

**Action Plan for
Improvement of Particulate Abatement Systems of
Coal-Fired Power Plants in China**

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China Electricity Council

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Contents

I. General Overview

II. Issues and Problems

III. Regulation Framework

IV. Reasons of Improvement Action

V. Criteria for Typical Plant Selection

VI. Measures to Address the Issues

Annexes - Technical Audit Report for Typical Coal-Fired Power
Plant in China

I. General Overview

In China, coal is the major one of primary energy, which is at 67% of total energy consumption. In 2003, raw coal production is 1,667 million ton and 50% is used for electricity generation.

By the end of 2003, total installed power capacity is 391.4 GW and No.2 of the world, in which, thermal power is 289.8 GW and at 74 percent of total; electricity production is 1905.2 TWh, in which, 1579.0 TWh from thermal power and at 83 percent. The capacity of coal fired units account for 95% of total thermal capacity, oil and gas units account for rest 5%. Coal fired plants play a leading role of China's electric power industry.

The demand of electricity is very strong in recent years. The growth rate of GDP in 2000-2003 was 8.0%、7.5%、8.0% and 9.1% , respectively. The growth rate of electric power during the same period was 10.97%、8.43%、11.48% and 15.30%, respectively. It is predicted that the total installed capacity in 2020 will be 950 GW, in which, coal fired power will be 600 GW and top one of the world.

By this reason, pollution prevention of power plant is an important issue for China.

Table 1 Ratio of Electricity from Various Energy for Different Countries(%), 2001

	Thermal power		Hydro	Nuclear	Others
	Coal	Others			
USA	51.03	21.90	5.74	20.80	0.53
Germany	51.62	13.13	3.98	29.41	1.86
UK	34.62	40.12	1.66	23.35	0.25
France	4.47	4.59	14.28	76.54	0.12
Italy	13.18	65.15	19.33	0	2.33
Canada	20.05	10.18	56.66	13.04	0.07
East North Asia					
Japan	22.89	37.09	9.00	30.67	0.35
Korea	38.94	19.34	2.11	39.58	0.03
China	75.39	6.35	16.60	1.60	0.05

Table 2 Power Ability of China

		2000	2001	2002	2003
Capacity (GW)	Total	319.3	338.5	356.6	391.4
	Thermal Power	237.5	253.0	265.6	289.8
	Coal Fired Power	227.0	242.0	253.4	277.0
Production (TWh)	Total	1368.5	1483.9	1654.2	1905.2
	Thermal Power	1107.9	1204.5	1352.2	1579.0

II. Issues and Problems

- Particulates Emissions

Before the seventies of 20th century, most thermal power plant in China used water scrubbers and mechanical particulate removal devices, particulate removal efficiency is very low, about 70% on average. After more than 20 years development, the proportion of ESP increases year by year, particulate removal efficiency on average has already been up to about 98%. Sack particulate catchers for unit of 200 MW have put into commercial operation. Among 22 years from 1980 to 2002, though the installed capacity of thermal power rose from 46.5 GW to 265.6 GW, had increased by 4.7 times, but the emission of particulate was fair basically, and began to obviously decrease in 1998. The emission of particulate was 3.99 million tons in 1980, 3 million tons in 2000 and 2.7 million tons in 2002.

Table 3 Particulate Emissions of China (million ton)

Year	Total	Industry	Power Plant
2000	11.65	9.53	3.00
2001	10.70	8.52	2.90
2002	10.13	8.04	2.70

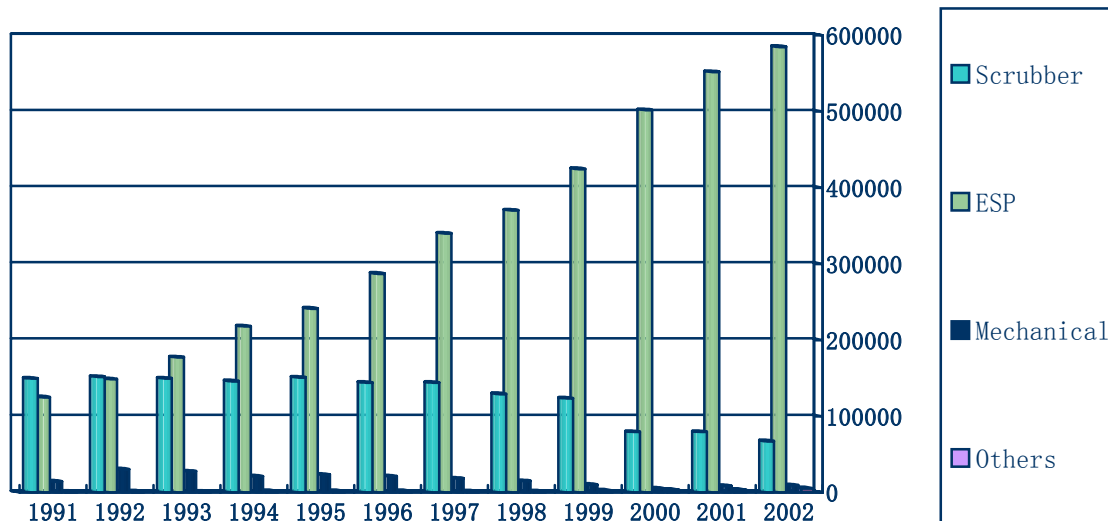


Fig.1 Particulate Abatement System Ability in Boiler Capacity (t/h)

- SO₂ Emissions

In 2002, total SO₂ emission quantity of China is 19.27 million ton, 15.62 million ton of industry and 6.66 million ton of thermal power plants.

Since Luohuang power plant of Huaneng Group introduced 2 limestone-gypsum wet flue gas desulphurization devices of 360 MW units and put into operation in 1991, it indicated that commercialized desulphurization device of thermal power plants started in China. After this, many kinds of desulphurization method began to use, such as lime-spraying dry process, simple wet limestone-gypsum process, circulation fluidized bed process, electron-beam process, sea water process, LIFAC etc. By the end of 2002, capacity of desulphurization units under construction was about 15 GW, capacity of desulphurization units in operation was over 6 GW in China.

Since 1991, with the help of Environmental Defense of USA, China State Environmental Protection Administration began the pilot work of licence system of air pollutant matters in 16 cities, Baotou, Kaiyuan, Liuzhou, Taiyuan, Pingdingshan, Nanjing, etc. also tried the emission trade of sulfur dioxide. Up to now, the licence system of air pollutant has not still implemented in an all-round way.

- NOx Emissions

In China, NOx emission limit was first set up for new, large capacity PC boilers in 1997 by the Standard GB13223-1996. According to new Standard GB13223-2003, the limit is applied to all type of boiler in 2005 for old unit and this year for new one.

At present, NOx emission control in China is mainly done by the control of combustion. Low NOx combustion technology was introduced together with new units from foreign countries to China. In addition, low NOx combustion burners have been developed in China since 1980's, various low NOx burners based on the features of Chinese coal and milling system have been developed and used for retrofitting part of existing units with capacity of 100-300 MW.

China just starts to use flue gas de-NOx technology to reduce NOx emissions (there are only two power plants).

- CO₂ Emissions

Greenhouse gas emissions and climate change are global issues. China government has been organizing the whole action. For electricity sector, changes of power energy composition and energy conversation have abatement effect. But it has not been requested for every coal fired plant to provide these data.

- Other Emissions – mercury, arsenic, chromium, lead

The effects of emissions of heavy metal are under study by university and research institute in China. There is no comment coming from most of power plants now.

- Energy Efficiency

The energy efficiency of electricity generation has a continuance of increase. The standard coal consumption rate for power supply is 381 gce/kWh which is 11 gce below 2000's, but 60 gce higher than advanced level of the world. There are many opportunities to raise efficiency and abate emission simultaneously.

Table 4 Main Energy Efficiency index

	2000	2001	2002	2003
Raw Coal Consumption (Million ton)	591.92	645.61	732.84	826.0
Specific Coal Consumption (gce/kWh)	363	357	356	
Self Power Consumption (%)	6.28	6.24	6.15	6.10
Standard Coal Consumption for Power Supply (gce/kWh)	392	385	383	381
Wire Loss Rate (%)	7.81	7.55	7.45	7.60
Average Utilization Hours	4517	4588	4800	5250
Average Unit Capacity (MW)	54.0	55.0	53.4	

- Health Risk Assessment

The health harm from the emissions of particulates, SO₂ and NO_x is obviously, but the exact health investigation and research are lack.

- General Policy

General policies concerned air pollution is list below:

Law - Law of Environmental Protection (1989)

Law of Air Pollution Prevention (2000)

Law of Cleaner Production Promotion (2003)

Rule - Rule of Collection and Usage of Pollution Fee (2003)

Regulation - Emission Standard of Air Pollutants for Thermal Power plants (GB13223-2003)

III. Regulation Framework

In 1973, China set up the first emission standard for coal fired power plants. It was modified four times as below and the latest one

was put forward last year.

- 《Industrial Waste Emission Standards for Power Plants》 (GBJ4-73)
- 《Emission Standard of Air Pollutants for Coal Fired Power plants》 (GB13223-91)
- 《 Emission Standard of Air Pollutants for Boilers 》 (GB13271-91)
- 《 Emission Standard of Air Pollutants for Thermal Power plants》 (GB13223- 1996)
- 《 Emission Standard of Air Pollutants for Thermal Power plants》 (GB13223-2003)

The change of new standard: adjustment of the emission limits; stipulation of period of time, by which the existing power plants must meet the requirement of new, more strict emission limits; adjustment of conversion coefficient of excess air for pollutant concentration; abolishment of original stipulation for the emission limits according to the type of particulate removal device and sulfur content of coal.

Table 5 Emission Limit for Coal Fired Power Plants (GB13223-2003)

Period of unit		Period I		Period II		Period III
Date of implementation		1 Jan,2005	1Jan,2010	1Jan,2005	1Jan,2010	1 Jan,2004
Particulates (mg/m ³)		300(urban) 600(rural)	200	200(urban) 500(rural)	50	50
SO ₂ (mg/m ³)		2100	1200	2100	400	400
NO _x (mg/m ³)	Vdaf<10%	1500		1300		1100
	10%≤Vdaf ≤20%	1100		650		650
	Vdaf >20%					450

Remarks:

Period I: All the thermal power plants which environmental evaluation reports were approved before December 31, 1996.

Period II: All the thermal power plants which environmental evaluation reports were approved between January 1, 1997 and the date in which this Standard starts to implement.

Period III: All the thermal power plants which environmental evaluation reports were approved after the implementation of this Standard.

The old limit of particulate emission (GB13223-1996) is from 200 to 3300 mg/m³. The new limit is from 50 to 600 mg/m³, aim limit of year 2010 is 50 and 200. According to this regulation, new power units need more efficient particulate removal device, old unit must be retrofitted.

IV. Reasons of Improvement Action

The origins of particulate abatement system to be retrofitted are:

- At the time of new emission regulation in operation, much more old units of coal fired power plants cannot meet new limit.
- Actual type of operation coal has been more different from design one, such as rise of ash content and reduce of heat value, etc.
- Design of particulate abatement system had some defaults, or system adopted old technology.
- Particulate abatement system is old after long period run, which cause low efficiency and need rehabilitation.
- For requirement of FGD, new-built desulphurization device need particulate abatement system in high efficiency.
- Public awareness raising
- Subregional cooperation agreement if action plan take effect.

V. Criteria for Typical Plant Selection

For selection of the typical coal fired power plants for priority of beneficiary rehabilitation, criteria are below:

- Air quality in the area of plant is an important issue which needs to be resolved as soon as possible.
- Emissions of plant have a great influence on city.
- Environment concern about exceeding the particulate emission limit.
- Urban power plant combined heat supply.
- Age of power plant is suitable for system refurbishing; the capacity of units isn't too small.
- Power plant has a basic prepare for particulate system rehabilitation, the overhaul is on schedule, major financial provision is ready and the beginning time is not too far, not too near also.
- Public awareness raising.

As a result, Datang Taiyuan Second Thermal Power Plant is selected to be the recommendation power plant, the reasons are:

- Shanxi province is located in the central area of China, which is the top one province of coal production. Electric power is the main industry, electric power capacity is tenth and generation is sixth in China. It is also the top one province to export electricity in the whole country.
- Environment of Shanxi province is weak, air pollution is very serious.
- Taiyuan is the capital of Shanxi Province. Air pollution there is at the front place in capital cities of China. It is the state experimental city of cleaner production.
- It is urban power plant with heat supply.
- It is at upper direction of wind for the city, its impact on air quality of the city is very great.
- The power plant is composed of new and old units built at different period.
- With the strict limit of state environmental standard, the old units faced to be reconstructed.

- The unit capacity of 200 MW is middling, the existing issues are typical.
- Some units of the power plant have installed desulphurization devices, the aimed units have planed to add FGD system, improvement on participate abatement system is the necessary precondition.
- The feasibility report of FGD has been revised, and major financial provision is ready. The overhaul of total unit is on schedule and will begin next year.

VI. Measures to Address the Issues

ESP Status

1. After the overhaul of NO. 7 ESP last year, the operating parameter is greatly improved. The operating efficiency of the electric filed is increased and the operating voltage and current are greatly increased. Although the parameter is not obviously decreased, the efficiency of emitted flue gas is not satisfied. This problem relates to the low exceed margin capacity between actual and design. When the quality of coal is greatly changed in combustion, the total area of electrode plate is relatively small, that results in low efficiency of emitted flue gas.

2. Because the aging, program control of rapping devices cannot be periodically functioned. That results in the amount of secondary fly ash is increased and efficiency of ESP is reduced. The most serious problem results from continuously long-time rapping, causes plates of anodic and frames of cathodic to be wrecked. After the overhaul of NO.7 ESP in 2003, the rapping joint and the anodic plate of NO.7 ESP are almost ripped.

3. Serious Leakage in the main body. Because the equipment has been used for 10 years, the leakage of the ESP caused by low temperature erosion is common.

4. Only half of the anodic plate is replaced because this half are almost broken. The other half of anodic plate is not replaced but continuing in operating by bottom up and welding repair for money

saving. It is difficult for maintains because plates are too thin to weld reliably, which lay a hidden trouble for the future.

5. Almost all of ESP are controlled by DCS system now, which can monitor more parameters and control them. However, NO.7 and NO.8 ESP's control system is behind time of 15 years. These two ESP cannot be controlled by computers, but they are controlled and recorded by manual work. It is impossible to act real time monition.

6. Channels and effective flow areas are insufficient because of the low exceed margin between actual and design value of ESP.

7. Actual type of operation coal has been more different from design one, such as rise of ash content and reduce of heat value, etc.

8. As an experimental sample, some sonic ash-cleaners are used to promote ash excluding from hopper. It was helpful, but be out of operation now because faults of its compressed air system occurred.

Measures

The maintenance of ESP #7last year provide a way of improvement. But a series of measures must be done to meet the emission regulation.

The potential improvement approach as below:

- Repairing anodic plate and cathodic line
- Adding an additional ash precipitator. However, this approach is constrained by field. It is required to change current flue gas duct and add supporting frames. The workload is large.
- Keeping 3 electric fields, but changing the last field to be fabric filter. This technique needs to be investigated before operation in work place. Calculating the ESP efficiency, life of fabric filter and large-size generating units operating situation.
- Reconstruction of Rapping Device.
- Reconstructing ESP HP/LP control system, adopting self adaptive control technique and on-line monitoring. Reducing the damage of equipments, improving operational management skill.

- Changing all ESP to fabric filters, but almost impossible to be changed in recent years.

Measures for Unit 8 by action plan:

- Adopt advanced DCS for control improvement.
- Reconstruction of rapping device.
- Rehabilitation anodic plate and cathodic line wholly
- Refurbishing main body of ESP

Timetable

Overhaul, desulphurization and ESP improvement must be operated at the same time.

Overhaul plan date: Because 200MW generating units need to be overhauled in every 5 years, the overhaul date of unit 8 changes from 2004 to August 2005, the period of 200MW units need to be repaired for 55 days.

Financial Provisions

Major financial provision for overhaul, desulphurization and ESP improvement may consider together.