中国能建 ENERGY CHINA | CPECC 中国电力工程顾问集团有限公司 CHINA POWER ENGINEERING CONSULTING GROUP CO., LTD.

# Selection and analysis of flue gas treatment technologies to achieve ultralow emissions from inferior coal fired power plants


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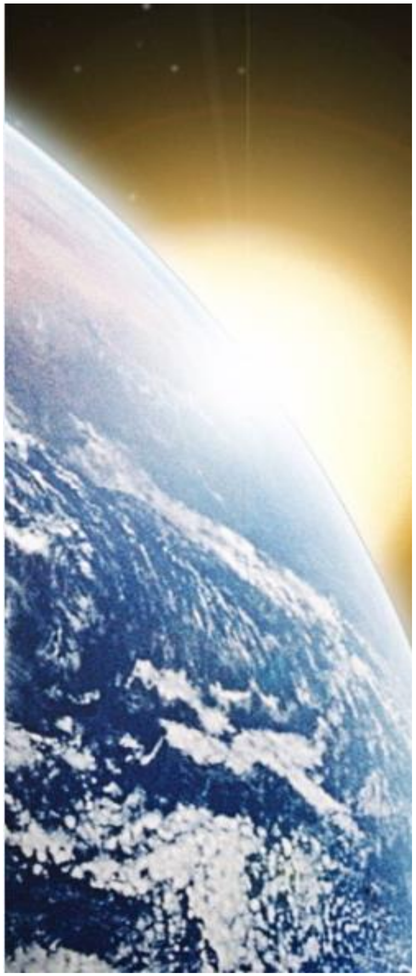
# CONTENT



# 1 Backgrounds of Emission Standards and Policy in China

## Dust Emission Standards---history

- Dust emission standard of thermal power plant was independently started from 1991, in Emission Standard of Air Pollutants for Thermal Power Plants (GB13223-1991) .
- GB13223 was revised in 1996, 2003 and 2011, and GB 13223-2011 is the current emission standard and has much stricter requirements, and uniformed one single dust emission limit of all thermal power plant constructed in different stages.

# 1 Backgrounds of Emission Standards and Policy in China

## $SO_2$ Emission Standards----history

- Emission Standard of Air Pollutants for Thermal Power Plants (GB13223-1996) firstly required $SO_2$ emission of thermal power plants.
  - Emission limit: 1200 mg/Nm$^3$(if Sar>1%), 2100 mg/Nm$^3$(if Sar≤1%)
- GB13223-2003 required desulfurization in thermal power plants.

# 1 Backgrounds of Emission Standards and Policy in China

## $NO_x$ Emission Standards----history

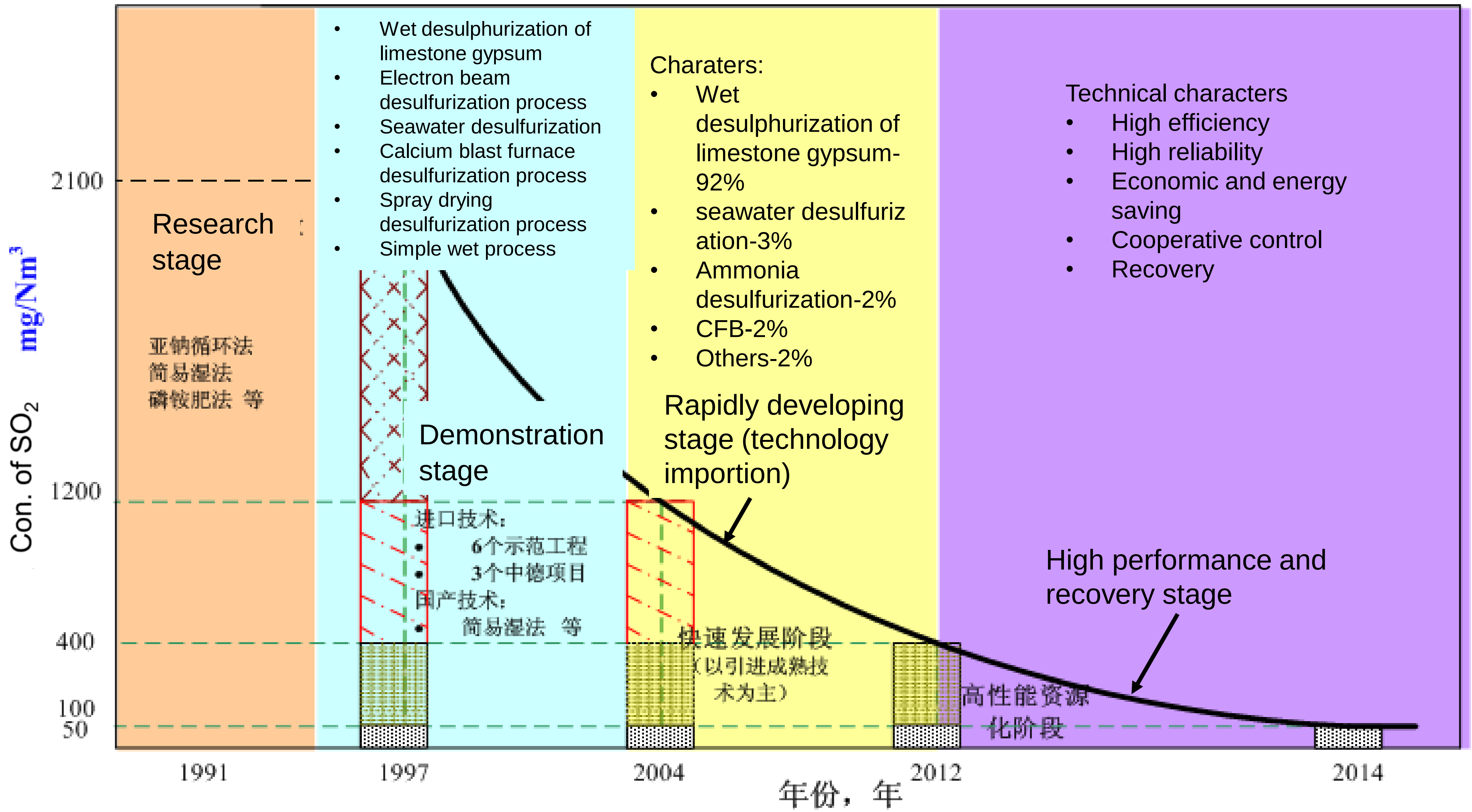
- GB13223-1996 firstly required $NO_x$ emission for new boilers higher than 1000t/h rated evaporation。
  - 1000mg/Nm$^3$ for liquid slag discharge; 650 mg/Nm$^3$ for solid-state discharge
- GB13223-2003 required emission limits on all thermal units distinguished from fuel characters and construction time.
- GB13223-2011 has much stricter requirements on pulverized coal furnace (including W-flame furnace) and CFB.

# 1 Backgrouds of Emission Standards and Policy in China

## Current emission limits

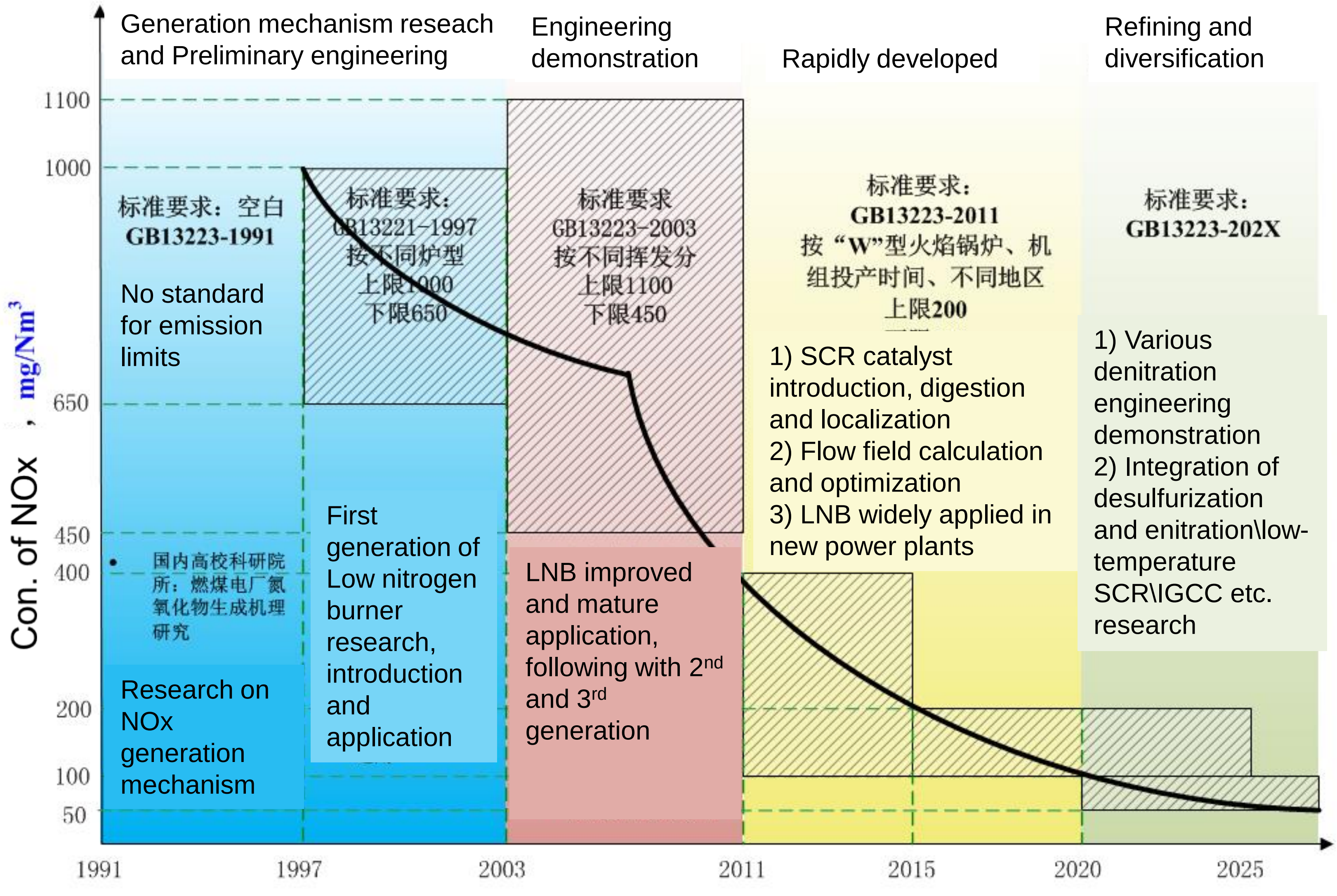
- GB13223-2011: dust-30mg/$Nm^3$, $SO_2$-100mg/$Nm^3$, $NO_x$-100mg/$Nm^3$ in general areas.
- Special emission limits: dust-20mg/$Nm^3$, $SO_2$-50mg/$Nm^3$, $NO_x$-100mg/$Nm^3$ in key control areas including 47 cities(2011).
- Eastern 11 provinces: dust-10mg/$Nm^3$, $SO_2$-35mg/$Nm^3$, $NO_x$-50mg/$Nm^3$ (2093, 2014)
- Zhejiang Province: dust-5mg/$Nm^3$, $SO_2$-35mg/$Nm^3$, $NO_x$-50mg/$Nm^3$ before 2017(600MW grade and above)

# 2 Development of Pollutants Control Technologies




Technology evolution of desulfurization in China

# 2 Development of Pollutants Control Technologies




Technology evolution of denitration in China

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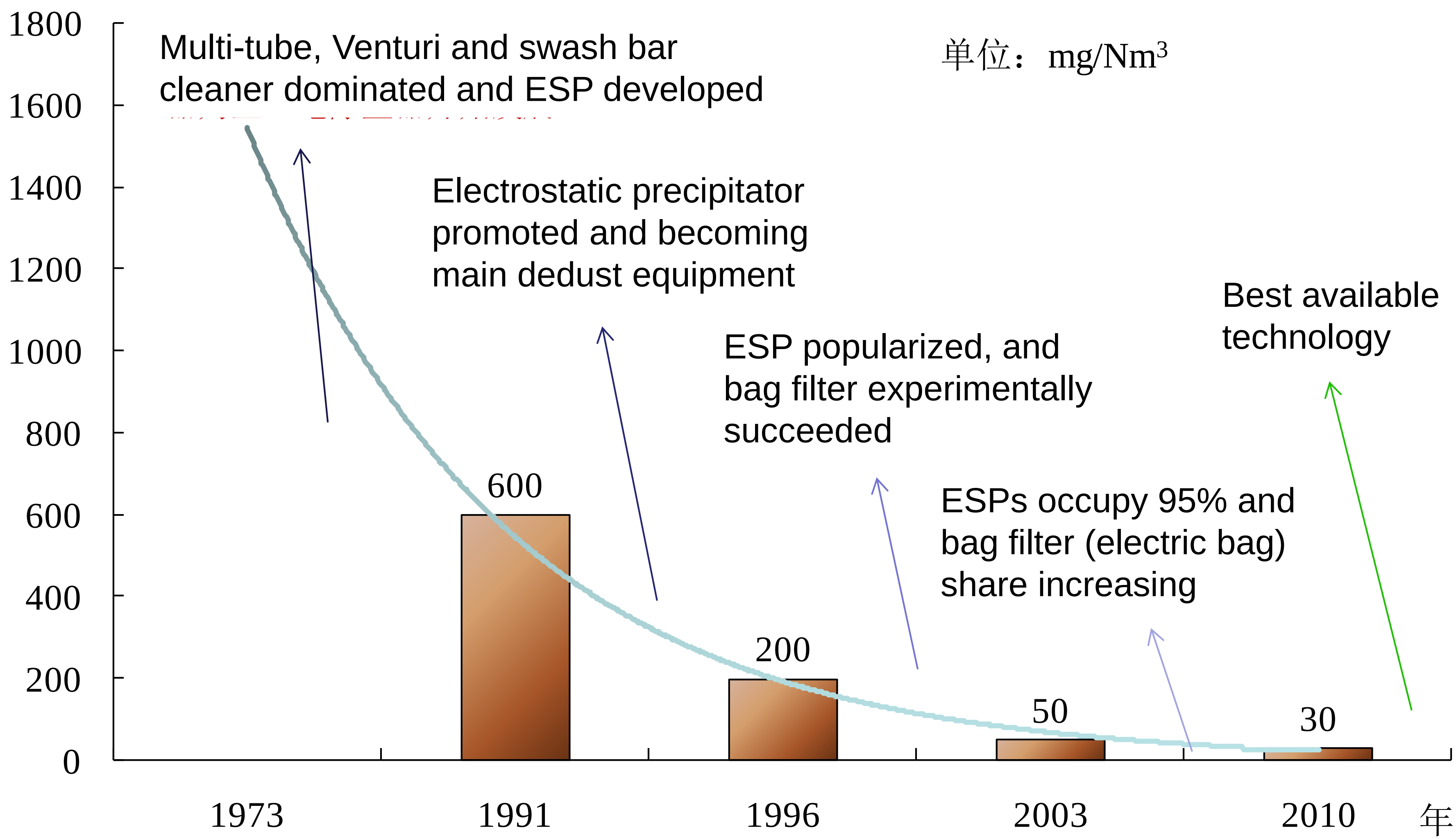
# 2 Development of Pollutants Control Technologies




Technology evolution of dust extraction in China

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# 3 Ultra-low Emission Engineering Reconstruction in China

## Up to 2017, pollutants emission control in coal-fired power plant

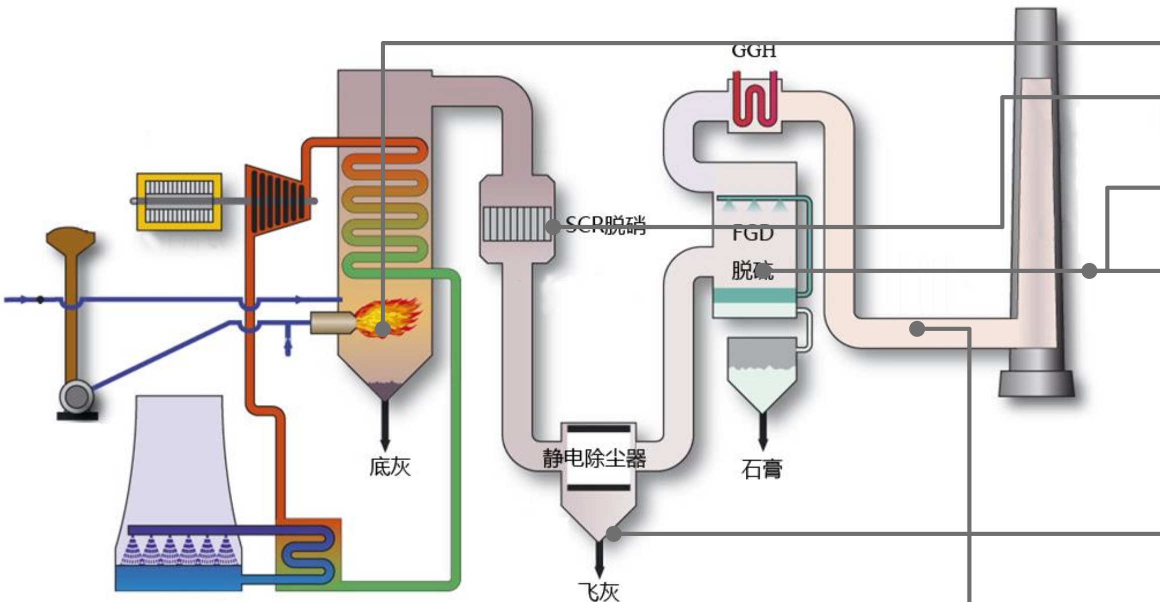
| | Operation of unit capacity | Explanation |
|---|---|---|
| Desulfurization | 940 GW (95.8%) | The rest are furnace desulfurization of CFB |
| Denitration | 960 GW (98.4%) | -------------- |
| Dedusting | 100% covered | EP proported 65.9%, the rest are bag filters and electric bag |

## Ultra-low Emission Reconstruction

- At the end of 2017, 700GW coal-fired units accomplished ultra-low emission reconstruction, and occupy 71% of all coal-fired units.
- The rest are inferior coal fired units to reconstruction to achieve ultra-low emission.

# 3 Ultra-low Emission Engineering Reconstruction in China

**Conventional technical route** **v.s.** **Novel technologies applied in ultra-low emission control**




- **Low nitrogen burner**
- **SCR catalyst layer increasing**
- **Two stage desulphurization**
- **Double tray, single or dual cycle in one tower**
- **Low-low temperature ESP**
- **Efficient power ESP**
- **Moving plate ESP**
- **Wet ESP**

# 3 Ultra-low Emission Engineering Reconstruction in China

## Technical routes successfully applied on ultra-low emission control of coal-fired power plants in China

- Route 1: Low nitrogen burner+ SCR+low-low temperature ESP+wet FGD+wet ESP
- Route 2: Low nitrogen burner+ SCR+ high efficiency ESP+wet FGD+wet ESP
- Route 3: Low nitrogen burner+ SCR+ low-low temperature ESP+optimized wet FGD (with high efficiency demister)



# 3 Ultra-low Emission Engineering Reconstruction in China

- Route 1: Low nitrogen burner+SCR+low-low temperature ESP+wet FGD+wet ESP

**Application:**

Jiahua power plant 7# &8# 2x600MW(Zhejiang Energy), Huizhou Power Plant 300MW (Shenhua Guohua), Yangzhou $2^{nd}$ power plant 630MW etc.

- Route 2: Low nitrogen burner+SCR+high efficiency ESP+wet FGD+wet ESP （High efficiency ESP including optimized ESP or electric bag）

**Application:**

Baiyanghe Power Plant 2x300MW (Huaneng), Huangtai Power Plant 2x300MW(Huaneng), Huangdao Power Plant 2x670MW(Datang)

# 3 Ultra-low Emission Engineering Reconstruction in China

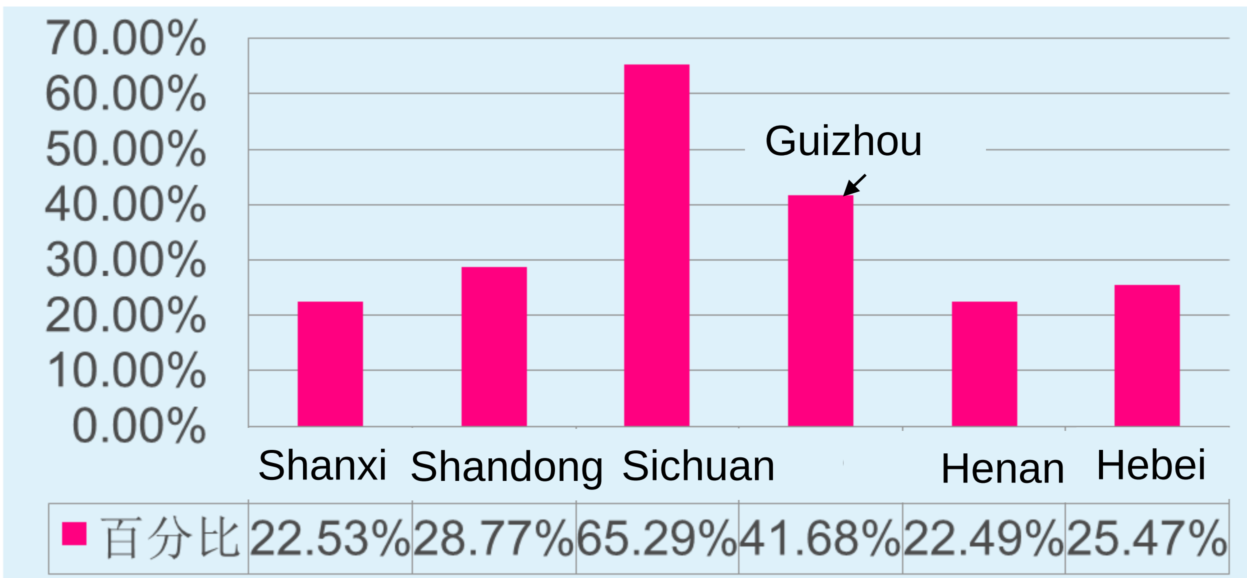
- Route 3: Low nitrogen burner+SCR+low-low temperature ESP+optimized wet FGD (with high efficiency demister)

Application:

Jinling Power Plant 2x1030MW (Huaneng), Chongqing Hechuang Power Plant 2x660MW, Shanghai Caoting Power Plant 1000MW

## Inferior Coal

- GB/T 15224-2010 classification for quality of coal (steam coal)
- $S_{ar}$ ≥2.0%, $A_{ar}$≥25%




The reserve proportion of high sulfur coal ($S_{ar}$ ≥2.0%,) in typical provinces in China

# 5 Flue Gas Treatment Technologies for Inferior Coal Fired Power Plants

## (1) Desulfurization reconstruction

When inlet concentration of $SO_2$ exceeds 3500mg/$m_3$(dry, 6%$O_2$), we can take liquid layer tray tower or two-stage series tower to meet ultra-low emission of $SO_2$.

## (2) Dedusting

ESP with wet ESP or with high efficiency wet FGD synergic dedusting is recommanded.

## (3) Denitration

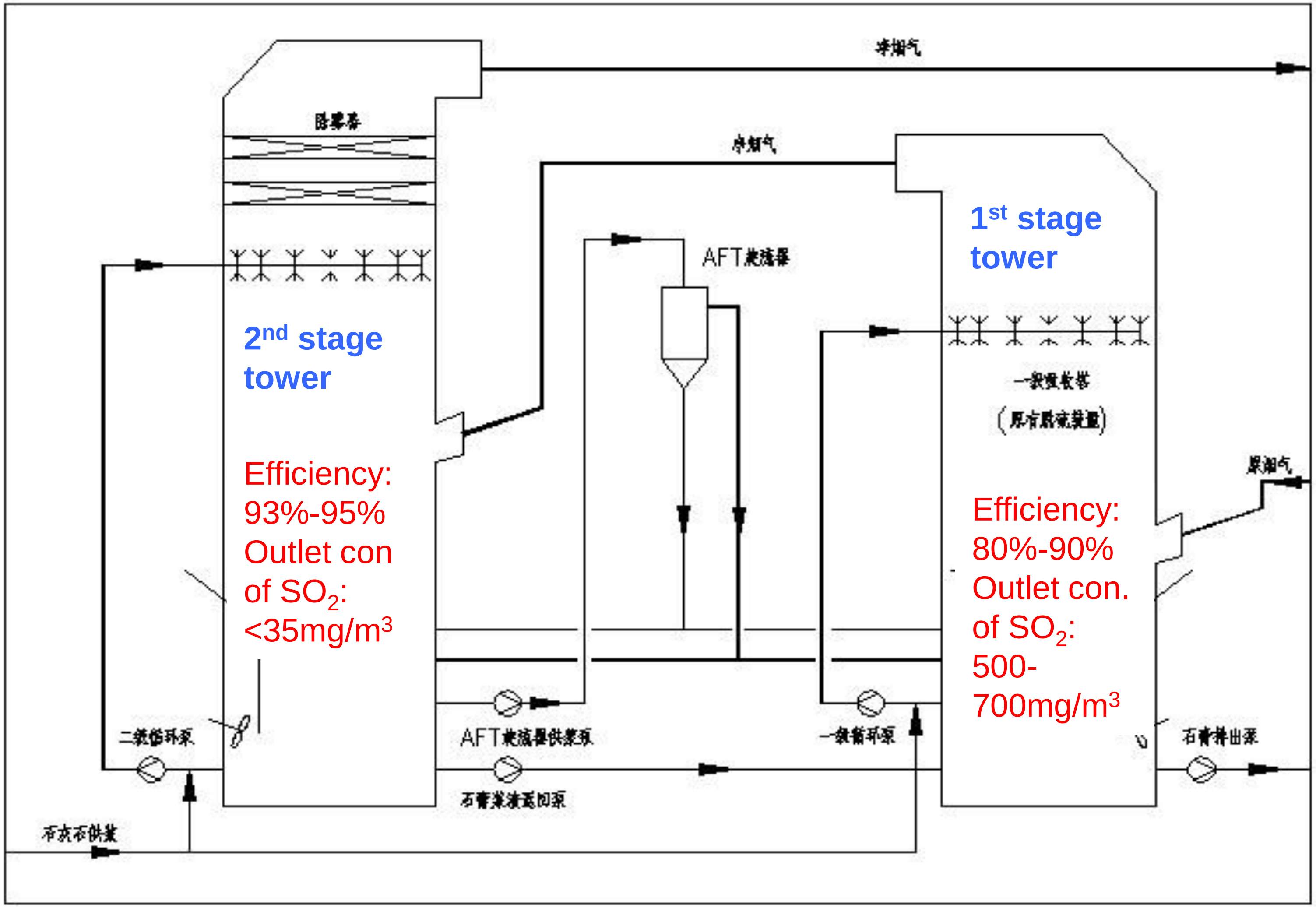
The main way to improve efficiency of denitration by SCR is increasing catalyst volume and decreasing sector velocity of flue gas. BUT the efficiency of denitration is limited by 90%, since the yield of $SO_3$ increases as well.

# 5 Flue Gas Treatment Technologies for Inferior Coal Fired Power Plants

## Case 1: two-stage series tower with wet ESP

- Capacity: 300MW
- $S_{ar}$:2.2%
- Inlet con. of $SO_2$: 5750mg/Nm3(dry, 6%$O_2$)
- Outlet con. of $SO_2$: 32mg/Nm3(dry, 6%$O_2$)
- Efficiency of FGD: 99.44%
- Outlet con. of dust: <5 mg/$Nm^3$(dry, 6%$O_2$)
- Efficiency of wet ESP:>85%

# 5 Flue Gas Treatment Technologies for Inferior Coal Fired Power Plants




Two-stage series FGD

# 5 Flue Gas Treatment Technologies for Inferior Coal Fired Power Plants

## Case 2: low-low temperature ESP with optimized wet FGD(including high efficiency demister)

- Capacity: 660MW
- $S_{ar}$: 2.4%(6000mg/Nm$^3$)
- $A_{ar}$:35.8%(~46g/m$^3$)
- Outlet con. of $SO_2$: <35mg/Nm$^3$
- Outlet con. of dust:<5mg/Nm$^3$

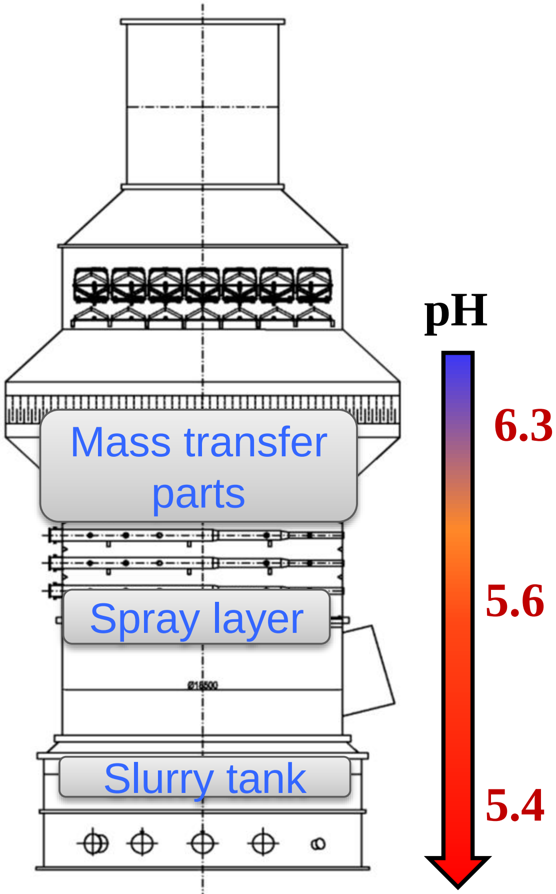
## Parameter of ESP reconstruction (flue gas of inlet)

| items | unit | Conventional ESP | Low-low temperature ESP |
|---|---|---|---|
| Volume | $\times 10^4 m^3/h$ | 340 | 289.9 |
| temperature | °C | 140 | 85 |
| Dust concentration | $g/m^3$ | 46 | 46 |
| Specific dust collection area | $m^2/m^3/s$ | 113.53 | 132.41 |

## Performance comparison between conventional ESP and low-low temperature ESP

| items | unit | Conventional ESP | Low-low temperature ESP |
|---|---|---|---|
| Efficiency | % | 99.82 | 99.91 |
| Specific dust collection area | $m^2/m^3/s$ | 116.38 | 132.41 |
| Inlet con. | $g/m^3$ | 31.78 | 46 |
| Outlet con. | $mg/m^3$ | 57.01 | 30 |

# 5 Flue Gas Treatment Technologies for Inferior Coal Fired Power Plants




liquid lay tray tower

Flue gas

⇧

High con. of $SO_2$

⇧

Low con. of $SO_2$

⇧

Ultra-low emission

Reconstruction of wet FGD

# 5 Flue Gas Treatment Technologies for Inferior Coal Fired Power Plants

## Summary

(1) More cases with medium Sulphur and ash or high Sulphur and ash have been reconstructed in China, which can not only meet ultra-low emission requirements but also remove most $PM_{2.5}$, part of $SO_3$ and mercury.

(2) According to practices, we recommand a technical route as follows:

Low nitrogen burner+SCR+$SO_3$ removal process(option)+mercury removal process (option)+high efficiency ESP +Wet FGD +Wet ESP(option)

# 6 Expectation of Ultra-low Emission of Coal Fired Power Plants

(1) New technology for novel pollutants controlled further

- $SO_3$
- Mercury (heavy metals)
- plume

(2) New technology for energy-saving and carbon emission reduction

# Thank you for your time!