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The Historical Progression of Pollution Control Measures in Shanghai's Coal-fired Power Plants

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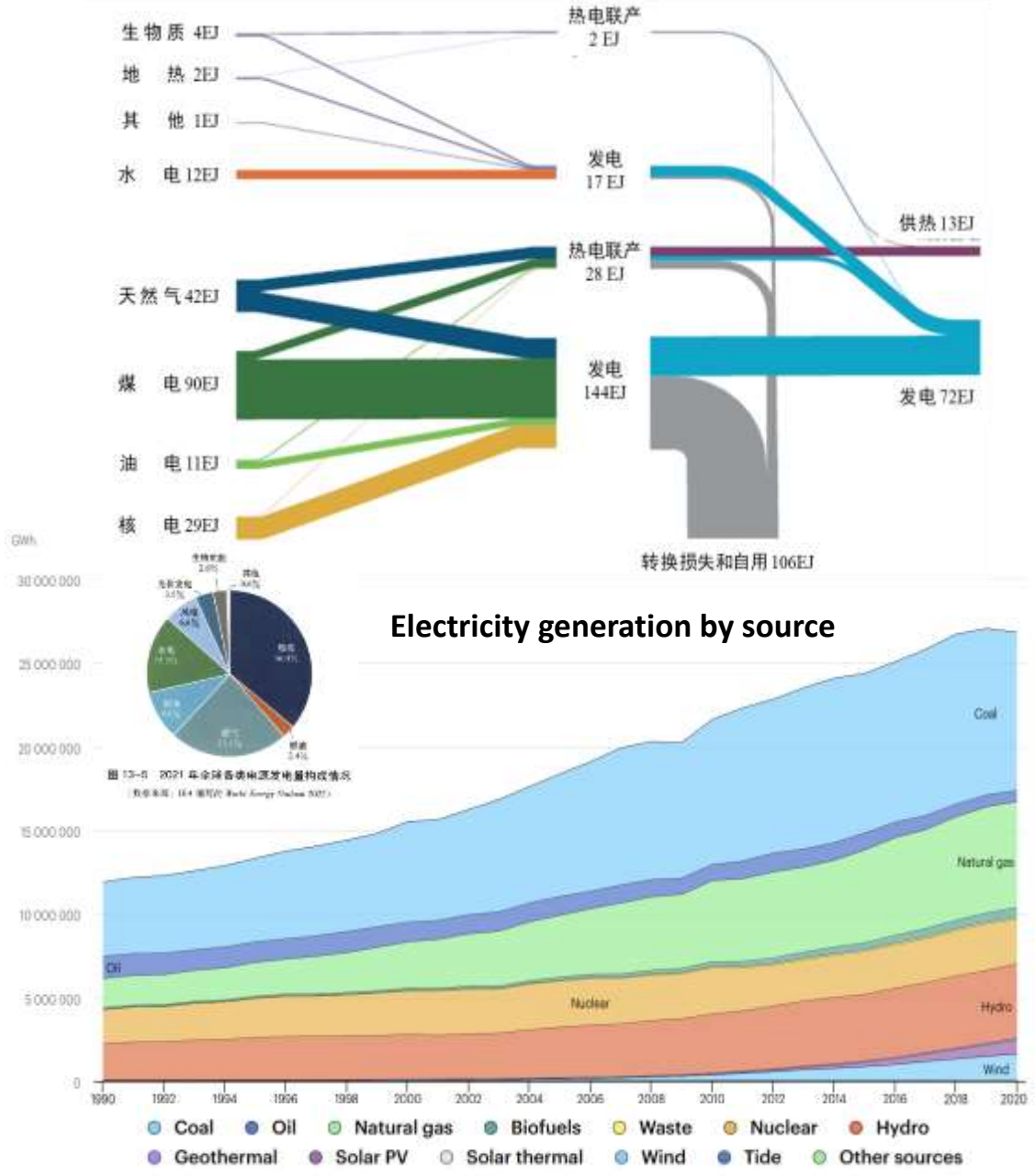
01 BACKGROUND

Overview of the global power generation sector

- Coal is the predominant source for electricity and heat generation globally, contributing to **36%** of global electricity production.
- Over the past 30 years, while the share of coal power continues to rise, other renewable energy sources also grows rapidly.
- In the coming 15 years, although increased adoption of renewable energy generation techniques is expected, coal **will still remain the main source of electricity and heat generation**.



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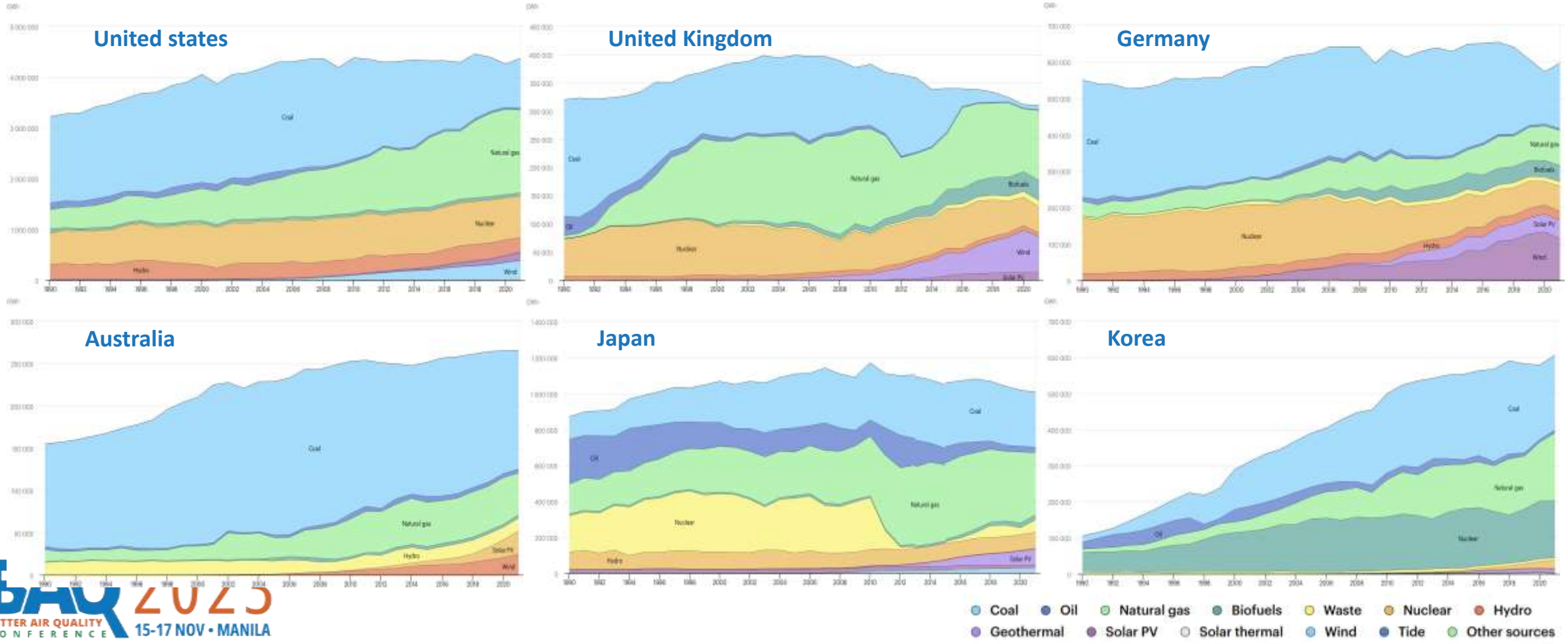
Energy sources for electricity generation in developed countries

Even in developed countries, i.e., the United States, Germany, Australia, Japan, and South Korea, coal is still the main energy source for electricity generation, accounting for **~20% to 55%**



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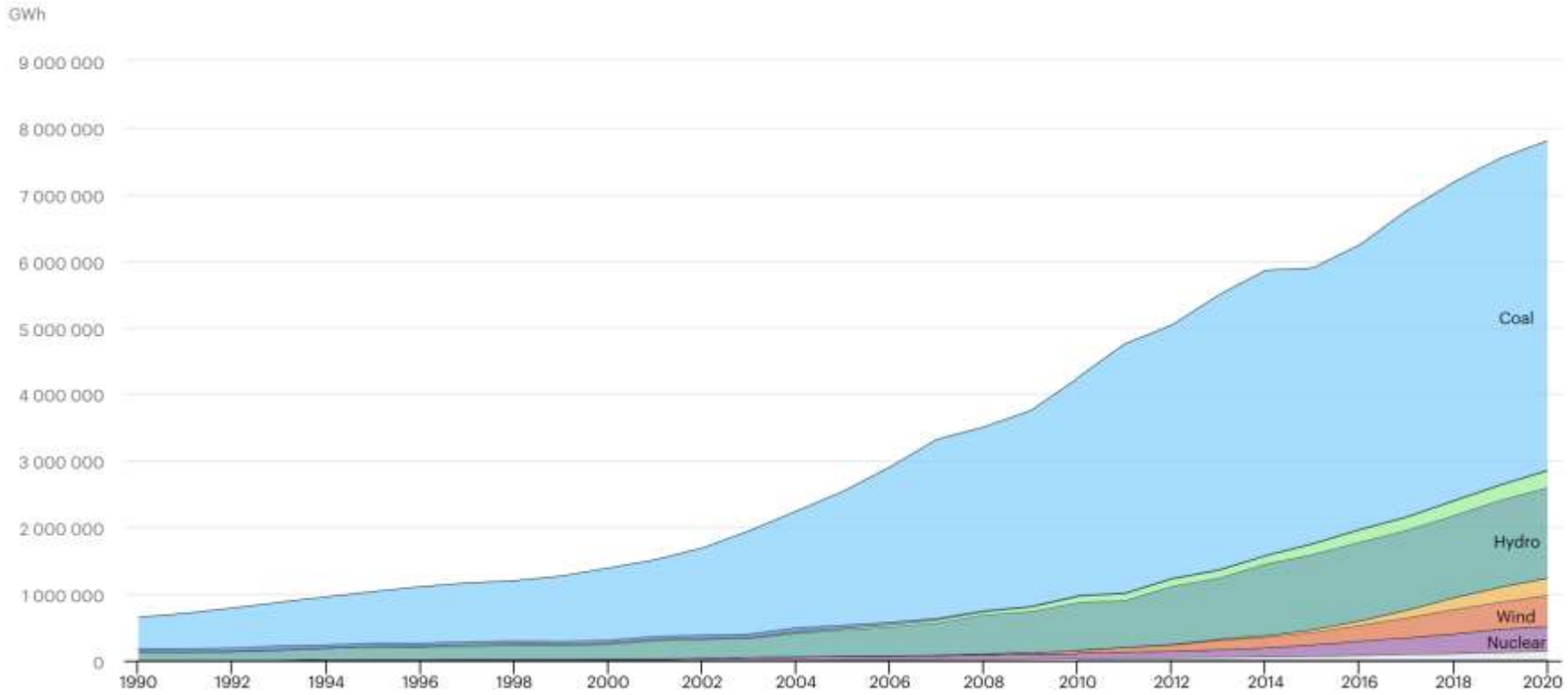
Energy sources for electricity generation in China

Although electricity generation from clean energy in China has been **increasing** year by year, coal still accounts for **over 60% of total energy utilized for electricity generation**



Electricity production in China using different sources of power between 1990 and 2020

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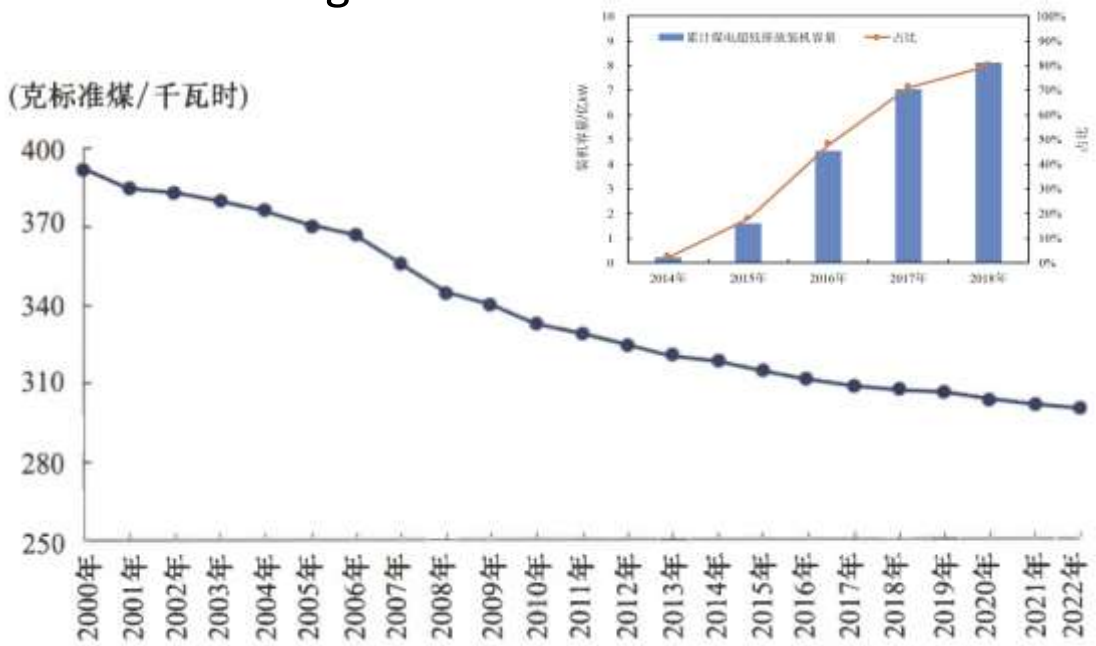
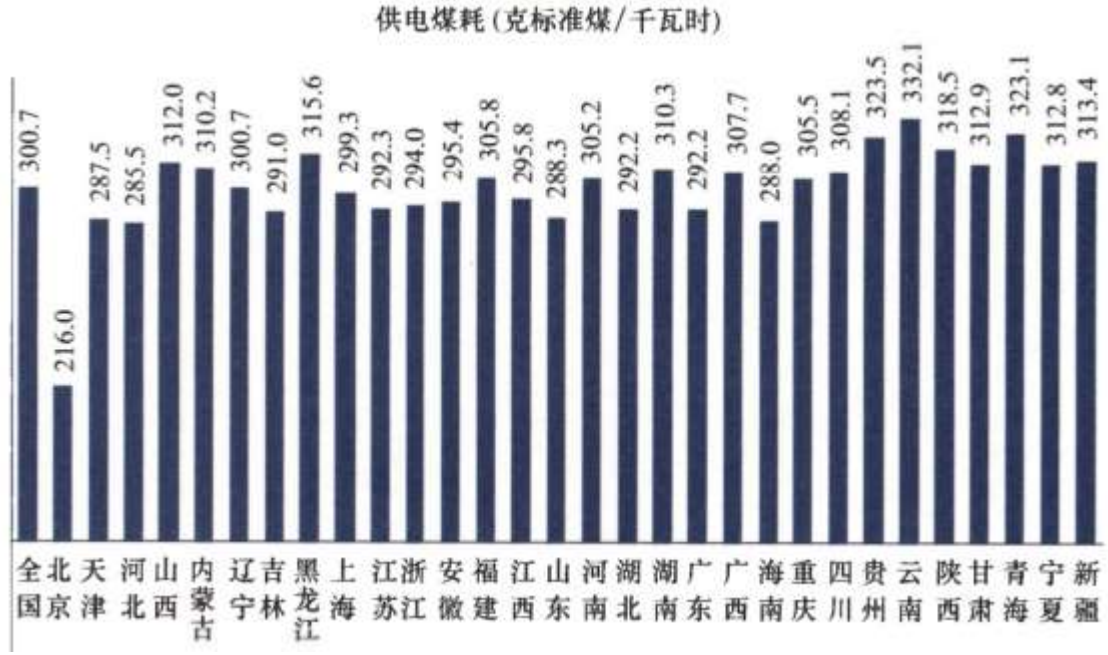
Coal consumption for electricity generation in China

- In 2022, the standard coal consumption for power generation in thermal power plants with a capacity of 6,000 kW or above was **300.7 g/kWh, lower by ~23%** than that in 2000
- The coal consumption for generating 1 kWh of electricity in Shanghai is slightly lower than the national average



National standard coal consumption for power generation of thermal power plants with ≥6000 kW from 2000 to 2022



Coal consumption for electricity generation across different provinces of China

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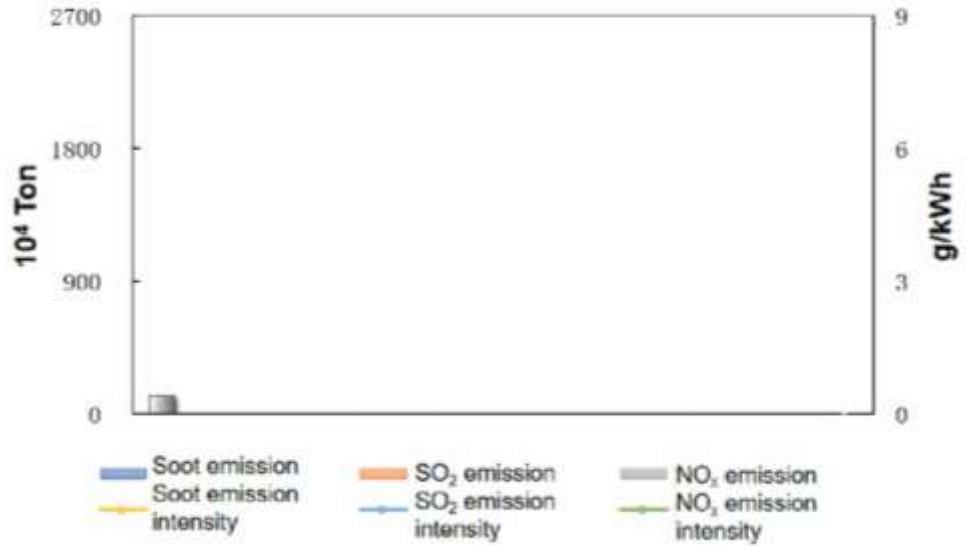
Clean coal-fired energy sector development in China

- **Elimination of outdated and excessive production capacity:** **300 million tons (MT)** of iron and steel, **400 MT** of cement, 150 million weight boxes of flat glass;
- The world's largest clean coal power supply system has been built, and ultra-low emission retrofit has been accomplished for 1.03 billion KW of coal power and 630 MT of crude steel production capacity ;
- National coal-fired boilers and furnaces reduced **by 400,000 units**; more than 27 million households has accomplished renovation for clean heating in winter, reducing the burning of raw coal by more than 60 MT in total; 2/3 of the newly increased energy consumption became clean energy.



Emissions from coal power plants (2005-2017)

Coal consumption and SO_2 annual concentration trend in Beijing from 2012-2017

Green Energy and Low Carbon Transition in Shanghai

Promoting the development of non-fossil energy sources

The 13th Five-Year Plan

Proportion of **primary energy** consumption

37%→31%

The 13th Five-Year Plan

Proportion of **natural gas** consumption

10%→12%

The 13th Five-Year Plan

Proportion **of non fossil energy** consumption

14%→18%

2025

Total **coal consumption** drop by **5%**;

Proportion of **primary energy consumption** drop to below 30%

Below 30%

2025

Proportion of **natural gas** consumption

12%→17%

2025

Renewable energy and **local renewable energy** respectively take up 36% and 8% of the total electricity consumption in the whole society

36% & 8%

2025

Proportion **of non fossil energy** consumption

20%

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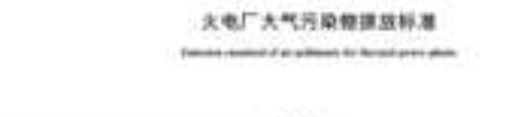
02 GOVERNANCE

Policies

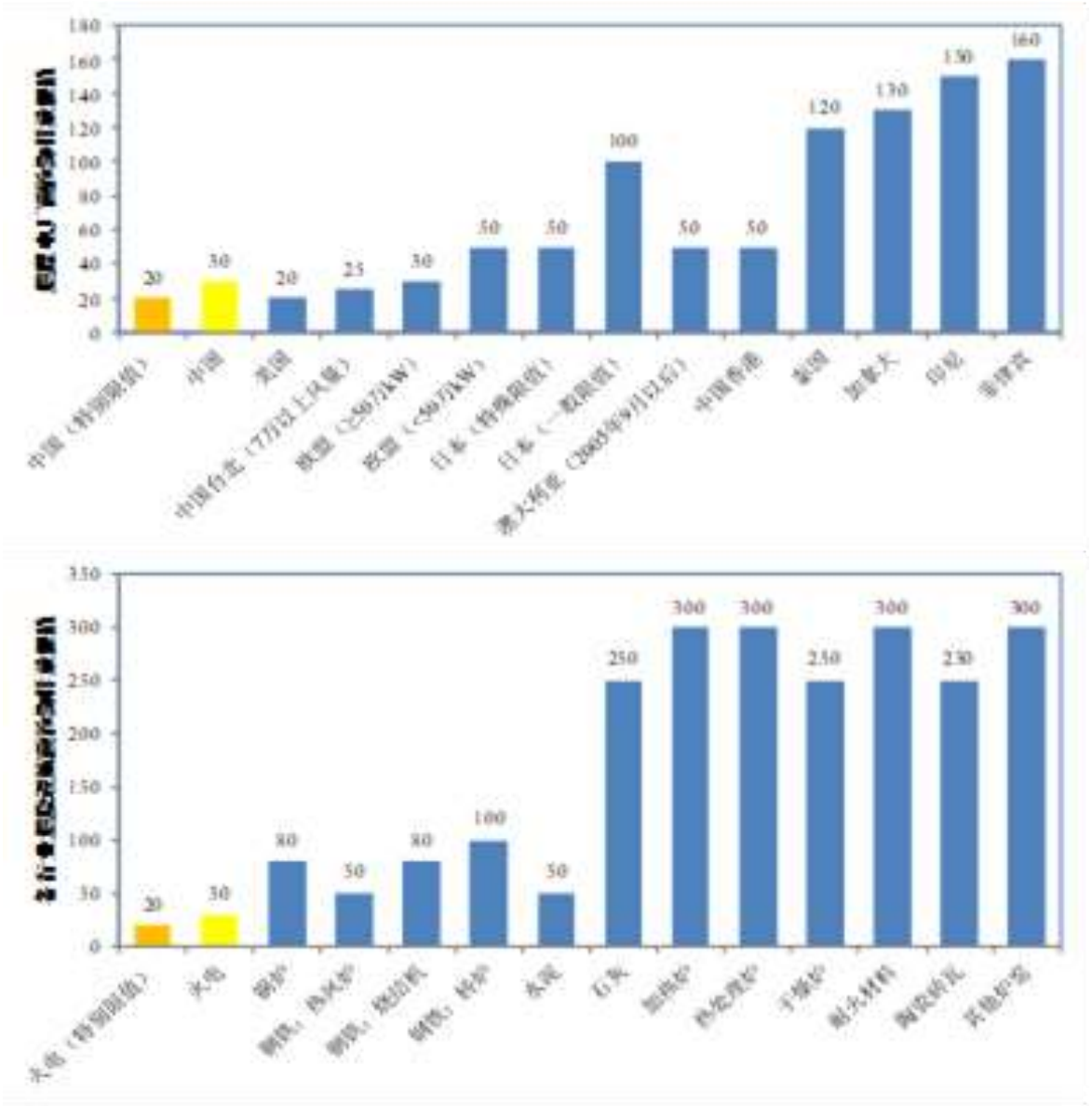


1. **Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution**: the fundamental law in China for the prevention and control of atmospheric pollution, including **regulatory requirements for emissions** from coal-fired power plants.
2. **Emission Standards for Air Pollutants from Coal-fired Power Plants (GB13223-2011)**: sets the **emission limits for primary air pollutants**, including SO_2, NO_x, PM, and other pollutants emitted from coal-fired power plants in mainland China.
3. **Emission Standards for Exhaust Gases from Coal-fired Power Plants (GB13271-2014)**: specifies the requirements for **exhaust gas emissions** during the operation of coal-fired power plants in mainland China.
4. **Shanghai Regulations on the Prevention and Control of Atmospheric Pollution**: specifically address the prevention and control of atmospheric pollutant emissions from coal-fired power plants in Shanghai.
5. **Shanghai Emission Standards for Air Pollutants from Coal-fired Power Plants (DB31/387-2012)**: supplements and refines the requirements of GB13223-2011 and provides specific emission requirements for coal-fired power plants in Shanghai.
6. **Environmental Protection Requirements for Coal-fired Power Plants in Shanghai**: These requirements outline specific regulations for environmental protection aspects, including air, water, noise, and other relevant factors for coal-fired power plants in Shanghai.

Standards

- Comparing with foreign countries overseas, the **new air pollutant emission standard** for thermal power plants is considered the most stringent (GB13223-2011)

- Comparing with other fixed coal-fired facilities in China, **the emission limit** for thermal power plants is the most stringent



Techniques – Ultra-clean emission retrofits

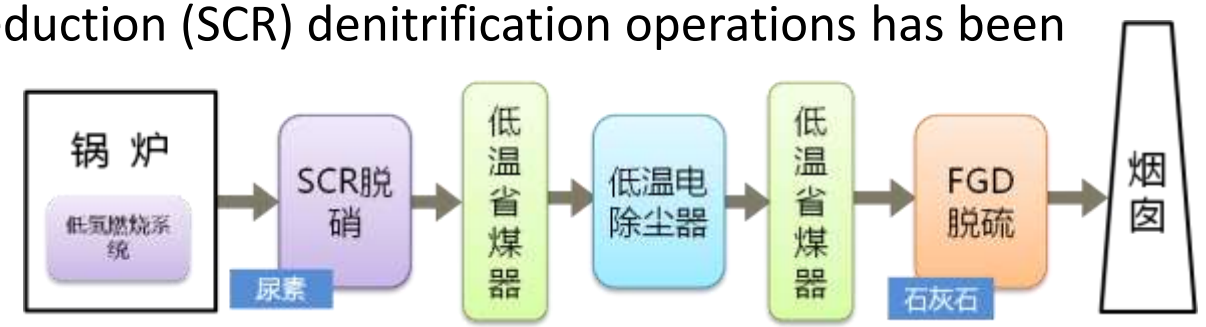
Shangdian Caojing Power Generation company in Shanghai:

It is a key project of Shanghai's 11th Five Year Plan, located in Jinshan District with two 1-million-kWh ultra-supercritical coal-fired units

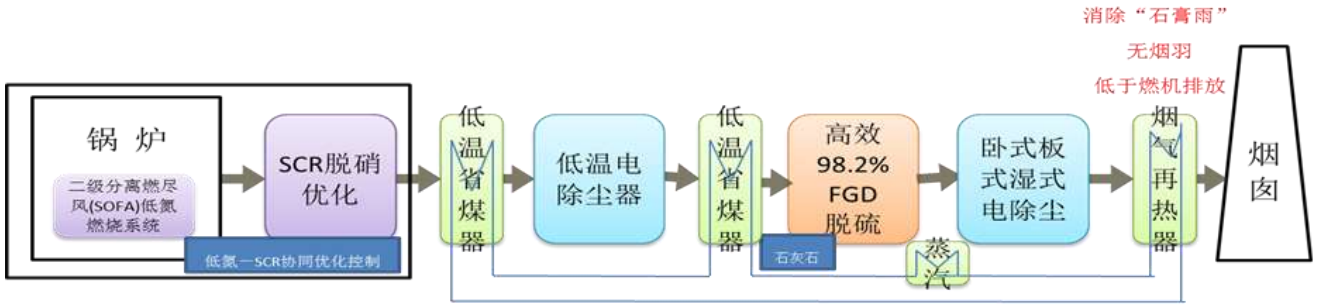
Techniques – technological progress

- Measures have been taken to **enhance the efficiency and coordinate retrofits for dust removal in the existing desulfurization system**, including the addition of a wet electrostatic precipitator, a flue gas reheat system, and a wet flue gas desulfurization wastewater collection and drainage device
- This project involved **comprehensive computational fluid dynamic simulations** and **optimization of the flue gas system and purification of the facilities**. Additionally, systematic optimization of **boiler low-nitrogen combustion** and selective catalytic reduction (SCR) denitrification operations has been carried out

Standard	PM (mg/m^3)	SO_2 (mg/m_3)	NO_x (mg/m_3)
Emission Standards for CFPP (GB13223-2011)	20	50	100
Ultra-low Emission Standards for CFPP	10	35	50



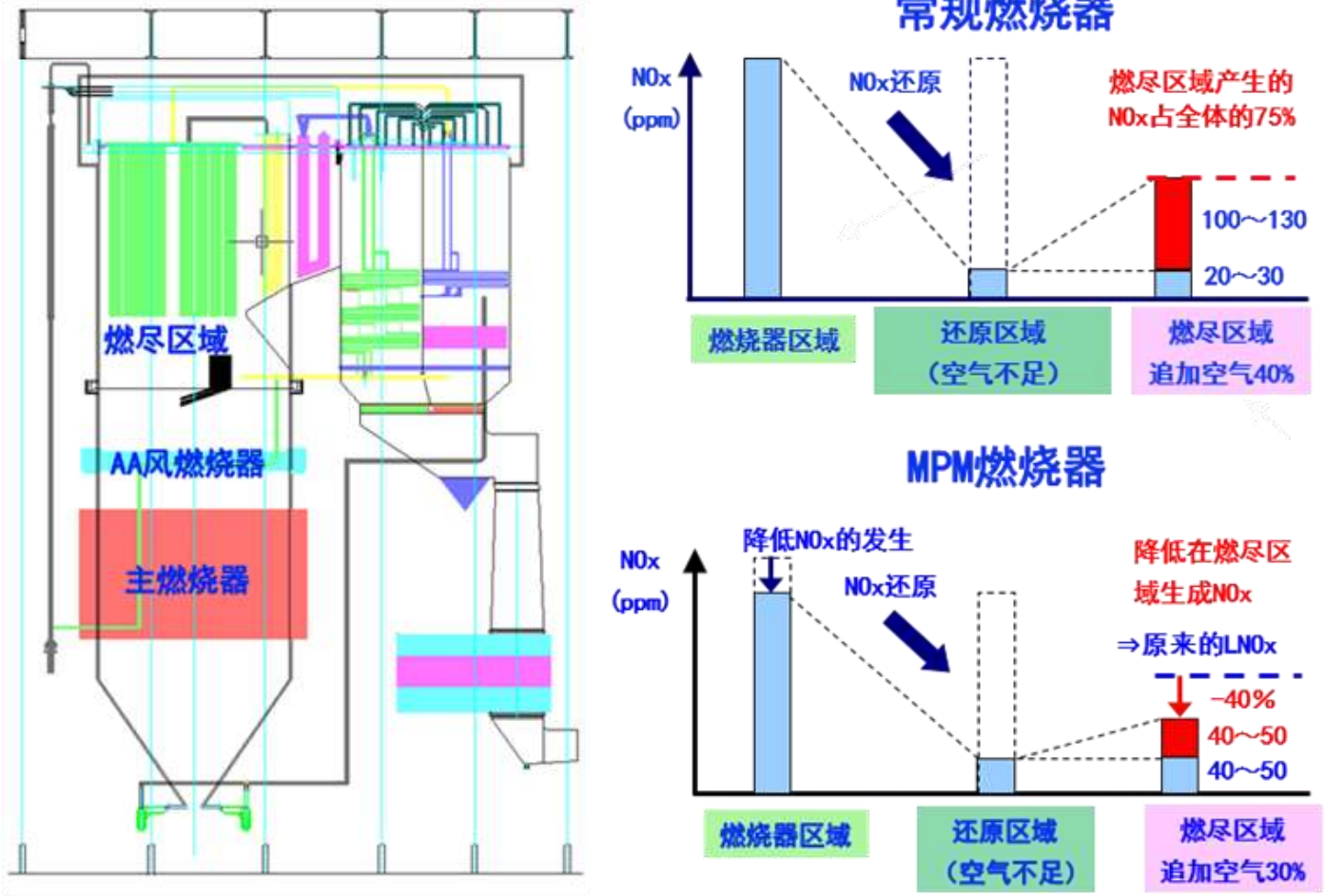
Process flow diagram of the system before modification



Process flow diagram of the system after modification

Denitration technology

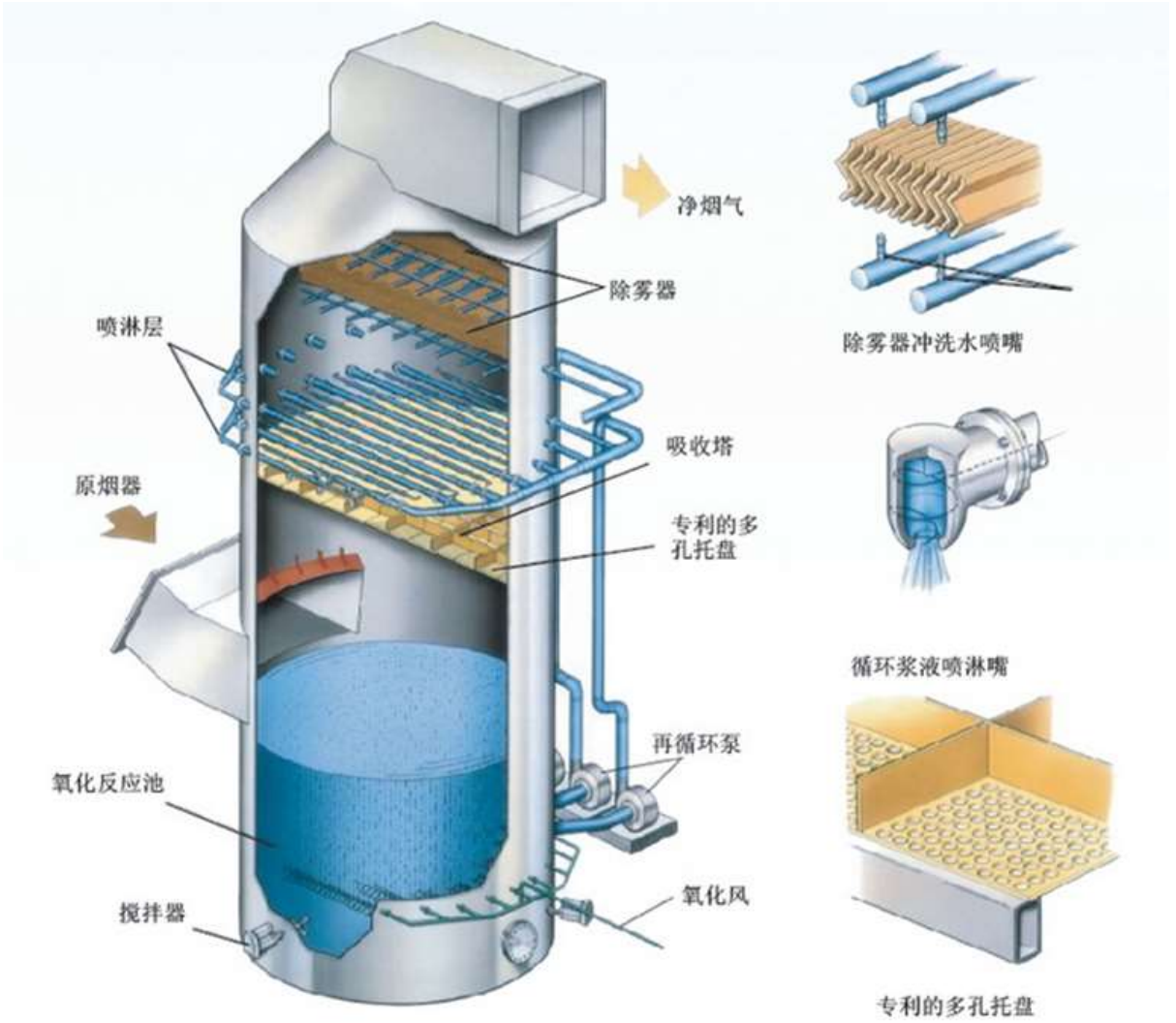
- This project adopts **low NO_x combustion + SCR denitrification synergistic optimization scheme** to reduce the NO_x concentration at the outlet of the furnace, to improve the efficiency of SCR denitrification, and meanwhile to **control the concentration of fugitive ammonia**.
- The flue gas NO_x concentration at SCR inlet is **160～220 mg/m³**, after the SCR denitrification, the emission reaches the design requirement of **22 mg/m³**.



Process flow diagram of denitrification system

Desulfurization technology

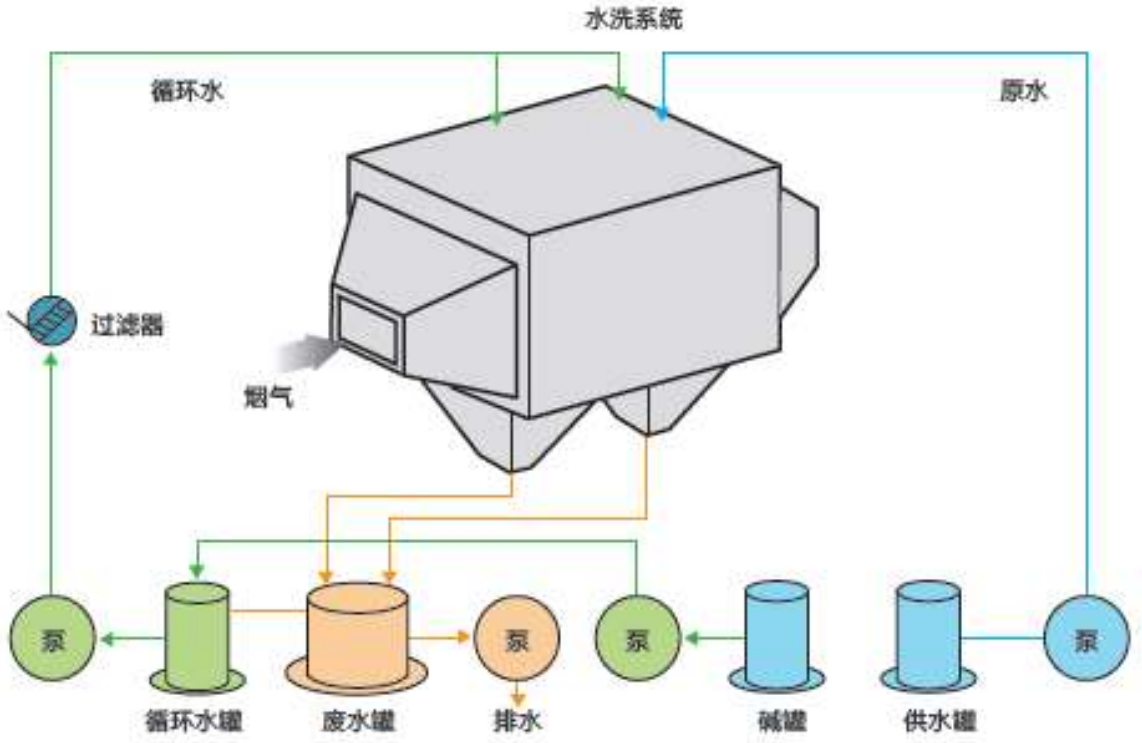
- Synergistic dust removal with single-pallet rectification efficiency
- **Wall ring rectification** prevents wall escape of raw flue gases and increases efficiency
- High liquid-gas ratio efficiency shower with **46.8% higher slurry flow rate**
- Three-stage roof-mounted high-efficiency mist and dust removal
- After the renovation, the efficiency of desulfurization reached **98.72%** and SO_2 emission concentration reduced to **16 mg/m³**



Process flow diagram of desulfurization system

Dedusting technology

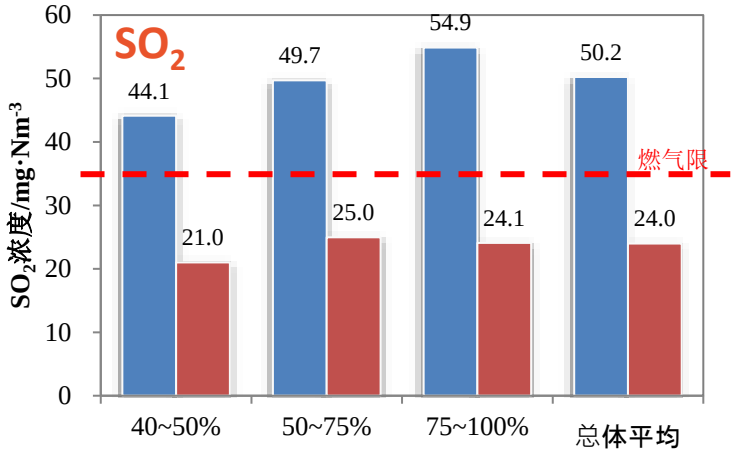
- Make full use of **low-temperature electric precipitator, absorption tower synergistic de-dusting and wet electric precipitator** to carry out deep de-dusting
- The particulate removal rate of wet **ESP is ≥75%**; SO_3 removal rate is **40%**

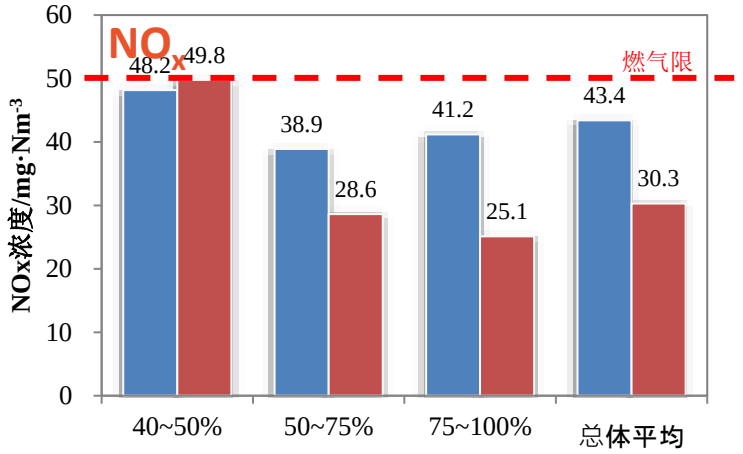


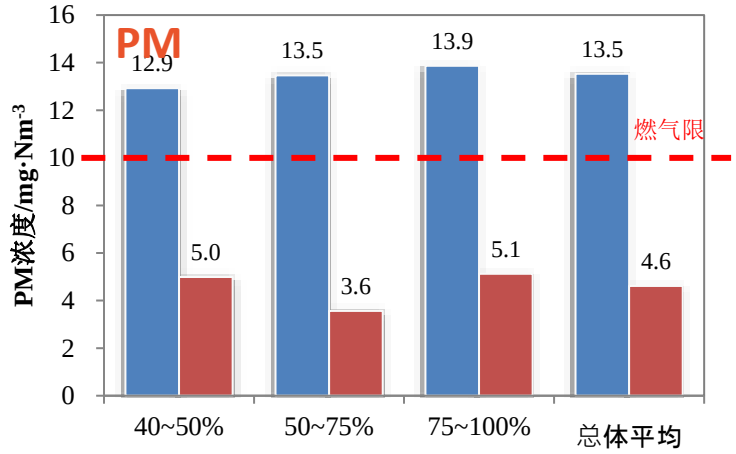
Wet electrostatic precipitator process flow chart and appearance

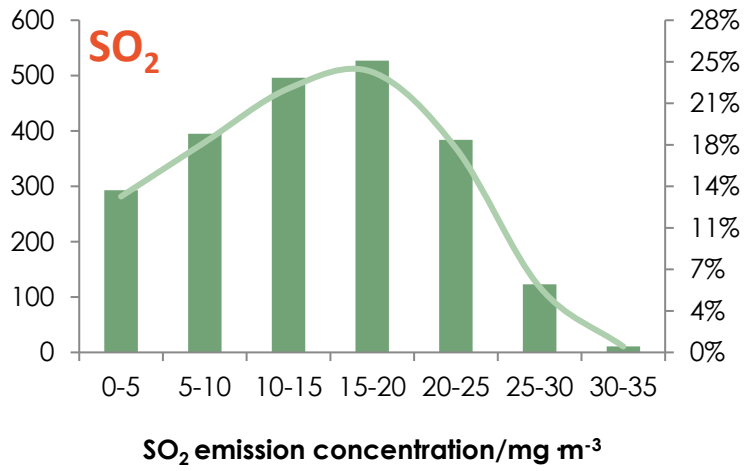
Improvement in emission

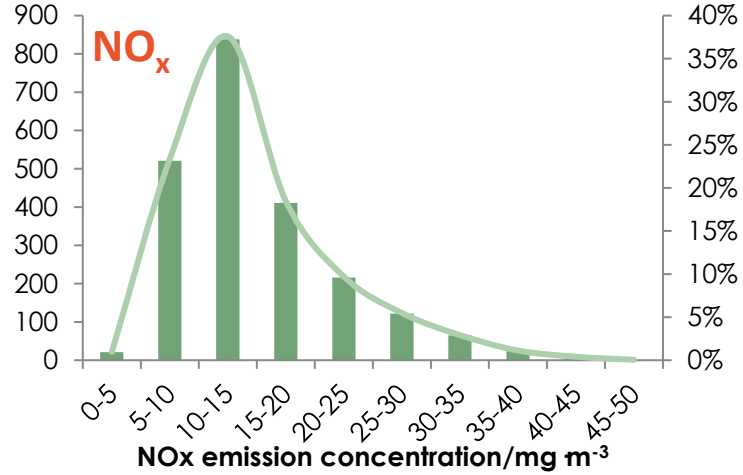
SO_2, NO_X, and PM concentrations are reduced by **52.3%, 30.2% and 65.9%**, respectively, compared to the pre-retrofit period

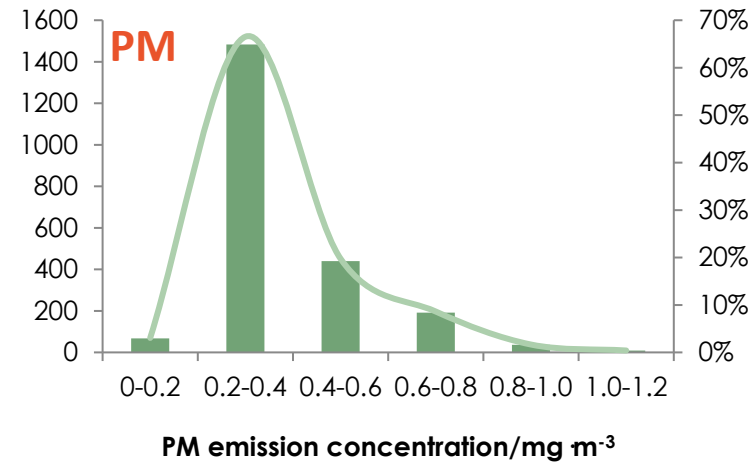












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03 INSIGHTS

Insights

- Coal-fired power generation is expected to remain the predominant method for electricity production for the foreseeable future. It is crucial to prioritize **the development of high-efficiency and clean power generation technologies**, as well as to **explore the potential for energy conservation and emissions reduction** in coal-fired power generation.

- To mitigate the adverse environmental impact of coal-fired power plants, it is recommended to conduct **research on secondary pollution, synergistic control of heavy metals, and CO_2 emission**.

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Thank you for listening!