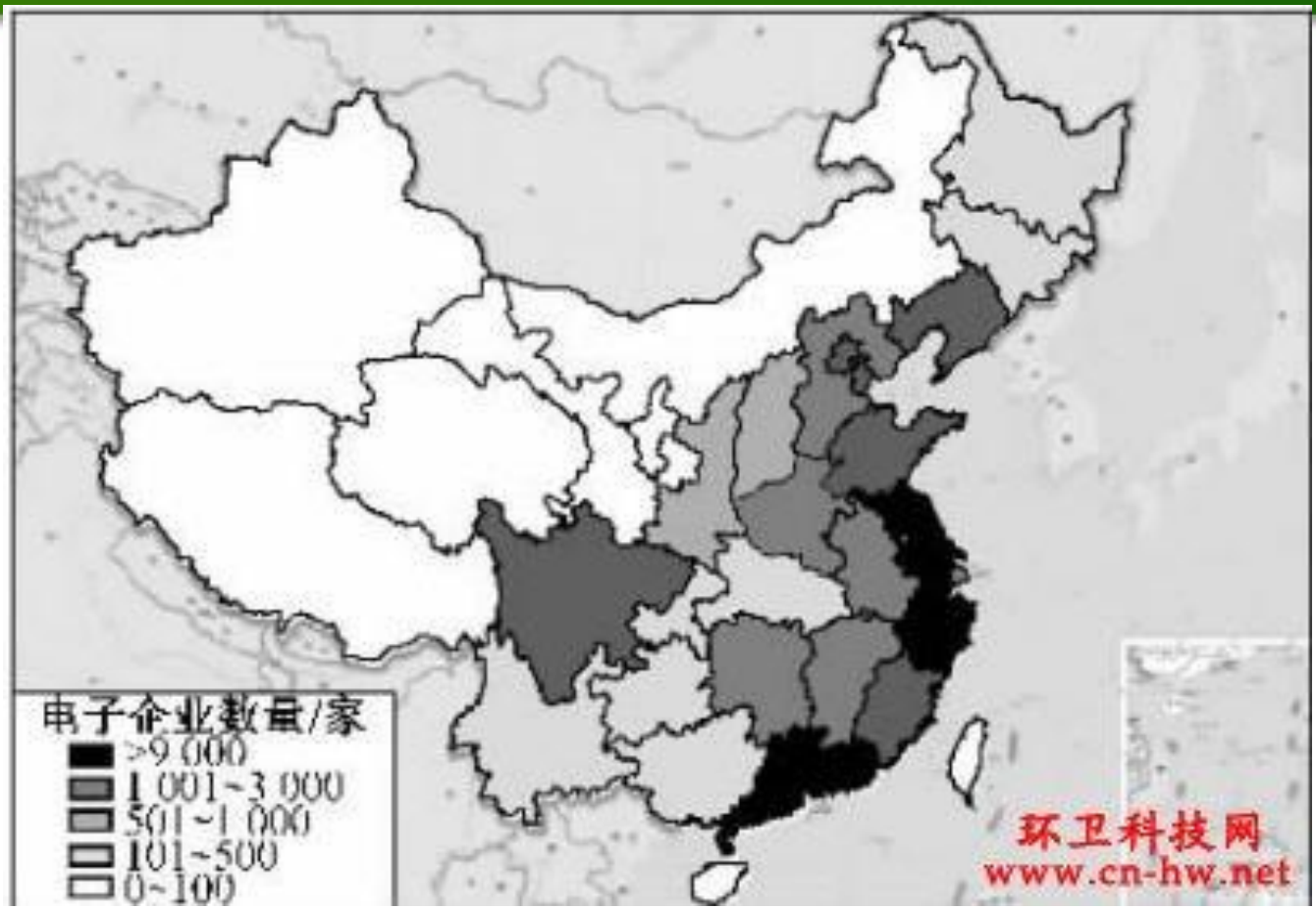
---TV, Refs，WM, AC, PCs.

NDRC & MEP
（Sep.2010）

北京工業大學
BEIJING UNIVERSITY OF TECHNOLOGY

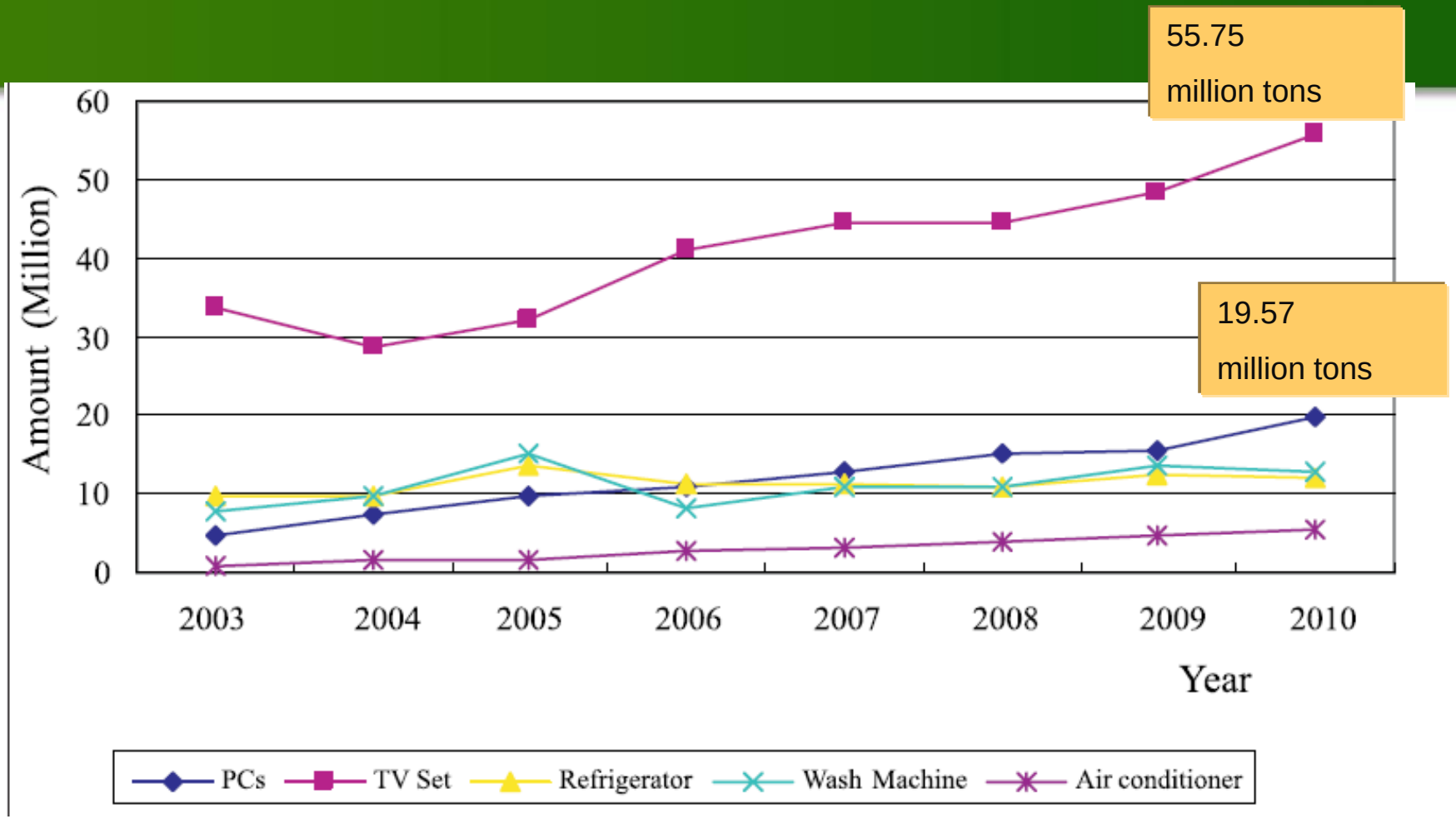
E-waste generation in China





Numbers of electronic manufactories in China

北京工業大學
BEIJING UNIVERSITY OF TECHNOLOGY



obsolete main electronic appliances in China

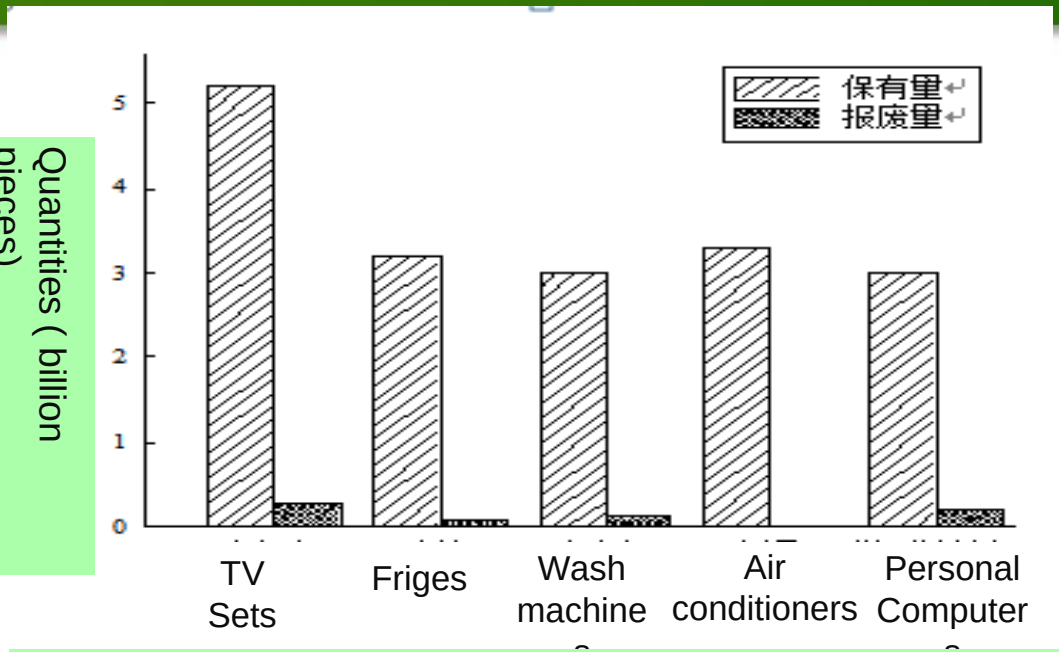


Fig. The quantities of holding and waste of electrical and electronic equipments in 2011

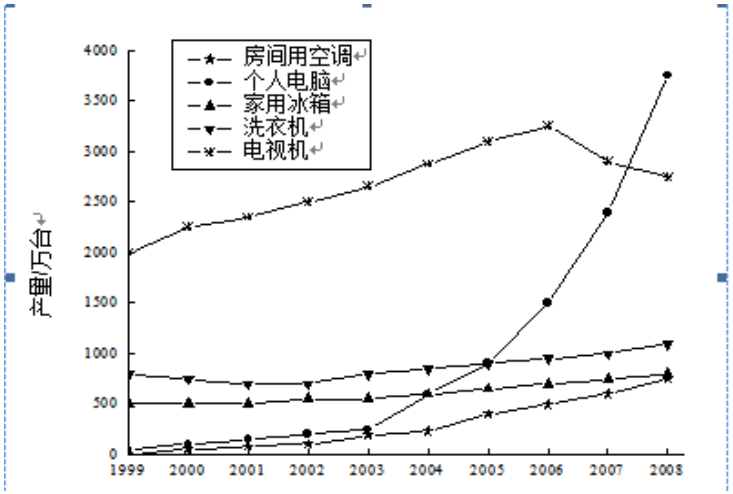


Fig. The amount of waste electrical and electronic equipments

Source: Report of “Urban Mining” (2012)

北京工業大學
BEIJING UNIVERSITY OF TECHNOLOGY

Lifetime of home appliances in China

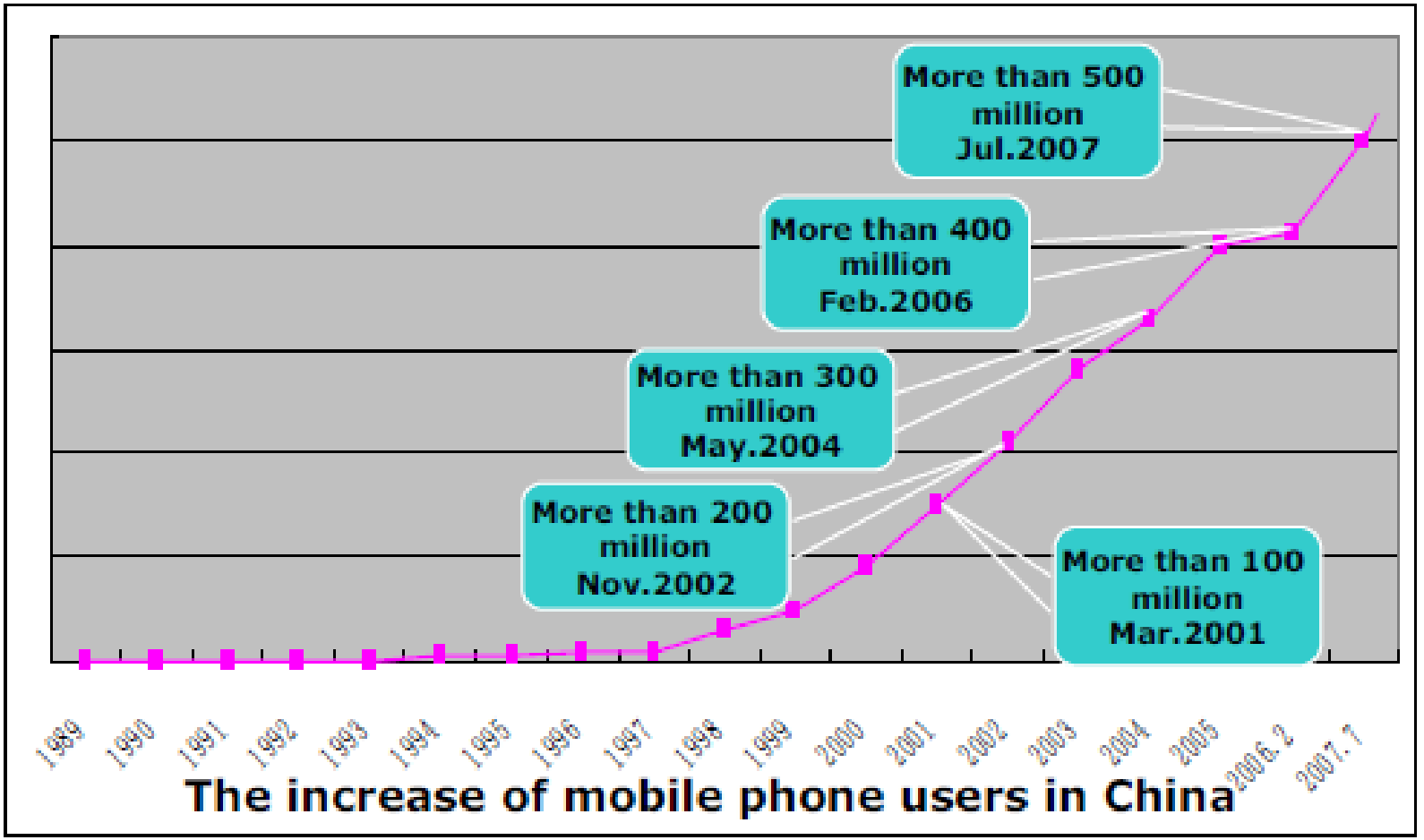
Product	Lifetime (years)
TV sets	8
Refrigerators	9
Washing machines	9
Air conditioners	10
Personal computer	5 in 1993 & 3.5 in 2003

Source:CRAES (2003）

Table. The predicted Data of Domestic electronic equipments & computers

Year	Quantities of Waste per year (Unit: ten thousand pieces)				
	TV Sets	Refrigerator	Wash machine	Air conditioner	Personal Computer
2013	4041.73	2094.18	1374.37	3875.04	24251.37
2014	4251.48	1242.00	673.12	2992.61	90491.88
2015	4449.13	1714.78	1519.46	3250.11	80904.88

Source: Report of “Urban Mining” (2012)



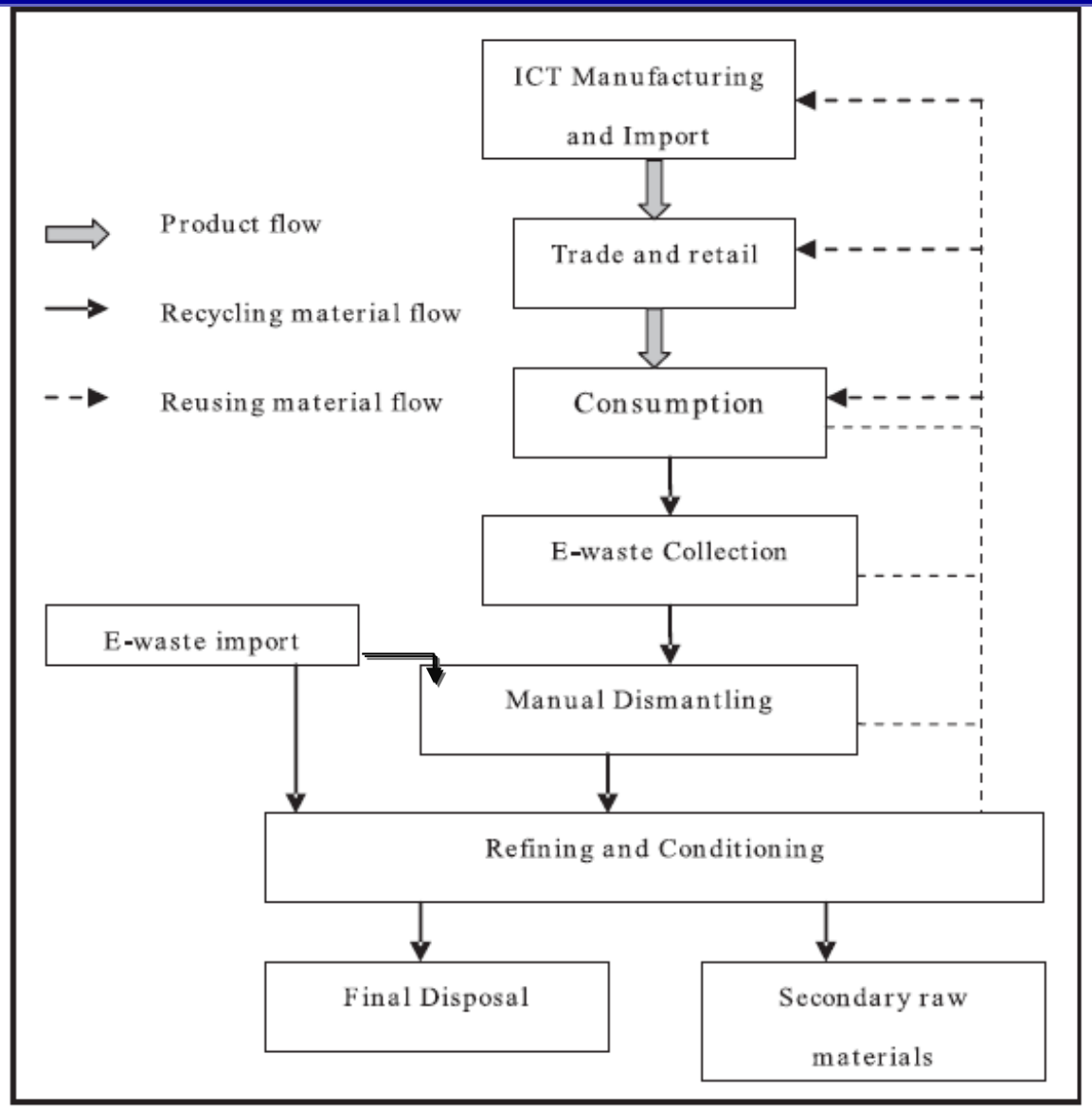
Source：Report on E-Waste Issues Related to Mobile Telecommunications in China（2008）

Imported of **E-waste**

Imported E-waste puts more pressure on Chinese E-waste management

Not clear how much E-waste is imported from other countries

E-waste recycling and disposal processes in China



Material flow of e-waste recycling in China

Table. Material composition and ratios(%) of typical domestic e-waste

Material	TV Sets	refrigerator	Wash machine	Air conditioner
Steel	10	50	53	55
Cupper	3	4	4	17
Aluminum	2	3	3	7
Plastics	23	40	36	11
Glass	57	—	—	—
others	5	3	4	10

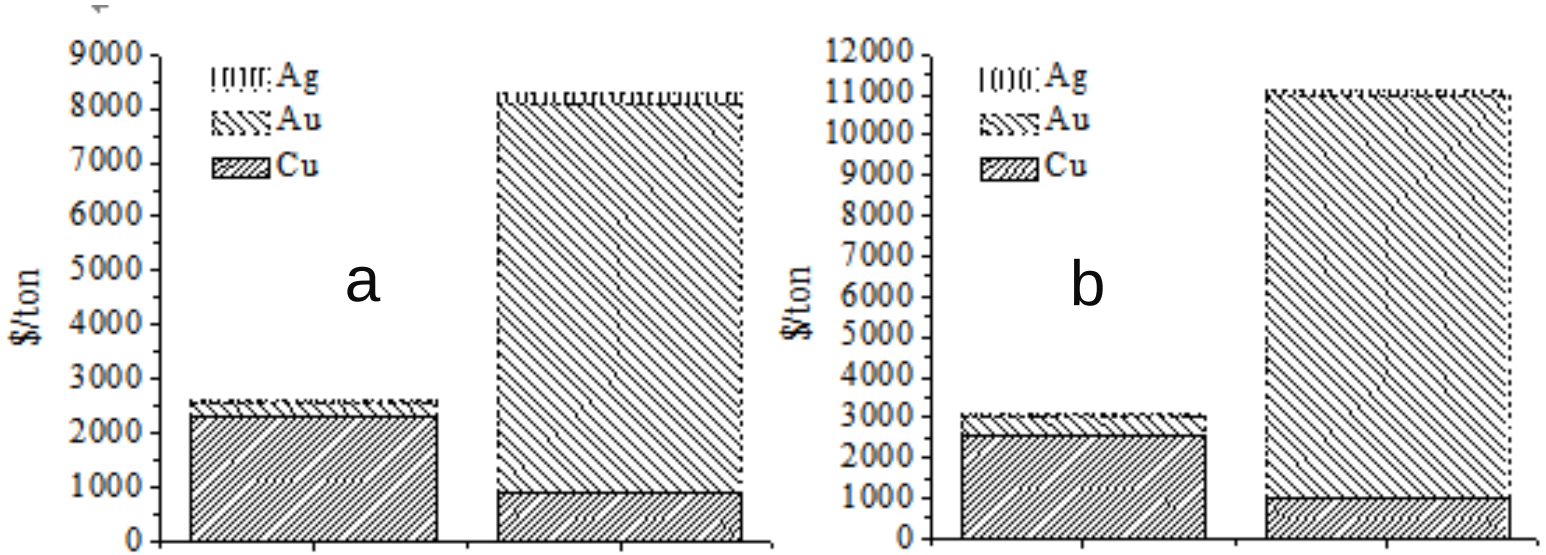
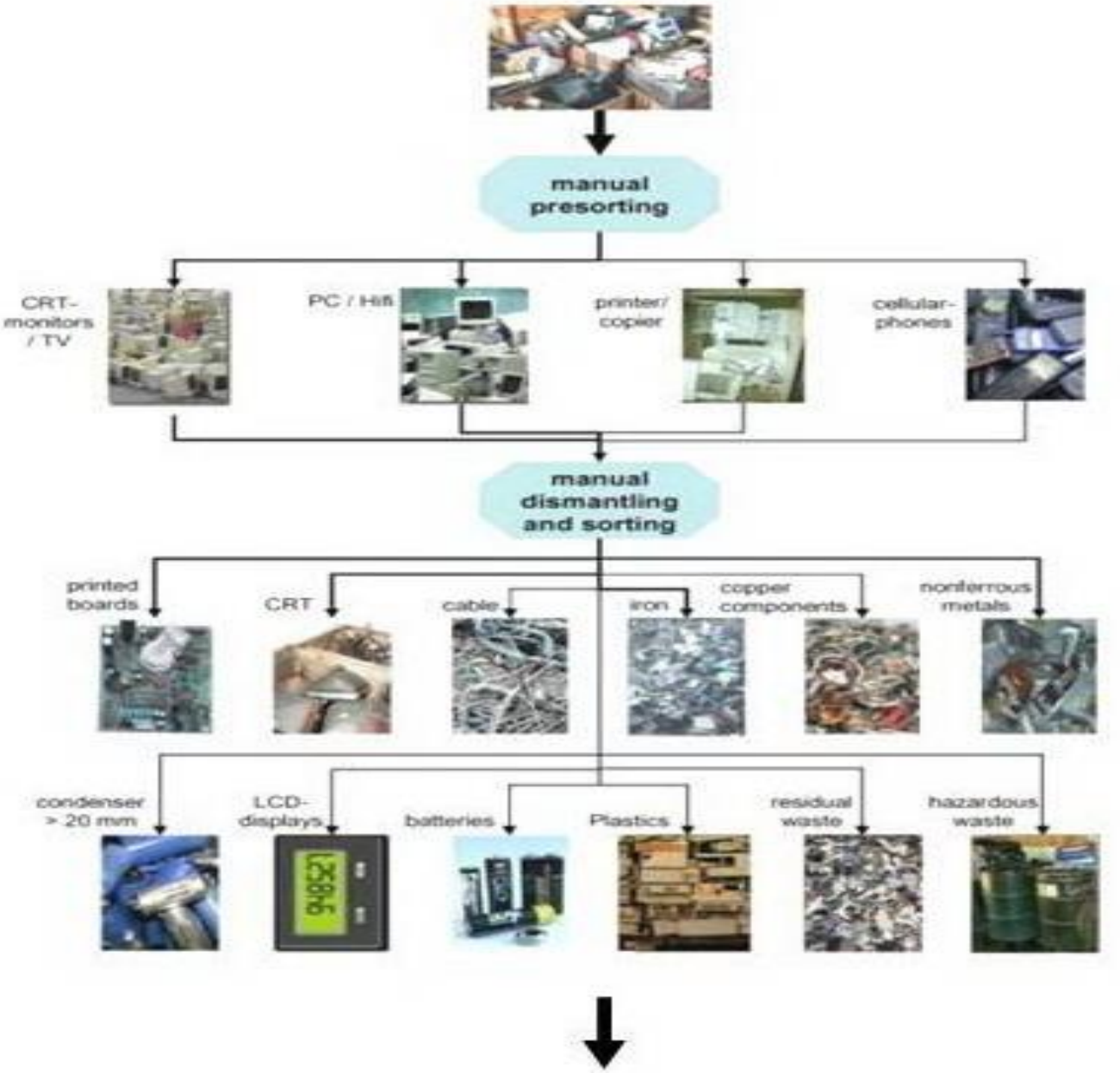


Fig. the value comparison of metals contained in the copper concentrate and a mobile phone between 2008 and 2010
(a：2008；b: 2010)



Peddlers Collect the E-Wast

Manual dismantling

Guiyu: The largest e-waste collection and distribution center, dismantling and recycling e-waste and plastic about 1,550,000 tons

Empoloyee：More than 60 thousands

Private enterprises: more than 300

Money: more than 2.0 billions

E-waste management regulation in China

Law of circular economy promotion(2009)

Law of solid waste pollution prevention and control(2005)

Law of clean production promotion(2003)

Ordinance on recycling and treatment of discarded electric and electronic appliances(2011)

Management measures for prevention and control of pollution of IT products(2007)

-Document on environmental management WEEE(2003)
-Regulation on the list of forbidden import goods(2002)
-Technical policy of prevention &control E-waste pollution (2008)

Improving the E-waste management

To establish formal collection systems

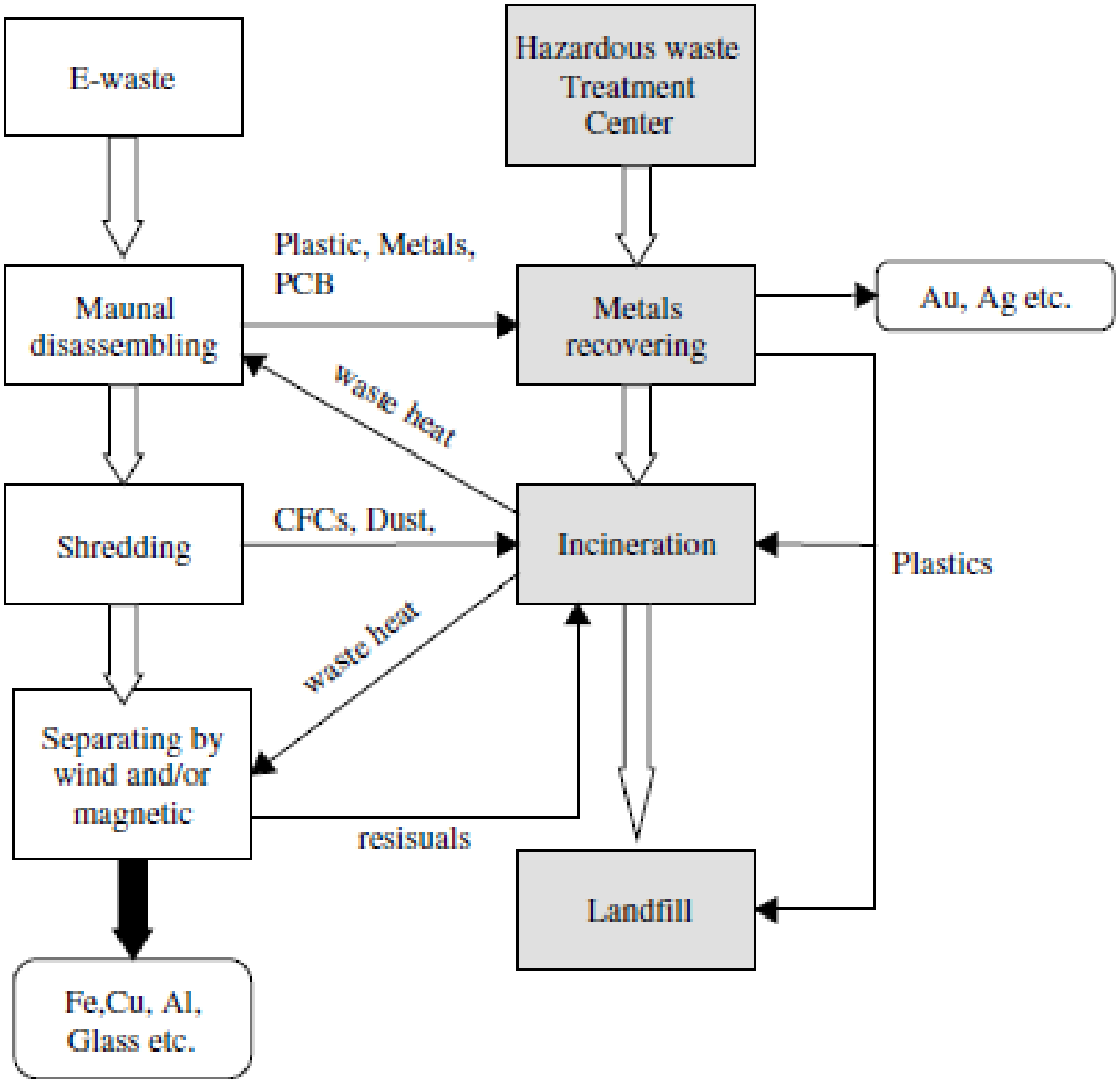
To establish a recycling certification system

To set up special National Fund

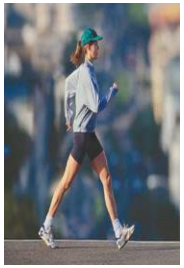
National pilot projects for domestic E- waste management

- To set up and support E-waste management institutions and policies.
- To set up a collection network for domestic E-waste.
- To help develop standards and regulations for E-waste management.
- To develop key technologies and equipments for E-waste recycling

Fig. Large-scale E-waste recycling facilities in China.



Flowchart for the Haier recycling center



我的低碳生活
LOW-CARBON LIFE

Community carbon emissions in Beijing

北京工業大學
BEIJING UNIVERSITY OF TECHNOLOGY

Context

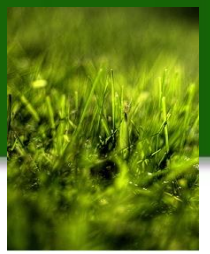
About Beijing

Population: more than 2.1million

Areas: 16.801 km^2

- Modern city with a long history
- National political and cultural center
- International exchange center
- Technology and innovation center

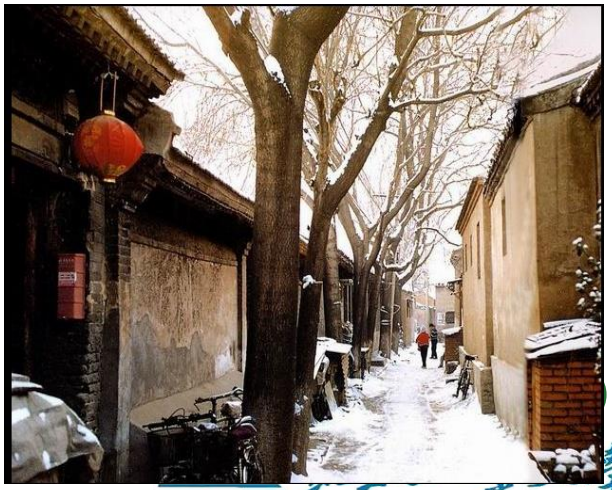
Context



◆To reduce CO2 emissions of per GDP to 40-45% from 2005 level till 2020;

◆To significantly reduce energy consumption intensity and CO2 emission intensity and effectively control greenhouse gas emissions.

◆It was reported about 30% CO2 emissions in China from residential life.



About the chosen community

Area： 87,318 m^2

Residents in flat： 1,700 persons

Residents in Building： 1,799 persons

Households： 1180

Methodology of community carbon emissions

- The geographic boundary of the community being taken as the assessment boundary;

- CO_2, CH_4 and N_2O, mainly relevant to the residential life in community, carbon emissions of community were expressed in equivalent tons of CO_2 (kgCO2-eq);

- Data were surveyed about the electricity consumption (including the public electricity in community), gas consumption, heating consumption and wastes generation (including household garbage and waste water) in 2010.

CCEM was formulated as follows：

$$EM=\sum (F_i * k_{ij} * EF_j)$$

Where

EM: the community carbon emissions, $kgCO_2$-eq.

F_i : quantity of various carbon emissions sources or carbon sinks(i) , its unit could be kwh, m^2,kg or km.

k_{ij} : factor of carbon emissions / carbon sink of j from i, the unit could be kg/kwh, kg/m^2, kg/kg and kg/km.

EF_j : The characteristic factor of j , $kgCO_2$-eq/kg.

Table 1 The global warming potential of three greenhouse gases

Greenhouse gases	Characterization factor	unit
CO_2	1	kg CO_2-eq
CH_4	25	
N_2O	298	

Table 2 The survey basic data of the community

types			data	unit
Energy consumption	Electricity	Building	1,119,664.35	kwh/a
		Bungalow	923,407.18	
		Public electricity	500,000.00	
	Gas	Natural gas	92,583.48	kg/a
		LPG	82,822.38	
	Heating	Construction area	38,600	m^2
Transport	Bus	Trip distance per capita	1,033.98	km/a
	Subway		617.70	
	Taxi		135.19	
	Private car		1,530.76	
	Train		1,347.68	
	Long-distance bus		887.62	
	airplane		876.78	
Waste	Domestic sewage	Water consumption	102,408.94	t/a
	Domestic garbage	Production amount	1,468.71	t/a
Public greenbelt		Areas	3,193	m^2

Table 3 Carbon emission/neutral factors

Carbon emission/neutral		factors	units
Electricity		0.944	$kgCO_2$-eq/kg
Gas	LPG	2.531	$kgCO_2$-eq/kg
	Natural gas	2.761	
Heating		27.502	$kgCO_2$-eq/m^2
Transport	Bus	0.037	$kgCO_2$-eq/km
	Subway	0.063	
	Long-distant bus	0.019	
	Train	0.062	
	Taxi	0.164	
	Private car	0.152	
	Airplane	0.069	
Domestic garbage		2.059	$kgCO_2$-eq/kg
Domestic sewage		6.663×10^{-4}	$kgCO_2$-eq/kg
Public greenbelt（carbon neutral）		-7.917	$kgCO_2$-eq/m^2

Table 4 Carbon emissions from electricity

Housing types	Electricity consumption（kwh/a）	Total population（capita）	Total carbon emissions（CO_2-eqkgCO_2/a）	Carbon emissions per capita（CO_2-eq kg /a）
Bungalow	1,119,664.35	1,700	1,056,963.14	621.74
Building	923,407.18	1,799	871,696.37	484.54

Table 5 Carbon emissions from gas consumption

Gas types	Population (capita)	Consumption (kg)	Total carbon emissions ($kgCO_2$-eq/a)	Carbon emissions（$kgCO_2$-eq/a）
LPG	1,700	82,822.38	209,623.45	123.31
Natural gas	1,799	92,583.48	255,623.00	142.09

Table 6 Carbon emissions from transport

	bus	Subway	Taxi	car	Train	Long-distance bus	Airplane	∑
carbon emissions（$kgCO_2$-eq/capita/a）	38.26	38.91	22.17	232.63	83.56	16.86	60.50	492.89

Table 7 The community carbon emissions（ $kg_{CO2\text{-}eq}$/capita/a）

	Energy consumption			transport	waste		Public greenbelt (carbon neutral)	∑
	Electricity	Gas	Heating		sewage	garbage		
Bungalow	619.44	123.31	------					2, 268. 2
Multistory Buildings	756.64	142.09	590.09	492.89	19.50	864.27	-7.22	2,702.3

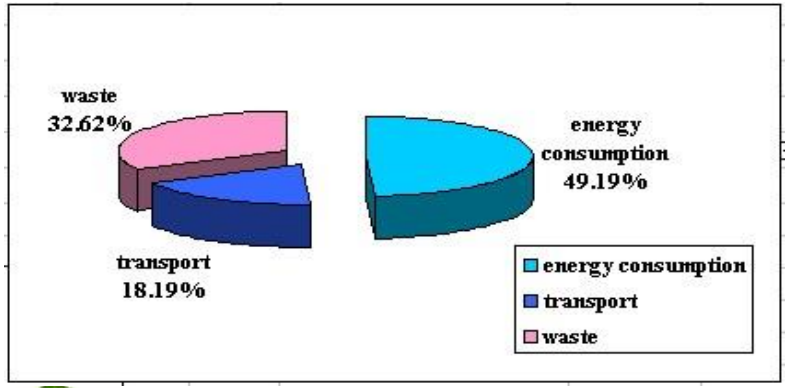


Fig.1 Carbon Emissions in the Multistory Buildings

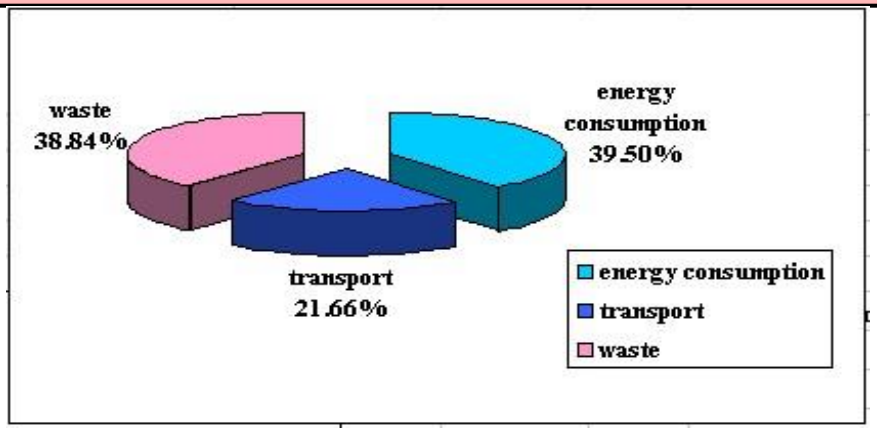


Fig. 2 Carbon Emissions from the Residents in the Bungalows

- The community carbon emissions were 2,702.3 and 2,268.2kgCO2-eq/capita/a in multistory buildings and bungalows, respectively.

- The largest contributor to CO_2 emissions in this community resulted from energy consumption. Because of more coal used in the heating system in the multistory buildings, the carbon emissions in the buildings were 434.11kgCO2-eq/capita/a more than those in the bungalows.

- In addition, the carbon emissions from the community public services accounted for almost 12.02% of the total energy consumption, so it is one of key points to reduce the public electricity consumption in terms of reducing community carbon emissions.

- The carbon emissions from the waste accounted for 35.73% of the total community carbon emissions, because most all of garbage went to the landfill.

- The carbon emissions from the transport were comparatively lower than those of reported cities.

➢The community greening rate was 3.66%, and green area of per capita was only 0.92m^2, which were much lower than the average greening rate 43% and 12.6m^2/ capita of Beijing city.

➢The characteristics of the community carbon emissions was different from those in Biggar community, locating in Scotland South Lannark Shire. The greatest source of carbon emissions in Biggar resulted from transport, whereas energy consumption was the largest in Beijing community. The energy carbon emission factor in Biggar is lower than it in Beijing community due to the more clean energy used and higher energy efficiency; The waste generation of per capita was 23% higher in Biggar compared to it in Beijing community, but its carbon emissions from the waste were only 42.56% of those in Beijing community.

Strategies of building low-carbon community in Beijing

◆ To improve waste treatment

Table 8 The potential efficiency of carbon emissions reduction by improving the waste treatment

	Recovery the landfill gas	The incineration to power generation
Actions	50%	20%
Amount of community garbage	137.26t	
Carbon emissions reduction	82.35tCO_2-eq	19.22tCO_2-eq
Amount of urban waste of Beiijng	619.5×10^6t	
Amount of carbon emissions Reduction	3.717×10^6tCO_2-eq	8.673×10^5tCO_2-eq

◆ **To increase the community greening rate and reduce energy demand**

✓ The greening ratio of the community is increased from 3.66% to 40%, the average greening areas of Beijing, the carbon offset from the green lands will be 306.2tCO2-eq/a.

✓It was reported that the heating energy consumption of per unit area in China was about 3 times as it in developed countries in the same climate condition. Thus, there is a huge potential for energy demand reduction in communities.

◆ To optimize energy structure

✓In 2012, the coal consumption was about 23million tons in Beijing, accounting for about 25% among the total energy consumption, which is much lower than the average level of the whole country.

✓Beijing government requires gas totally replaces coal as energy for electricity and heating production till 2017.

✓ More clean energy and renewable energy will be used, such as solar and wind energy.

For example, CO2 emissions will decrease 490.20tCO_2-eq/a when the public lighting facilities are replaced by solar energy in this community.

北京工業大學 BEIJING UNIVERSITY OF TECHNOLOGY

◆ **To insist on public transport priority**

Because public transportation was chosen by most of residents in this community, the carbon emissions from transportation is much lower than other community.

However, it was reported that there were more than 43 families owning cars among 100 families in Beijing in 2012, so encouraging residents to take public transportation and improve the convenience of the public transportation are very important .

◆To Strengthen publicity and education on low-carbon life

✓It is the most important in terms of building a low-carbon community to strengthen publicity and education on low-carbon life.

✓With the economic development and living level increasing, people will pursue the more comfortable and convenient life, which inevitably results in more energy and resource consumption.

For example, turning down the heat by 1° will result in 412t carbon emissions reduction in a common family.

Thank you

chensha@bjut.edu.cn