Meeting the Challenge of Particulate Air Pollution in China

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Outline

- Situation of Particulate Pollution in China
- Cause of Particulate Pollution
- Countermeasure & Recommendations

PM_{10} Pollution in Beijing in Jan-12,2013

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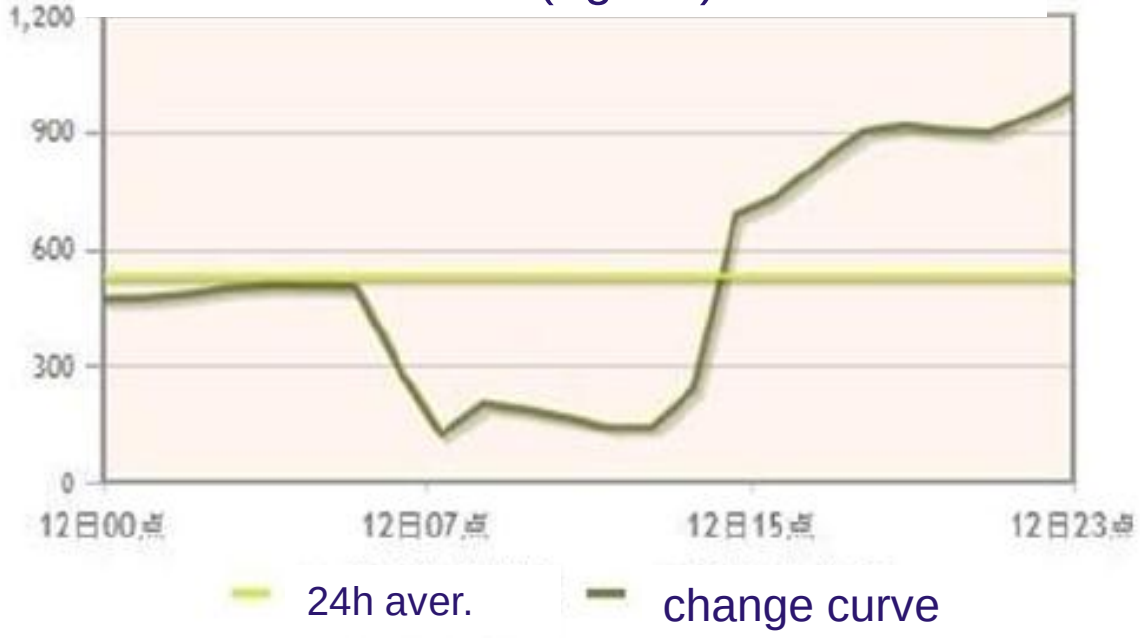
PM_{10} Jan. 12,2013			
Max.	24h aver.	AQI	Grade 6 Heavy Pollution
993	528	428	

PM_{10} (εg/m3)

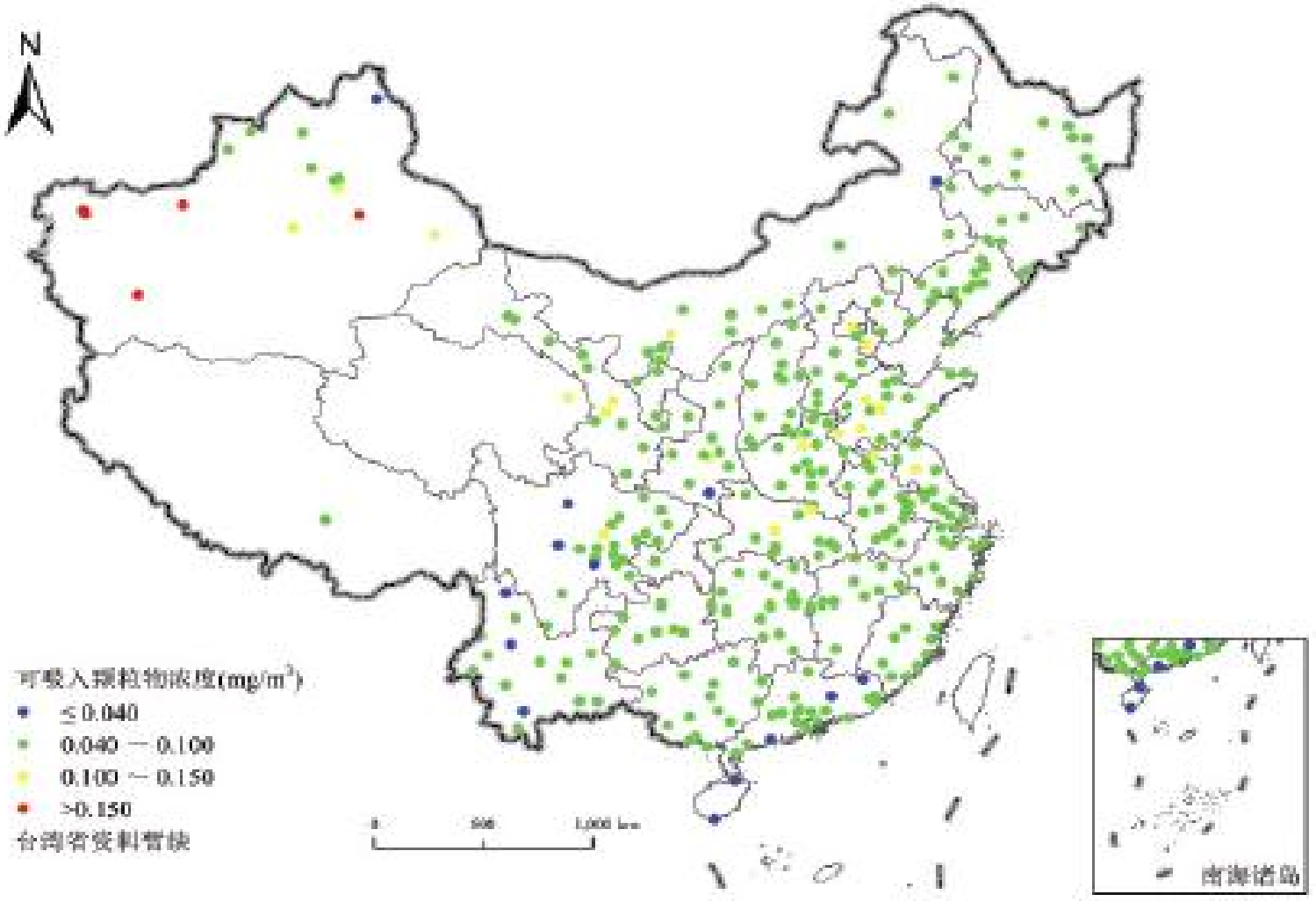


the north of Xizhaimen

A residential area of Xicheng District

Soure:network

PM_{10} annual aver. In 2012



PM10 from 0.021 to 0.262,annual average 0.083 in 325 cities, in which 92% meet with GB3095-1996

Source: Ministry of EP

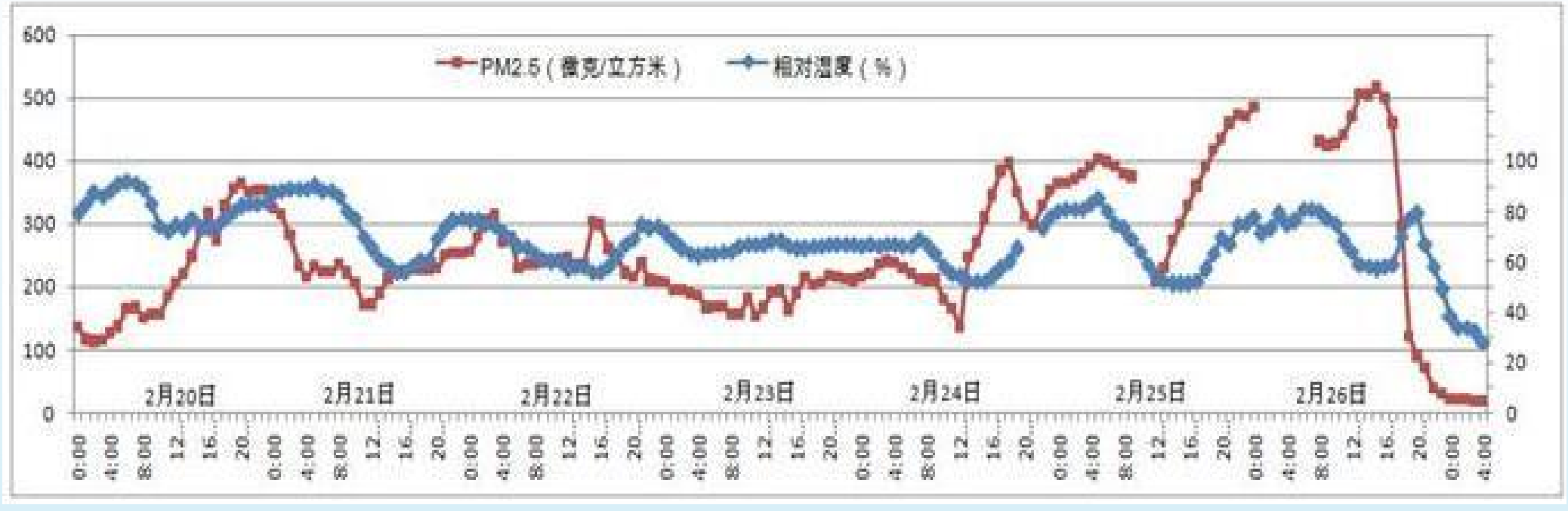
PM_{10} ambient and dust emission

	2000	2005	2006	2007	2008	2009	2010	2011	2012
PM_{10} Concentration(mg/m^3)	-	0.099	0.100	0.094	0.088	0.086	0.087	0.085	0.083
Dust emission(10^4 tons)	1165.4	1182.5	1088.8	986.6	901.6	847.7	829.1	1278.8[1]	1234.3

1. Not calculated by smoke dust and industrial dust separately from 2011

Source: Environmental statistic

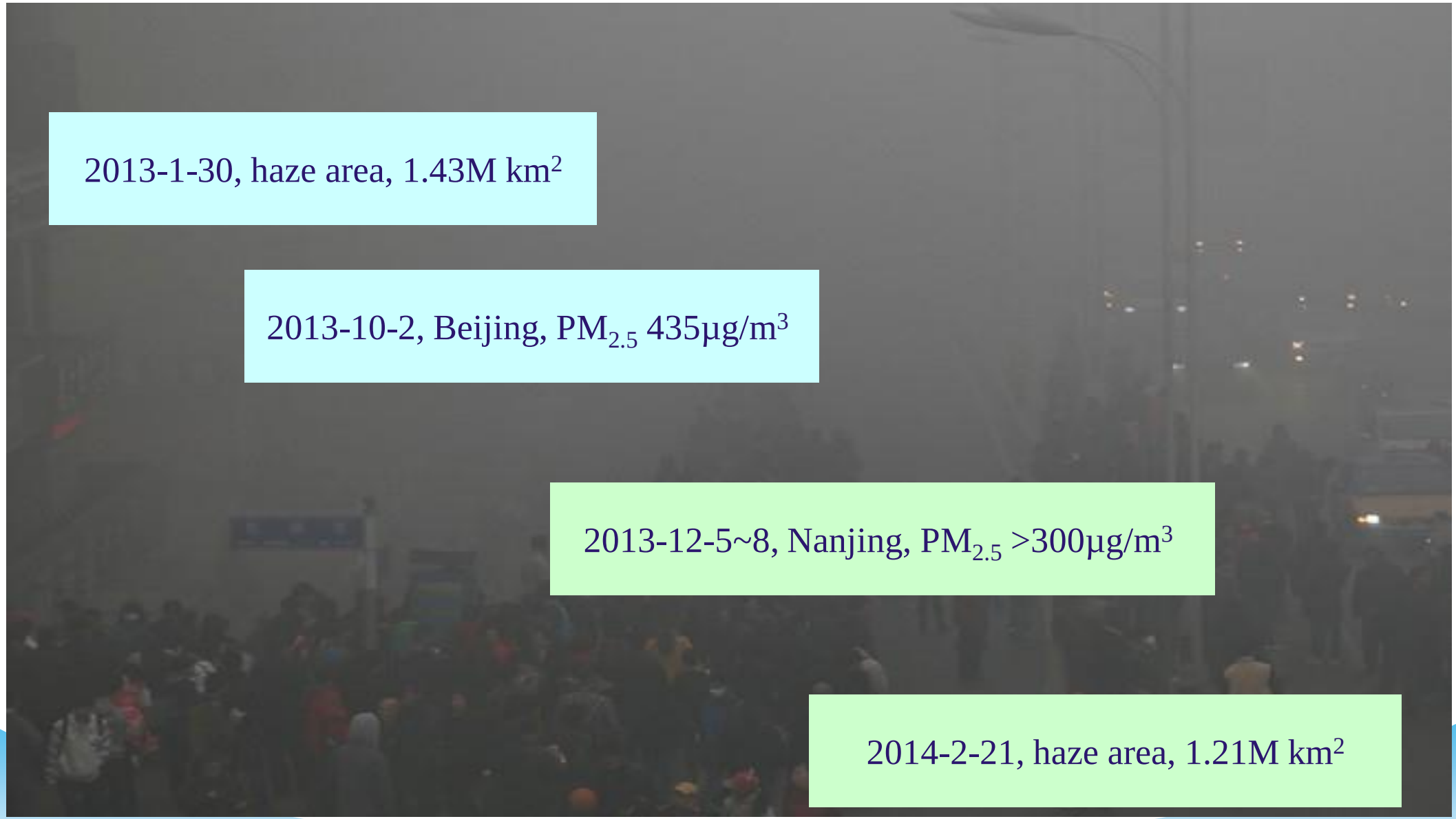
Haze happed in Feb, 2014 in Beijing



Haze happed 4 times in Jan,2013 in Beijing

Source: network

Haze and $PM_{2.5}$ pollution



Source: network

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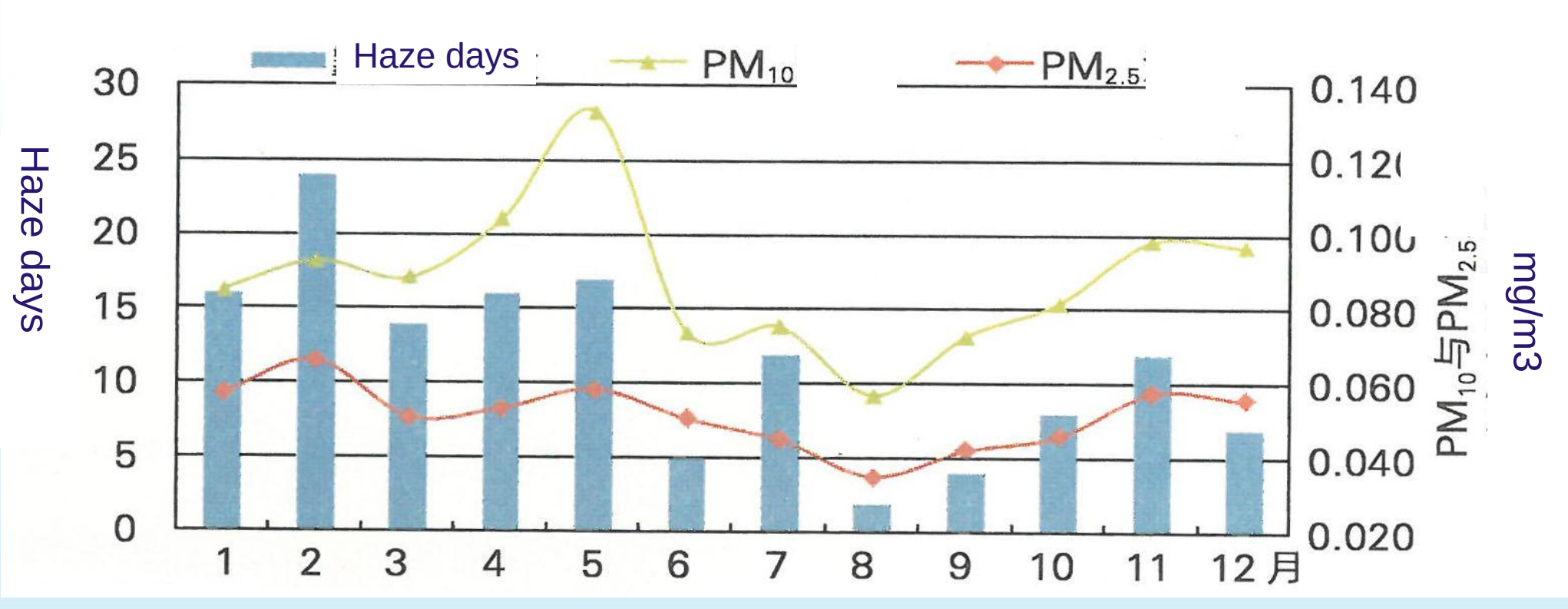
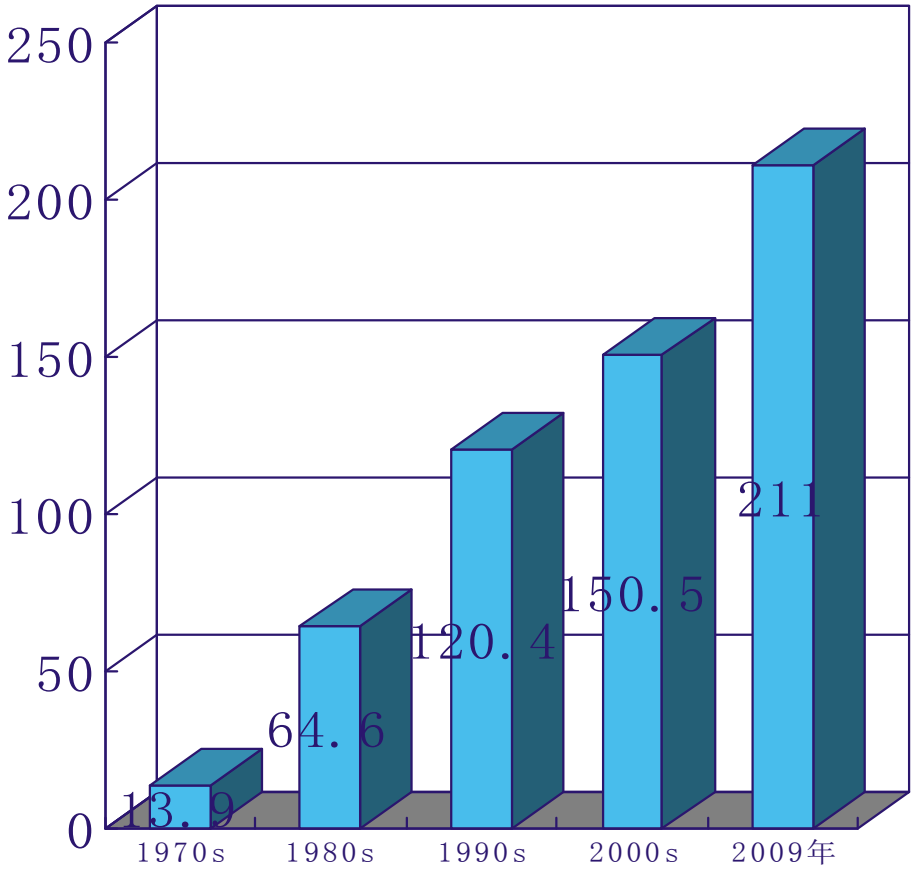
Positive correlation between haze days and $PM_{2.5}$ in Suzhou

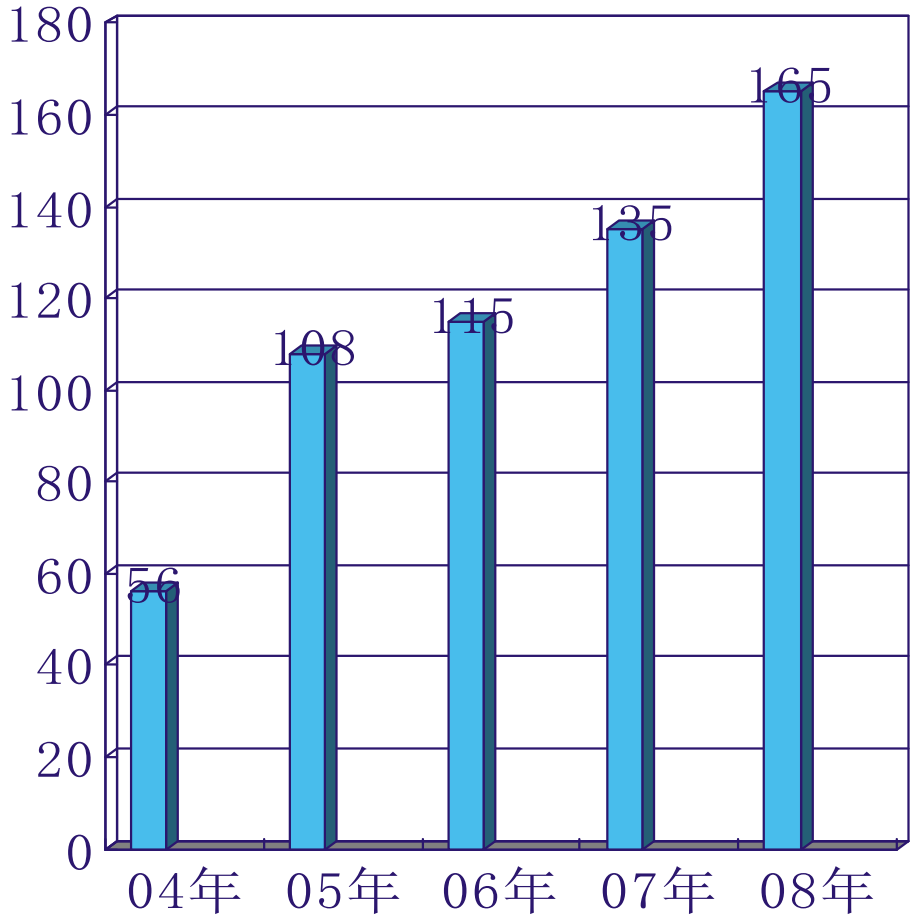


Source: Jiangsu EPB

Haze days in Nanjing



The annual haze days in Nanjing



The number of severe and moderate haze

Source: Modern Fast News

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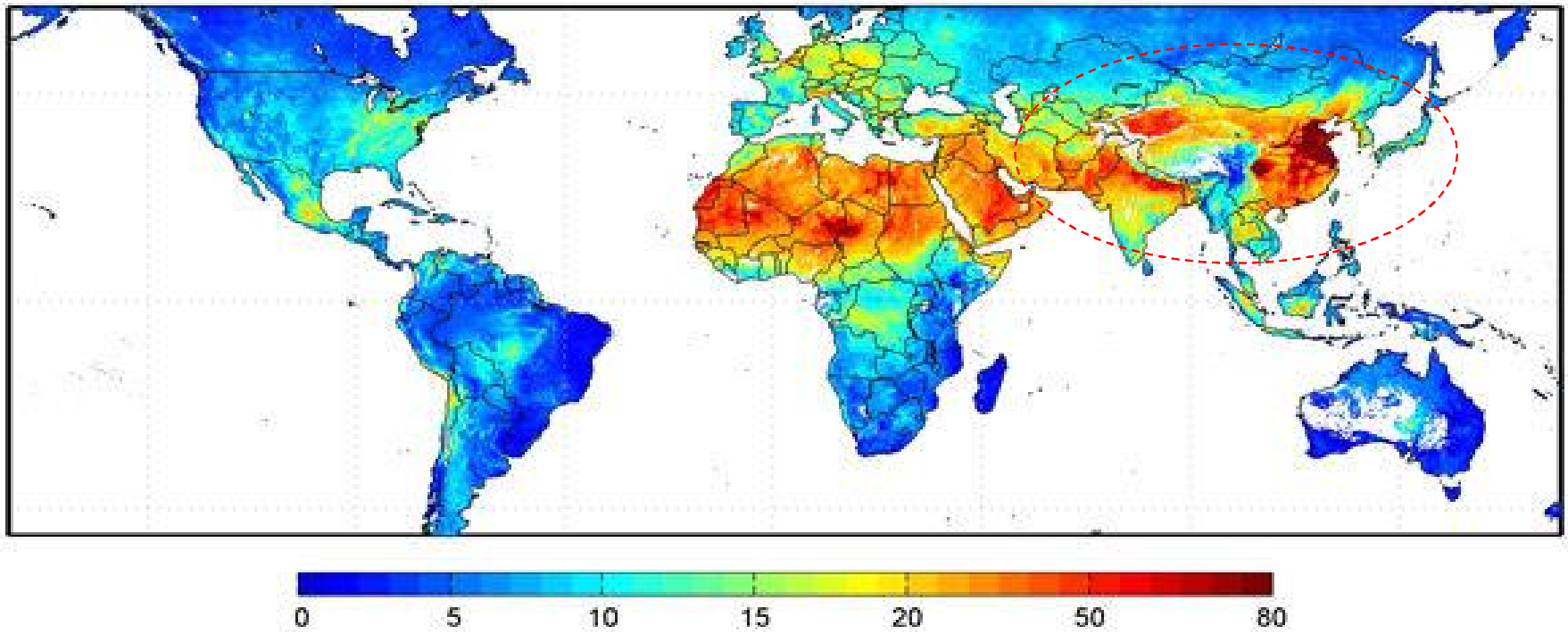
Particulate concentration in Guangzhou

year	$PM_{2.5}$	PM_{10}	$PM_{2.5}/PM_{10}$(%)
1989	54.8	117.0	46.8
2004	88.8	143.6	61.8
2005	75.2	129.8	57.9
2006	65.2	88.9	73.3
2007	48.9	61.7	79.3
2008	49.2	61.9	79.5
2009	42.0	52.9	79.4
2010	39.4	51.9	75.9
2011	42.2	62.5	67.5

Source: Wu D.

$PM_{2.5}$ annual average in the world



$PM_{2.5}$ mass concentration distribution from NASA （2010）

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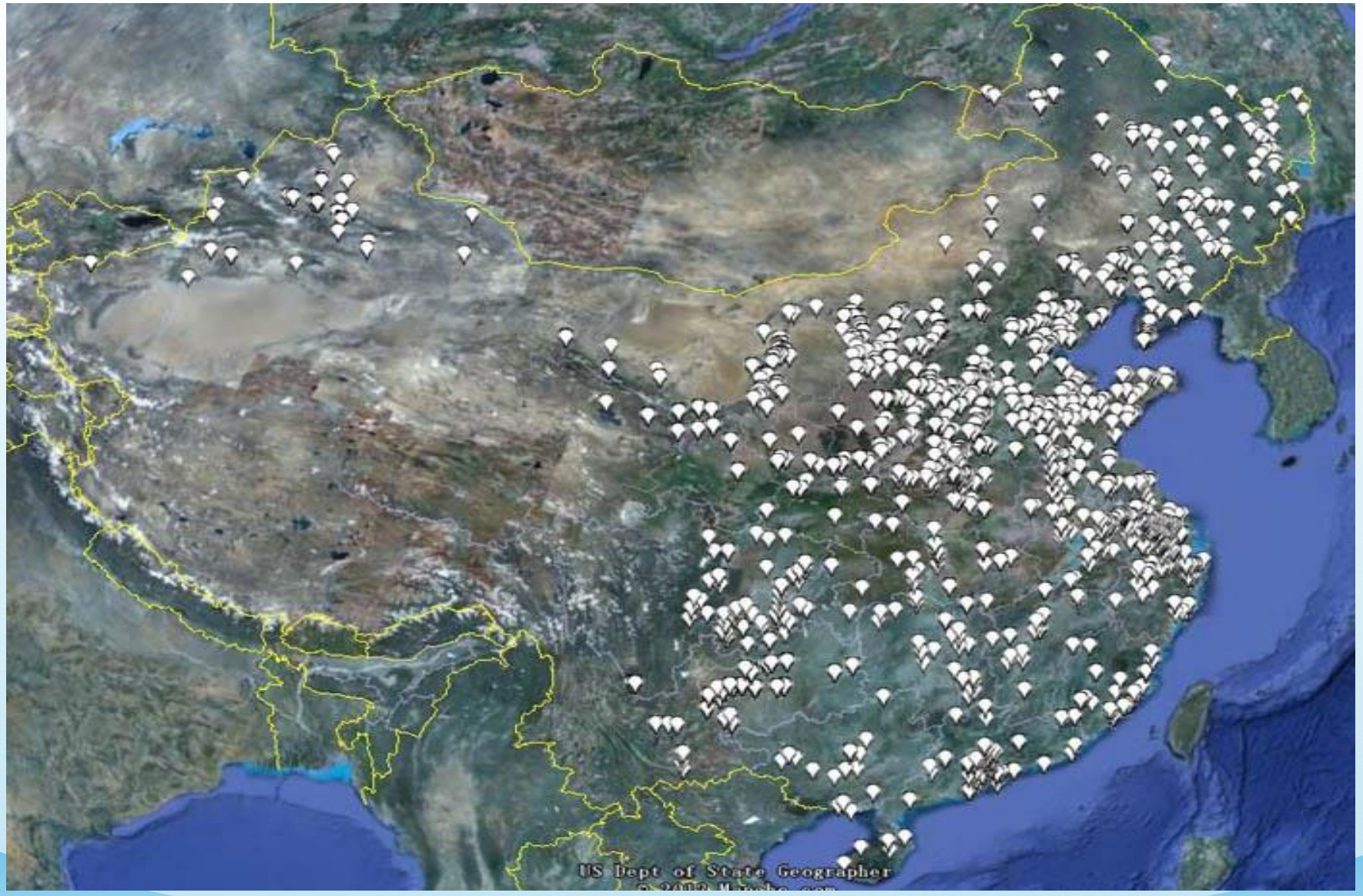
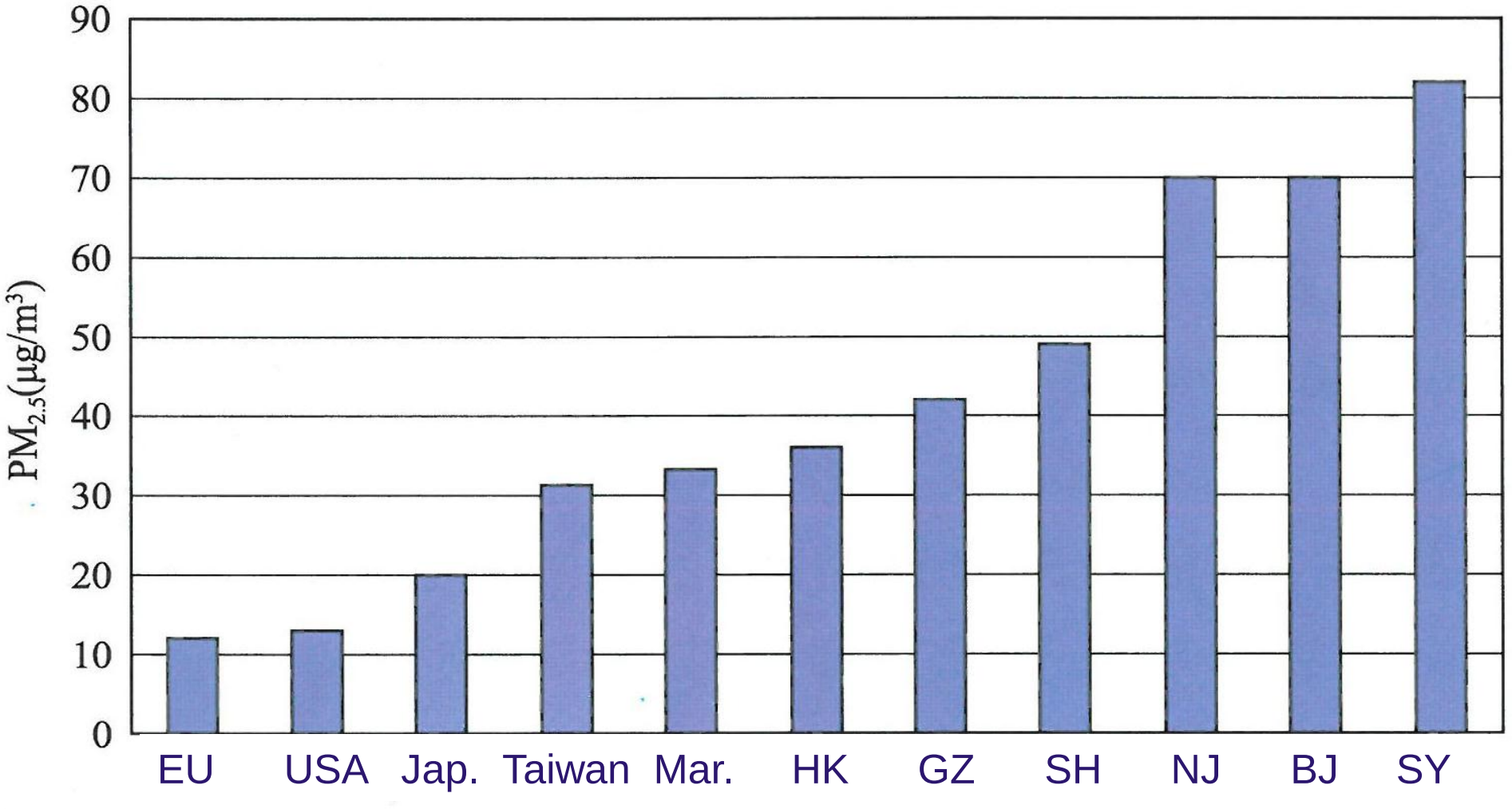
Distribution of coal fired power plants in China



Annual average $PM_{2.5}$



Source: Wu D.

Status of Particulate Pollution

- Dust emission and PM_{10} ambient concentration decrease gradually, 92% of cities meet with GB3095-1996, PM_{10} less than 0.1mg/m3
- $PM_{2.5}$ percentage of PM_{10} increase gradually, especially after 2005
- Haze originate from heavy $PM_{2.5}$ pollution, since 2005 and much heavier after 2013

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Outline

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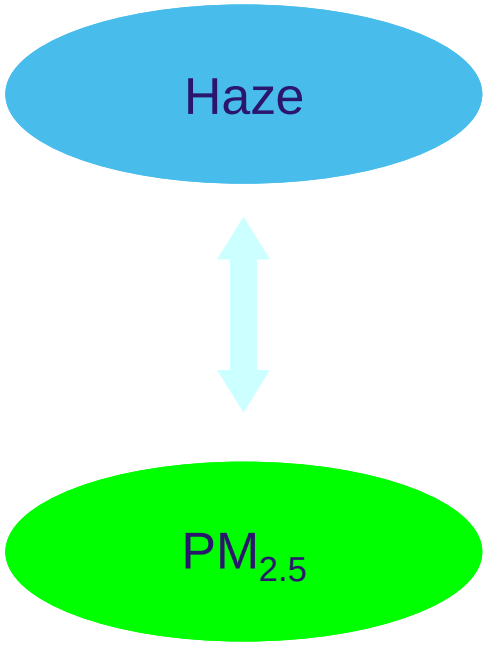
- **Cause of Particulate Pollution**
- Countermeasure & Recommendations

$PM_{2.5}$ classification exclude natural formation



- **primary PM2.5**
- secondary PM2.5

Combustion
Including fossil fuel
and non-fossil fuel

Oxidation from
SOx ,NOx,
VOC,
NH3

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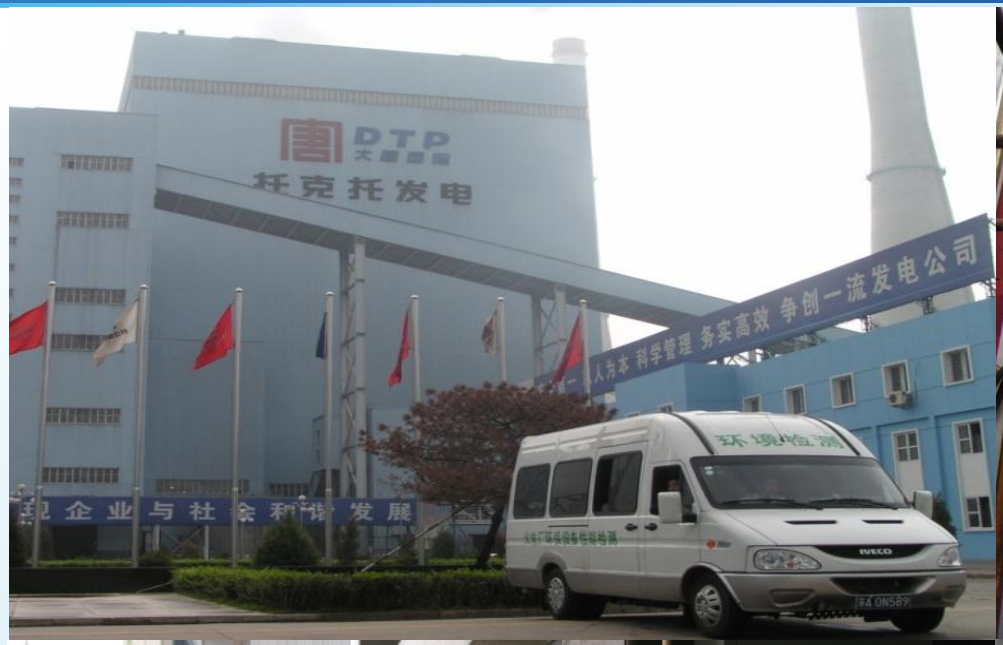
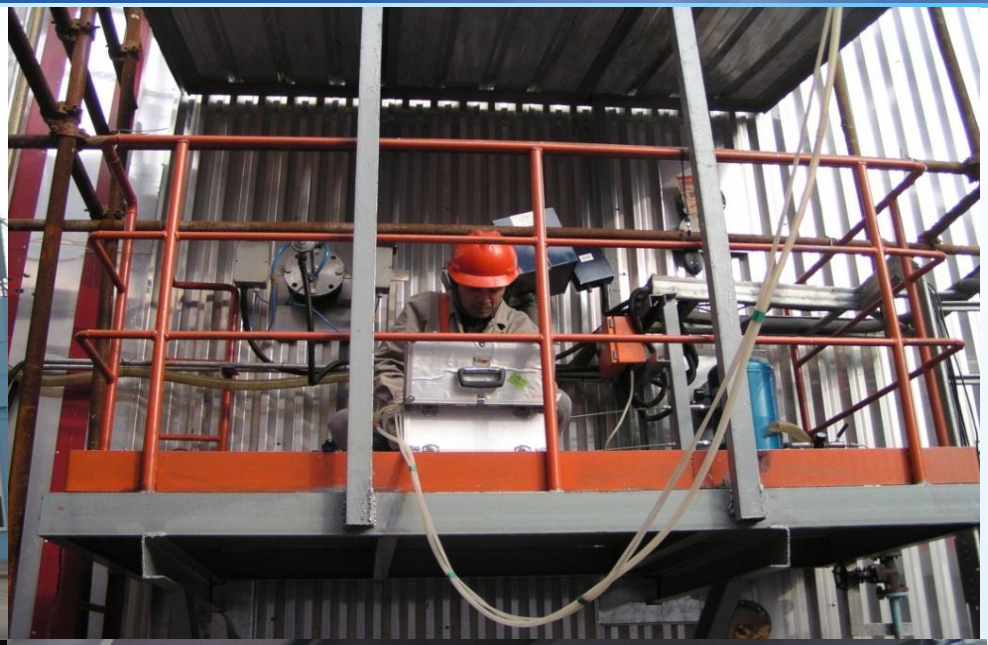
Primary $PM_{2.5}$ measurement





Particulate size of coal-fired power plant dust emission

Before/after precipitator

	before (%)			after (%)		
	PM1	PM2.5	PM10	PM1	PM2.5	PM10
ESP	0.5	5.7	35.8	3.9	24.6	64.8
ESP	0.4	2.9	18.4	5.0	21.1	62.0
ESP	0.9	3.4	14.1	14.7	44.1	83.9
BH	0.1	1.7	16.7	0.8	8.6	71.3

Removal efficiency of various particulate

	PM1	PM2.5	PM10	PM
ESP	90.83	95.58	98.20	99.00
ESP	98.59	99.16	99.62	99.89
ESP	95.74	96.75	98.58	99.76
BH	99.54	99.72	99.76	99.94

PM2.5 account averagely for 30% of smoke dust after ESP in 2005

Particulate size of coal-fired power plant dust emission

	Plant A		Plant B		Plant C		Plant D	
	before	after	before	after	before	after	before	after
Dust content (mg/m^3)	11719.6	46.9	9385.5	42.4	27505.7	95.91	24481.9	26.27
PM_{10} (%)	31.66	80.56	34.21	77.88	28.08	87.23	24.89	87.45
$PM_{2.5}$ (%)	6.84	47.32	4.95	41.21	4.31	41.98	4.09	47.81
$PM_{1.0}$ (%)	2.14	-	1.74	-	1.24	-	2.42	-
PM_{10}去除效率(%)	98.98		98.97		98.92		99.62	
$PM_{2.5}$去除效率(%)	97.23		96.24		96.60		98.75	

PM2.5 account averagely for 45% of smoke dust after ESP in 2010

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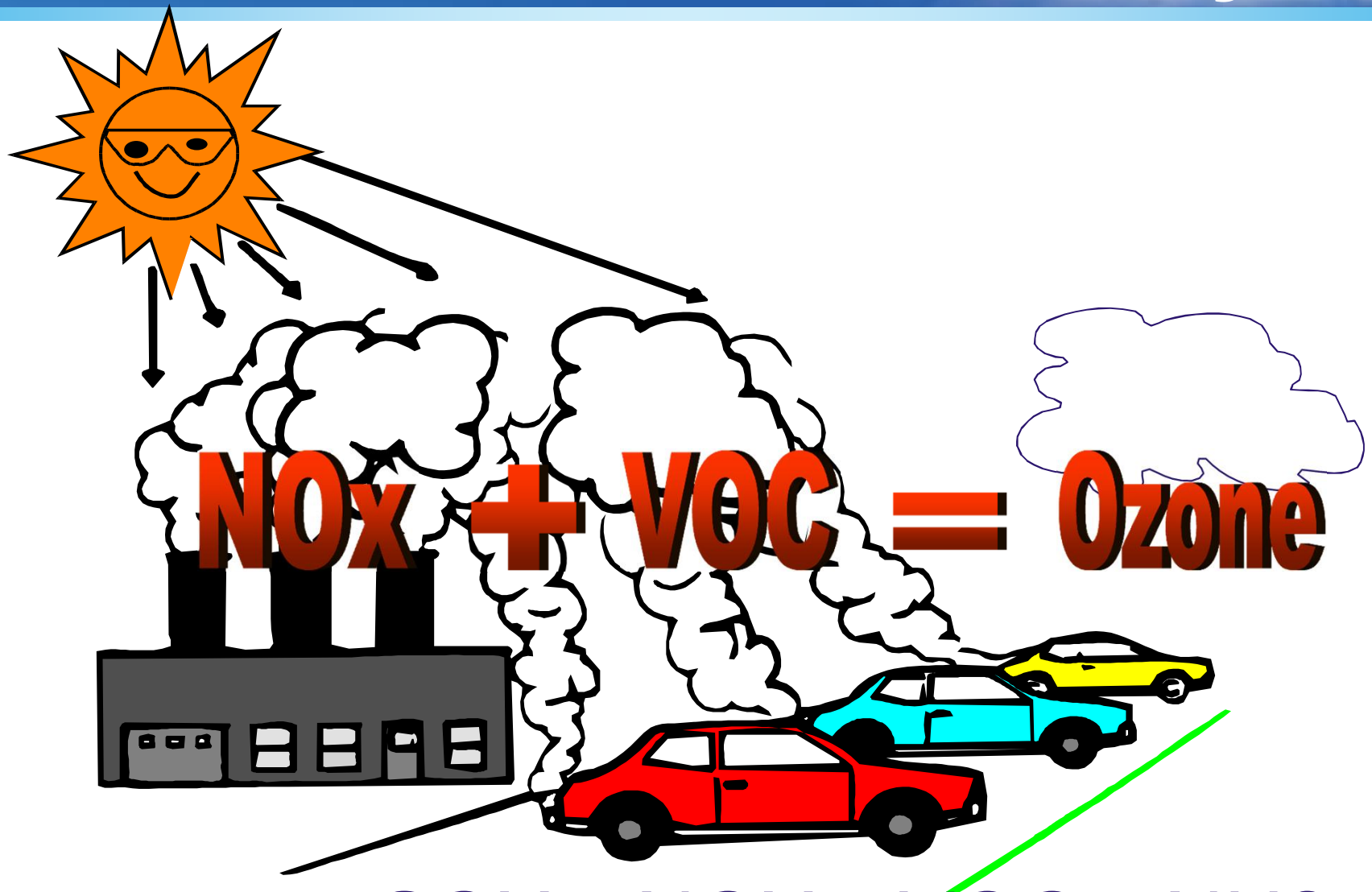
$PM_{2.5}$ emission from power plants in China

	2005	2010	decrease
Total dust	1182.5	829.1	29.9%
Smoke dust from PP	360	160	55.6%
$PM_{2.5}$ from PP	108	72	33.3%

Dust emission from PP decreased sharply, PM2.5 emission also decreased significantly.

Total primary PM2.5 emission in China decrease also.

Secondary PM2.5



precursor：SOX、NOX、VOC、NH3 etc.

Secondary PM2.5

The formation of sulfate particles

$$H_2SO_4 + 2\ NH_3 \longrightarrow (NH_4)_2SO_4\ (s)$$

gas:

$$SO_2 + OH \xrightarrow{O_2,H_2O} H_2SO_4$$

liduid:

$$SO_2 + H_2O_2 \xrightarrow{H_2O} H_2SO_4$$ (acid circumstance)

$$SO_2 + O_3 \longrightarrow H_2SO_4$$

The formation of nitrate particles

$$HNO_3 + NH_3 \longleftrightarrow NH_4NO_3\ (aq,s)$$

gas: (day)

$$NO_2 + OH \longrightarrow HNO_3$$

Gas or liquid: (night)

$$N_2O_5 + H_2O \longrightarrow HNO_3$$

The formation of organic particles

gas:

VOC + OH --->organic particles

Emission from PPs and Proportion

Year	SO_2			Dust			NO_X		
	Total (10^4 tons)	Power (10^4 tons)	Proportion(%)	Total (10^4 tons)	Power (10^4 tons)	Proportion(%)	Total (10^4 tons)	Power (10^4 tons)	Proportion(%)
2005	2549.3	1277.2	50.1	1182.5	405.2	34.3	-	-	-
2006	2588.8	1320.2	51.0	1088.8	386.4	35.5	1523.8	721.4	47.3
2007	2468.1	1245.5	50.5	986.6	329.3	33.4	1643.4	811.0	49.3
2008	2321.2	1151.0	49.6	901.6	279.0	30.9	1624.5	810.3	49.9
2009	2214.4	1028.1	46.4	847.7	246.6	29.1	1692.7	828.7	49.0
2010	2185.1	984.4	45.0	829.1	218.4	26.3	1852.4	954.2	51.5
2011	2217.9	901.2	40.6	1278.8[1]	155.0	12.1	2404.3[2]	1106.8	46.0
2012	2117.6	883.0	41.7	-	151.0	-	2337.8	948.0	40.6

1. Not calculated by smoke dust and industrial dust separately from 2011
2. 2011 Nox emission including vehicle emission 637.6, which has been counted independent of life source from 2011

Source: Ministry of EP

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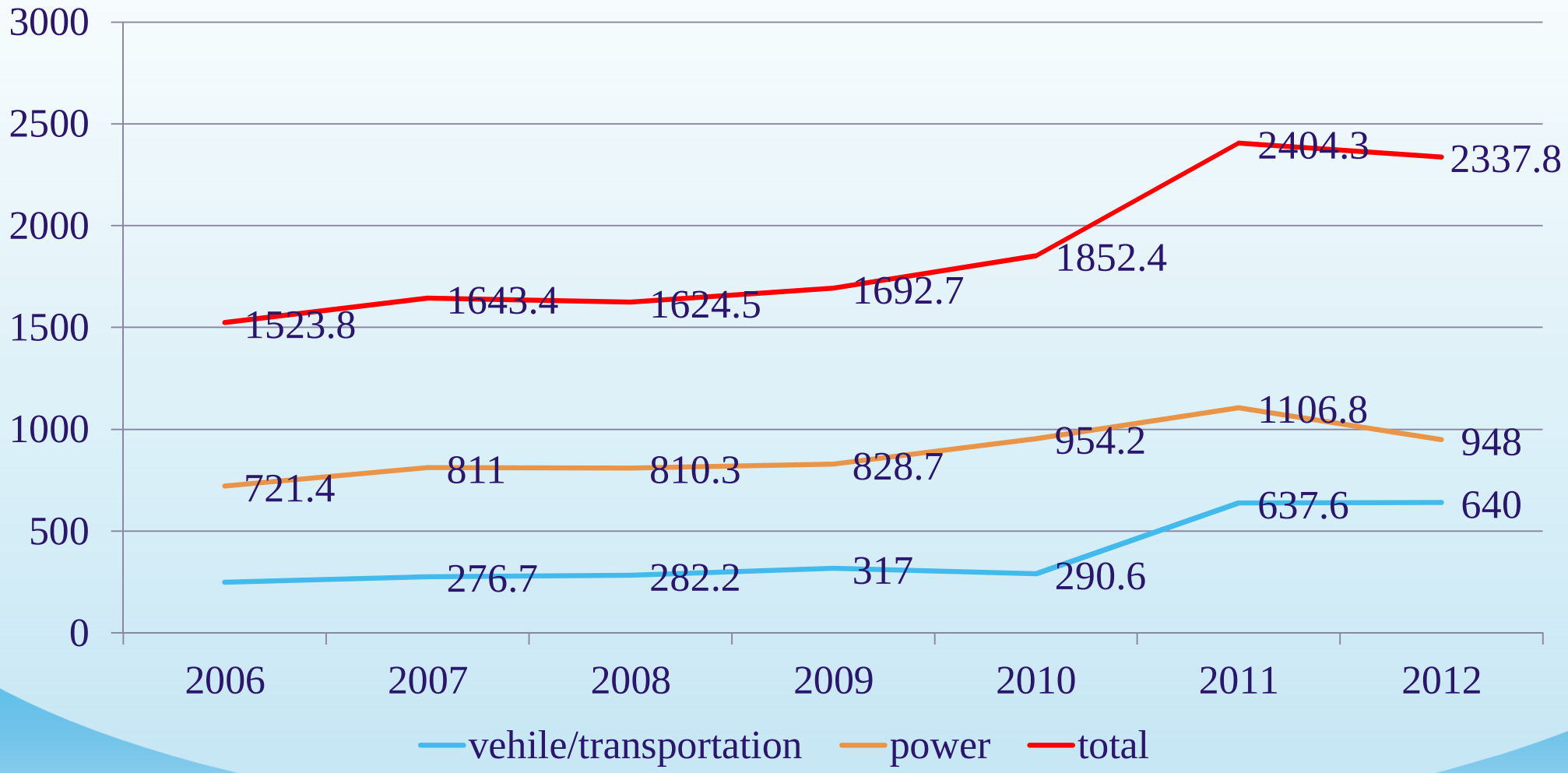
NOX emission in China



Source: Ministry of EP

HC & NOx emission from car

NO.	time	Thousand km	fuel	standard	HC		NOx	
					g/km	E-multiple	g/km	E-multiple
1	2011	5.7	G	G4	0.41		0.07	
2	2012	6.0	G	G4	0.06		0.03	
3	2010	370	G	G3	2.23	10.1	1.63	16.5
4	2010	320	G	G3	1.87	8.3	1.99	18.9
5	2004	180	G	G2	1.84	10.7	3.03	10.74
6	2008	707	CNG	G4	31.2	312	9.04	113

G-gasoline CNG-Compressed Natural Gas

Long mileage is corresponding to high emissions of HC and NOx

Source: China Environment News

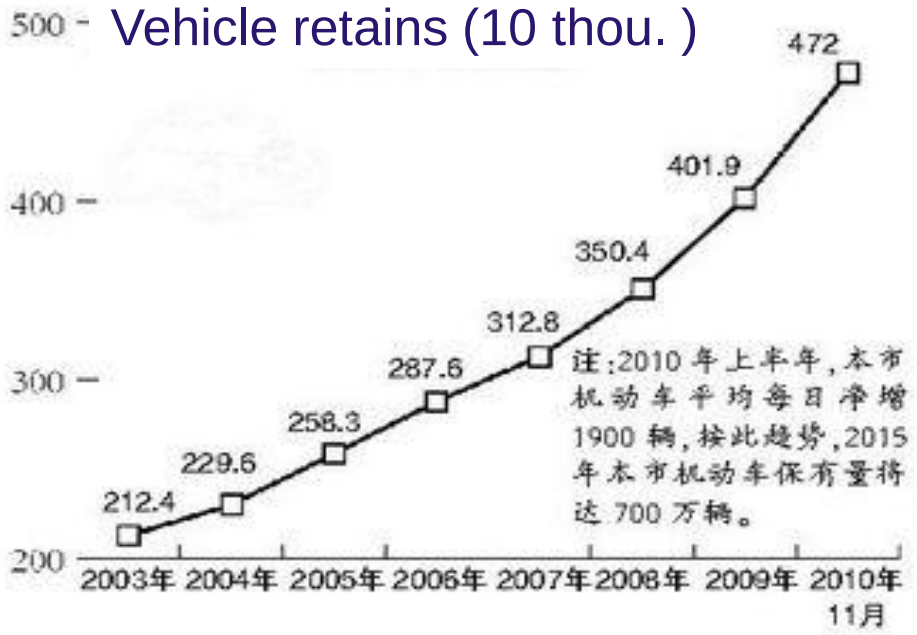
VOC emission & vehicle in China

- At the end of 2012, national motor vehicles retain 240 million, in which the car 120 million, an annual increase of 15.1 million is more than the number of car by the end of 1999

- In 2012 the national motor vehicle hydrocarbon emissions of 4,382,000 tons. Among them, the car emissions 3,452,000 tons, accounting for 78.7%; motorcycle emissions 754,000 tons, accounting for 17.2%.
- In 2012 the top 5 provinces of hydrocarbon emissions from motor vehicle are Hebei, Guangdong,Shangdong,Henan,Jiansu.
- Top VOC area are corresponding to heavy haze area.

Source: network

VOC emission & Vehicle in Beijing



- By the end of 2012, Beijing motor vehicle quantities (including motorcycles) has reached 5.2 million, of which, 4.957million civilian vehicles

Source: network

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Cause of PM2.5 Pollution

- Total emission amount of primary $PM_{2.5}$ decreases gradually. That of secondary $PM_{2.5}$ increases sharply and becomes the main reason of haze

- Sharp increasing emission of NO_X and VOC/Hydrocarbon enhanced atmospheric oxidation. So much more secondary $PM_{2.5}$ are formed

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Reduction of NOx

- **Transform energy structure**
  - Develop safely nuclear power
  - Develop gas power, wind power and so on
- **Clean coal**
  - Upgrade the proportion of coal used for power-generation
  - De-NOx of various coal-fired PP and cement plants
  - Shutdown of Industrial coal-fired Boilers less than 20t/h

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Reduction of VOC

- Replace in time catalytic of cars with over mileage 80-100 thousand km
- Adopt clean energy vehicles, such as electricity, CNG
- Upgrade oil quality
- Develop public transportation and limit quantity of vehicles
- Control VOC emission from petroleum-chemistry enterprises

Other recommendations

- Observe strictly environmental laws and punish responsible persons in order to avoid excess standard emission of enterprises
- Replace coal with electricity
- Develop coal-fired power base in west China and transmission electricity to east China
- Reduce dust emission from construction sites and road

Thank You!

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