Addressing NO_X emissions from China's power sector

China Environment Forum

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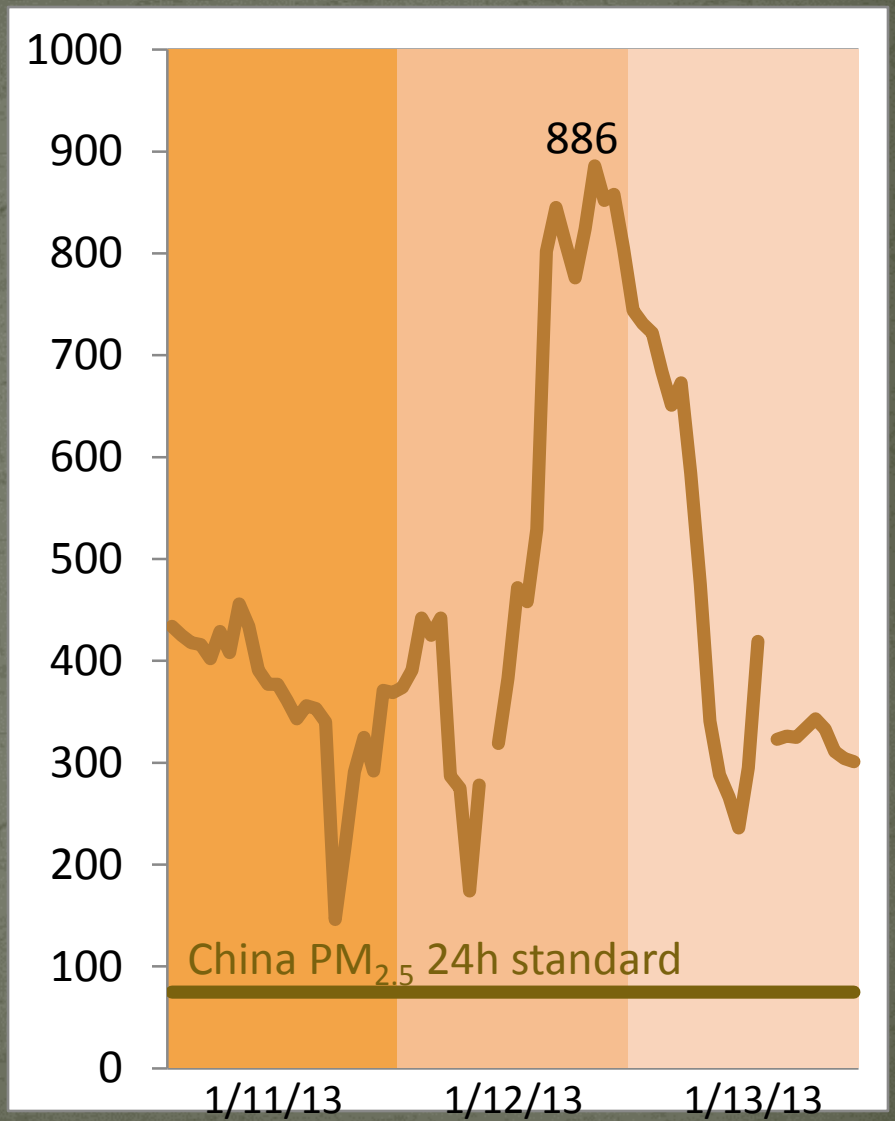
Air pollution episode in January 2013 in Beijing



Source: US Embassy – Beijing. @BeijingAir Twitter account

Smoke billows from the chimneys of a power plant during sunrise in Jiaxing, Zhejiang province, on December 23, 2011. China introduced stricter air pollution standards to monitor $PM_{2.5}$ of pollution in Beijing and other big cities. (Reuters/Stringer) - http://www.theatlantic.com/infocus/2013/01/chinas-toxic-sky/100449/#img11

Rooftops of Beijing's Forbidden City, obscured by thick smog, in Beijing, China, on January 16, 2013. (Feng Li/Getty Images) - http://www.theatlantic.com/infocus/2013/01/chinas-toxic-sky/100449/

Northeastern China on January 14, 2013 as captured by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. The image shows extensive haze, low clouds, and fog over the region. The air quality index (AQI) in Beijing was 341. (NASA, Jeff Schmaltz, LANCE MODIS Rapid Response) - http://www.theatlantic.com/infocus/2013/01/chinas-toxic-sky/100449/#img02

Unprecedented air pollution?

“Lunch Atop A Skyscraper”: Construction workers taking lunch during construction of the RCA Building (renamed as the GE Building) at Rockefeller Center (Charles C. Ebbets, 1932)

Lewis Wickes Hine, 1931 – Empire State Bldg, NY

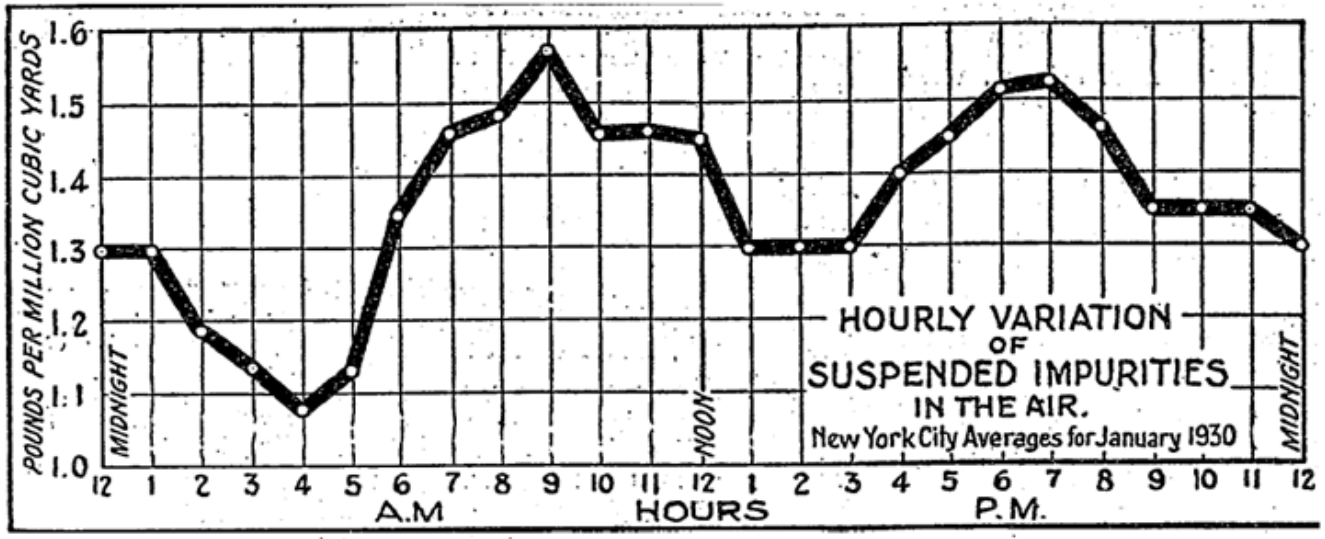
New York Central Park (1930) - average PM_{100} 800 $\mu g/m^3$

FINDS CITY'S AIR PUREST AT 4 A. M.

Device That 'Breathes' in Park Records 9 A. M. as Hour of Greatest Pollution.

WORKS EACH QUARTER HOUR

61,199 Dust Particles Per Cubic Foot Is Average for January, Against 50,524 in Same Month of 1929.



HOW THE CITY'S AIR POLLUTION FLUCTUATES HOURLY.
Chart Prepared by New York Meteorological Observatory in Central Park Based on January Averages Shows the Rise in the Air's Dust Content From the Low Point at 4 A. M. to the Peak at 9 A. M.

Using a new apparatus that "breathes" the city air and registers its dust and smoke content every fifteen minutes, the New York Meteorological Observatory in Central Park has found that every million cubic yards of New York's atmosphere contained, during January, an average of 1.35 pounds of impurities. The instrument, which was installed on Jan. 1, showed the city's air to be purest at 4 A. M. and most polluted at 9 A. M., according to a report of the first month's operation made public yesterday by David R. Morris, meteorologist.

The apparatus, which is known as the Owens automatic air filter and is much used in England, keeps an automatic record throughout the day and night. It was lent by the Stevens Institute of Technology. Samples of air examined each noon by another instrument, in use at the observatory for a year, showed a higher dust content this January than last year. This year the average for the month was 61,199 particles per cubic foot, compared to 50,524 last year. January is usually the dirtiest month of the year.

The pollution of the air shown by the Owens filter varied during the month from 0.27 pound of impurities per million cubic yards, registered on Jan. 11, to 2.70 pounds on Jan. 27.

Mr. Morris has prepared a chart showing the average variation during the day, in January, of the air pollution. Starting from the low point at 4 A. M., when the air is at its purest, the curve gradually rises, as fires are made in homes and offices, until it reaches its peak at 9 A. M. It declines until after noon, and does not begin to rise again until 3 o'clock, probably because the home fires are started up again in preparation for the evening. The second peak is reached at 7 P. M., and thereafter the curve declines almost steadily, with a slight retardation between 9 and 11.

The air filter "breathes in" two liters of air every fifteen minutes. The air is sucked in through a small tube which hangs out the window. It passes through filter paper, leaving its dust and smoke in a small, round mark the size of a small pea.

Ninety-six of these marks are left around the edge of a circular filter paper. They are compared with a series of sixteen standard shades, each of which represents a certain percentage of impurity, and the amount of dust per million cubic yards is then calculated.

Andy Blair, 1966 – Midtown and Lower Manhattan, NY

[Note: Photoshopped] St. Boniface's Catholic College Class of 2008 recreating "Lunch Atop A Skyscraper" - http://www.flickriver.com/photos/bonifaceplymouth/2956126142/

Select government strategies for pollution control

10th Five-year Plan: Focus on primary PM_{10} emissions

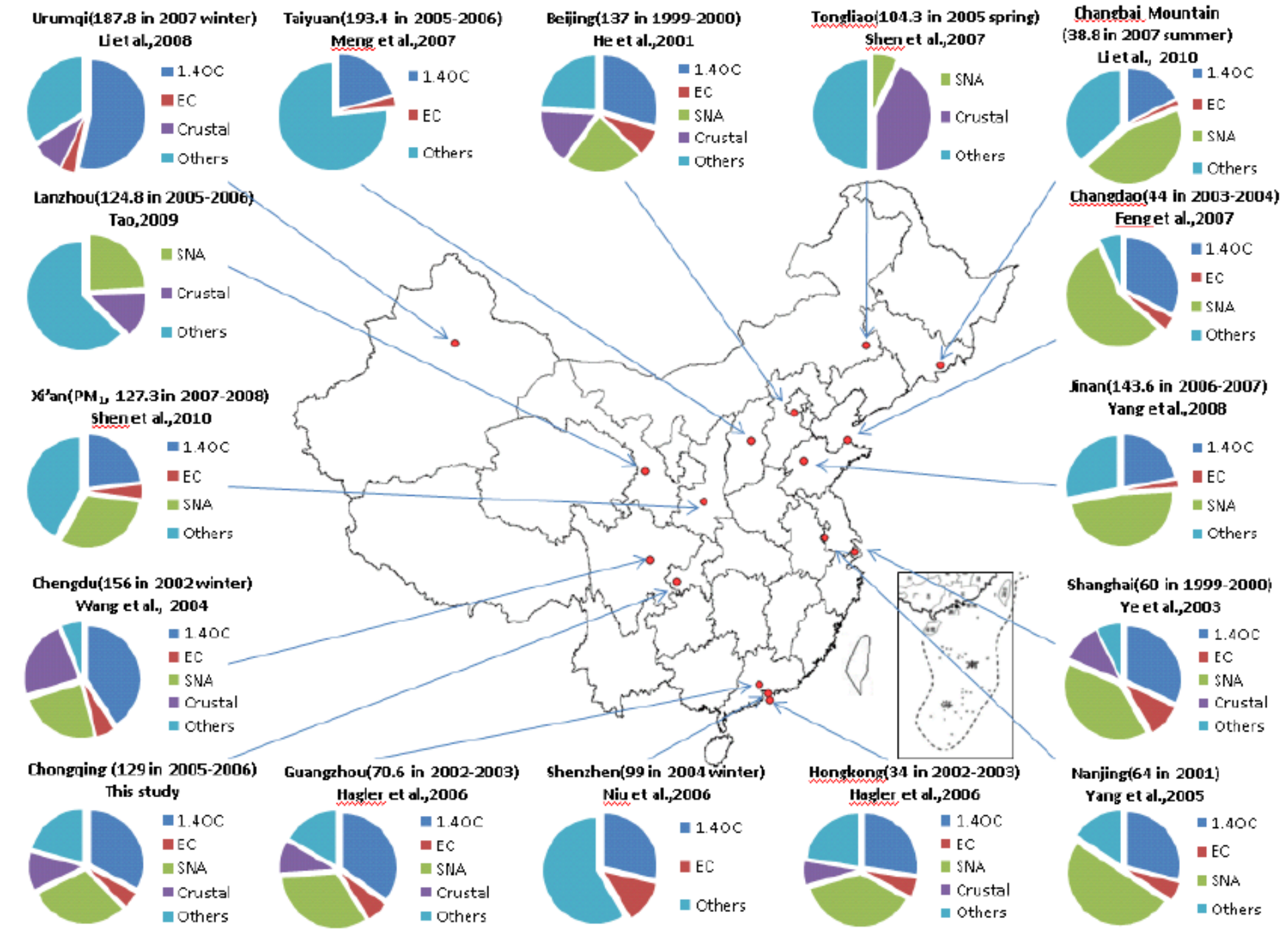
11th Five-year Plan: Focus on SO_2 and primary PM_{10} emissions, energy efficiency, and renewable energy

2007: Enhanced political support; revised SO_2 emission control strategies

12th Five-year Plan: Focus on NO_X emissions and secondary $PM_{2.5}$, CO2 emissions, and energy efficiency

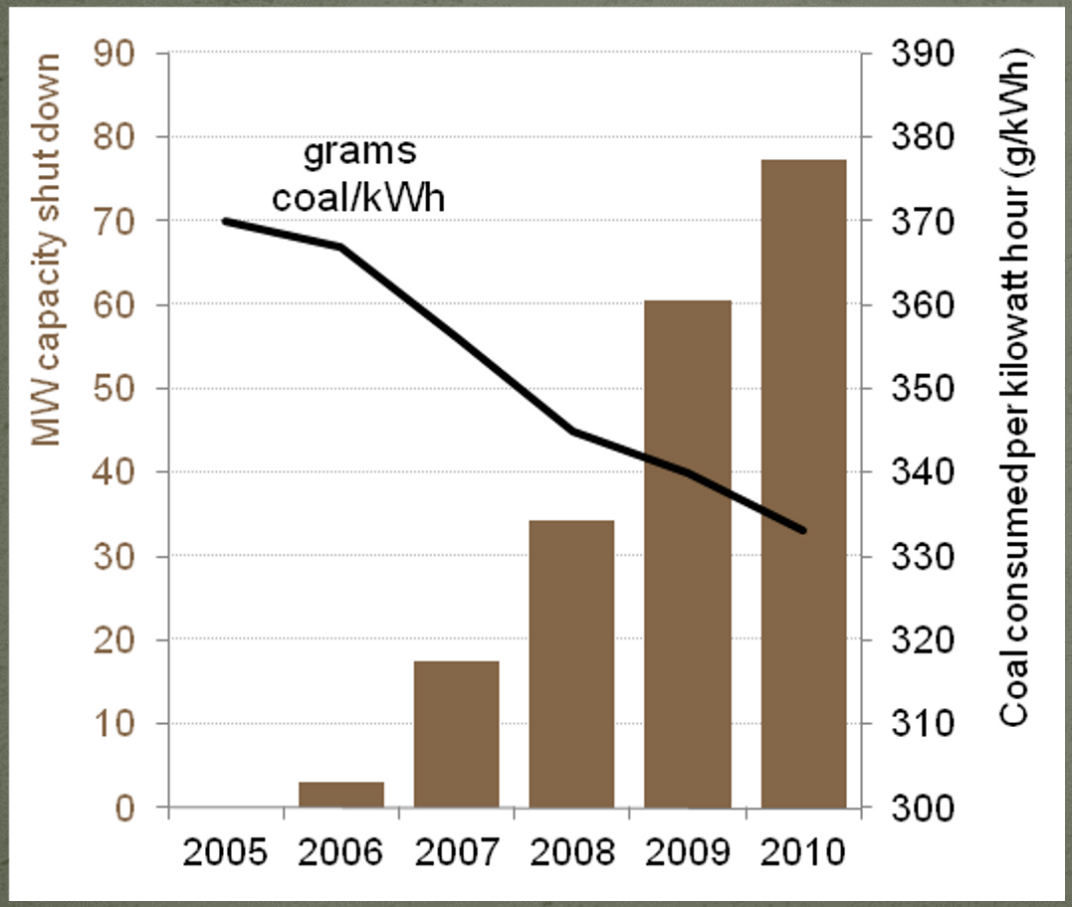
2012: $PM_{2.5}$ monitoring requirements and standards

2013: Regional air quality $PM_{2.5}$ reduction targets; tighter emission standards; coal caps



Source: Yang et al., 2011. Characteristics of PM2.5 speciation in representative megacities and across China. Atmospheric Chemistry and Physics. 11: 5207-5219.

Primary particulate matter (PM_{10}) and sulfur dioxide (SO_2) were priorities of the 11th Five-year Plan (2005-2010)



Build big-close small (上大-压小) policy led to retirement of 77GW of small, inefficient, high-emitting coal power plants and an 11% improvement in electric generating efficiency

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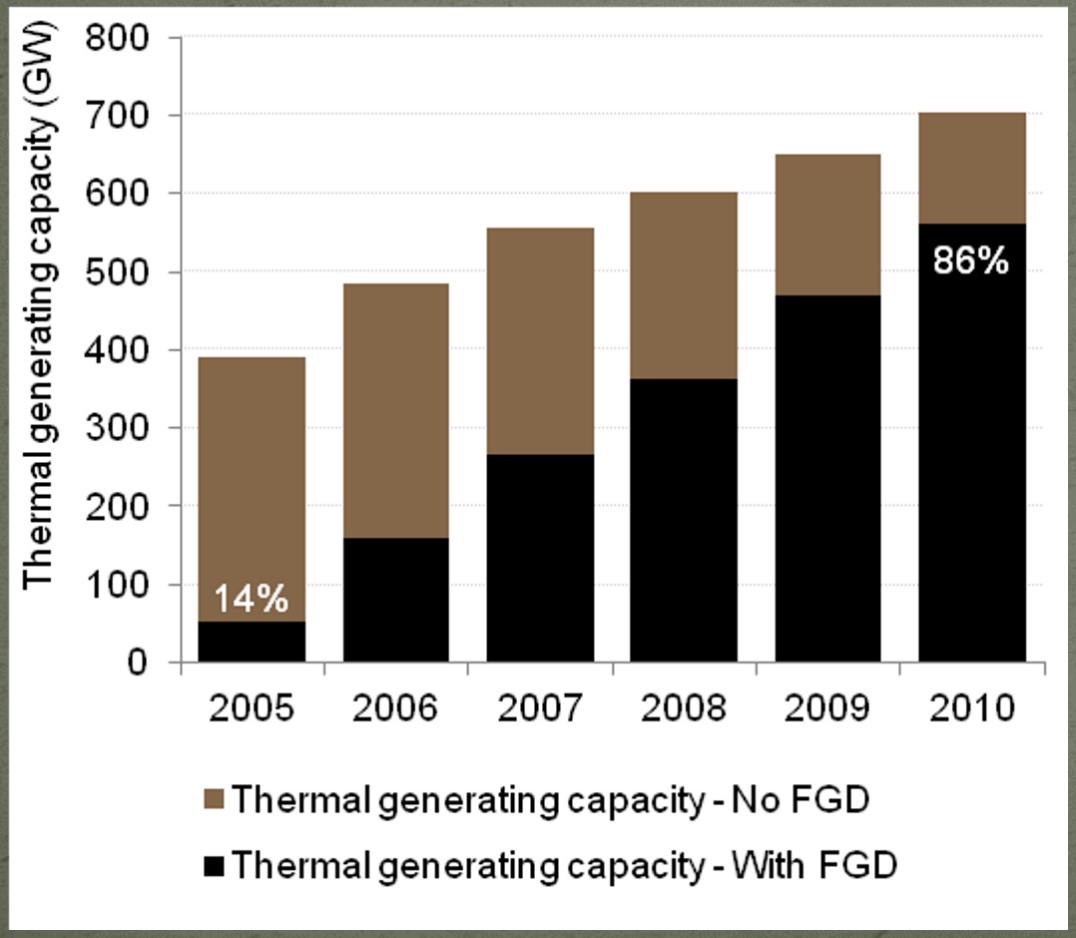

Government-power company agreements and incentive programs (price premiums) contributed to greater installation and use of SO_2 controls

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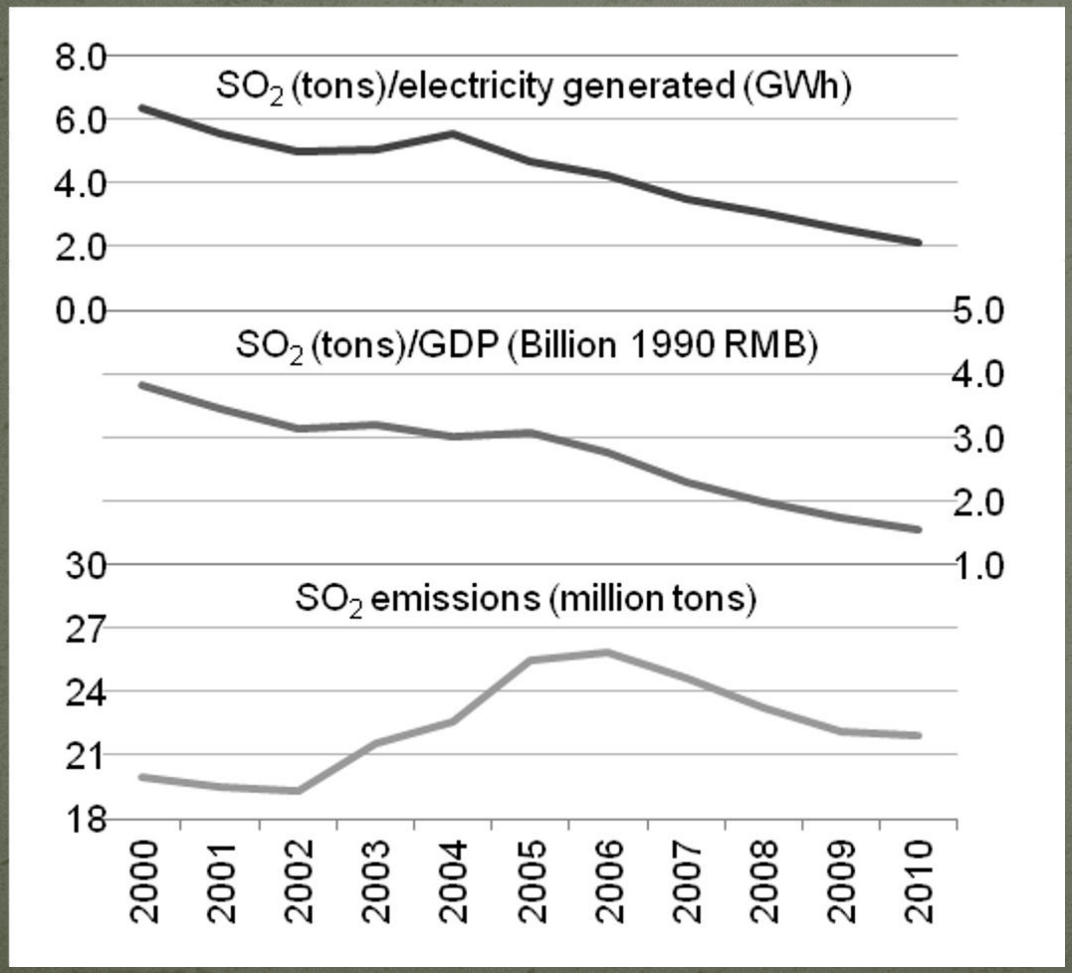
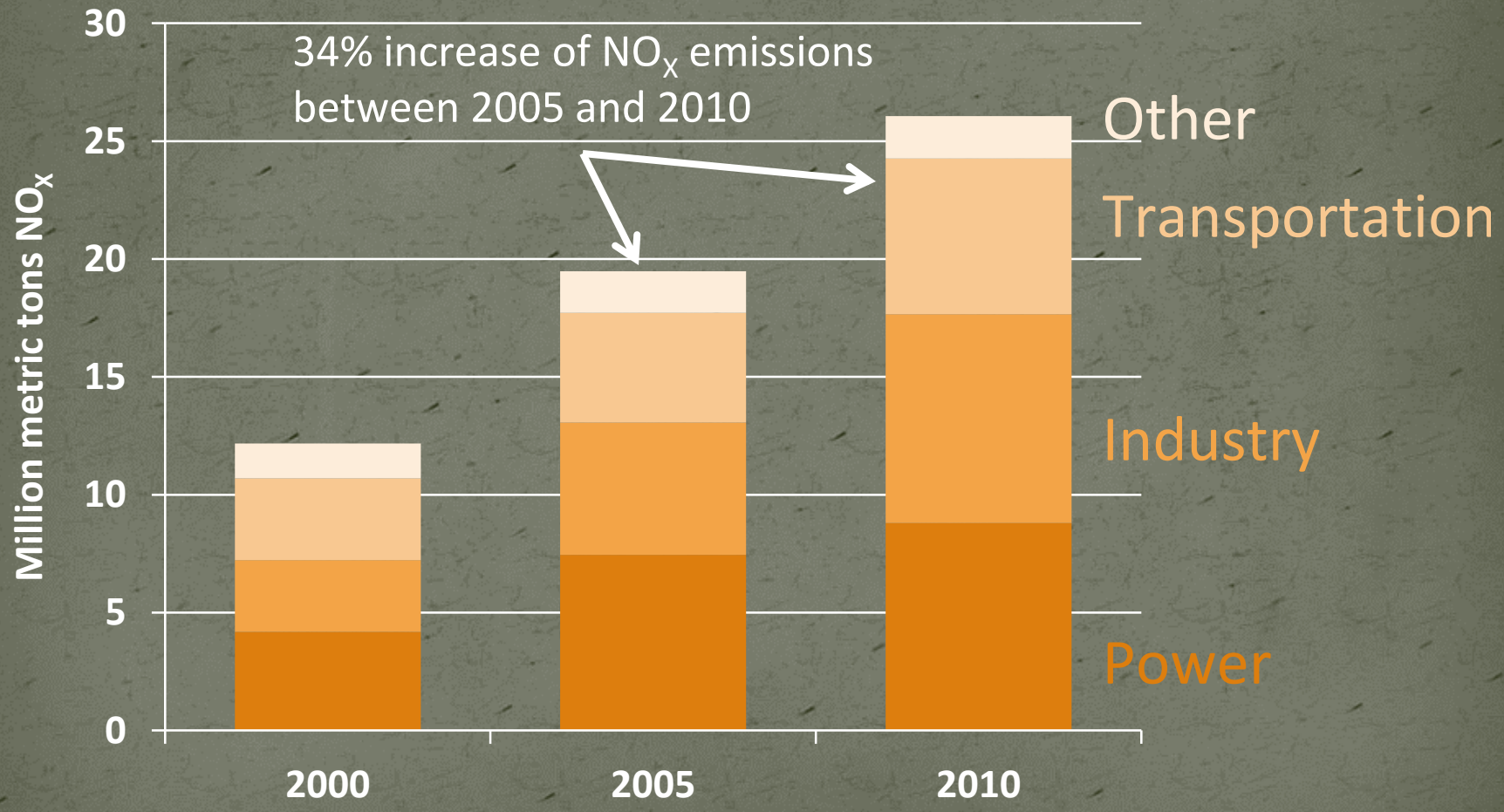


SO_2 Total Emission Control targets for provinces, power sector, and industry were strongly enforced and led to a 14% decrease in nationwide SO_2 emissions

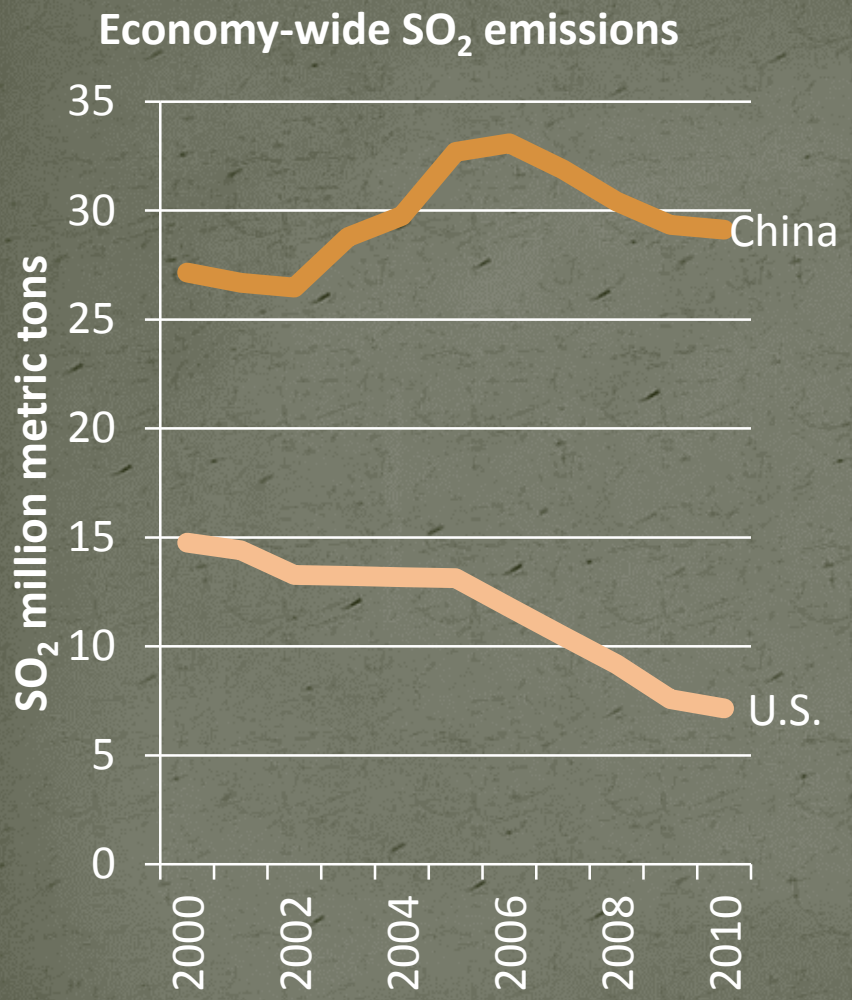
Factors contributing to success of SO_2 emission reduction goals

- Mandatory goals outlined in national Five-year Plan
- Political commitment to enforce targets
- Accountability for achieving the targets
- Verification of emission measurements
- Greater government focus on SO_2 target
- Policies and programs that emphasized performance and incentives

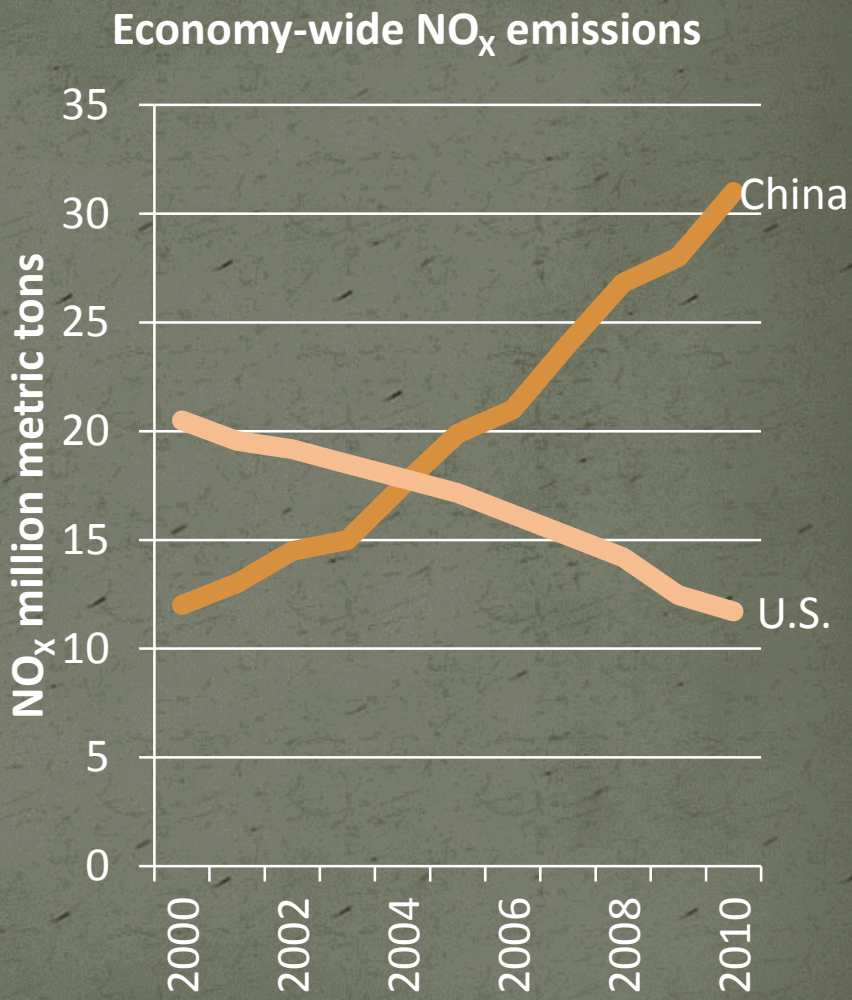
While primary PM_{10} and SO_2 have declined, NO_X, VOCs, and secondary $PM_{2.5}$ are on the rise



Relative to the U.S., China's SO_2 and NO_X emissions are high



Source:
EPA, 2011. National Emissions Inventory Air Pollutant Emissions Trends Data; Zhang, He & Huo, 2012. Cleaning China's air. *Nature*.



Source:
EPA, 2011. National Emissions Inventory Air Pollutant Emissions Trends Data; Wang & Hao, 2012. "Air quality management in China: Issues, challenges, and options." *Journal of Environmental Sciences*.

Achieving the NO_X emission reduction targets of the 12th and 13th Five-year Plans