



Guohua Power Coal-fired Generating Unit
“Near Zero Emissions” Engineering Practice

September 15, 2014

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Part I Background of Near Zero Emissions

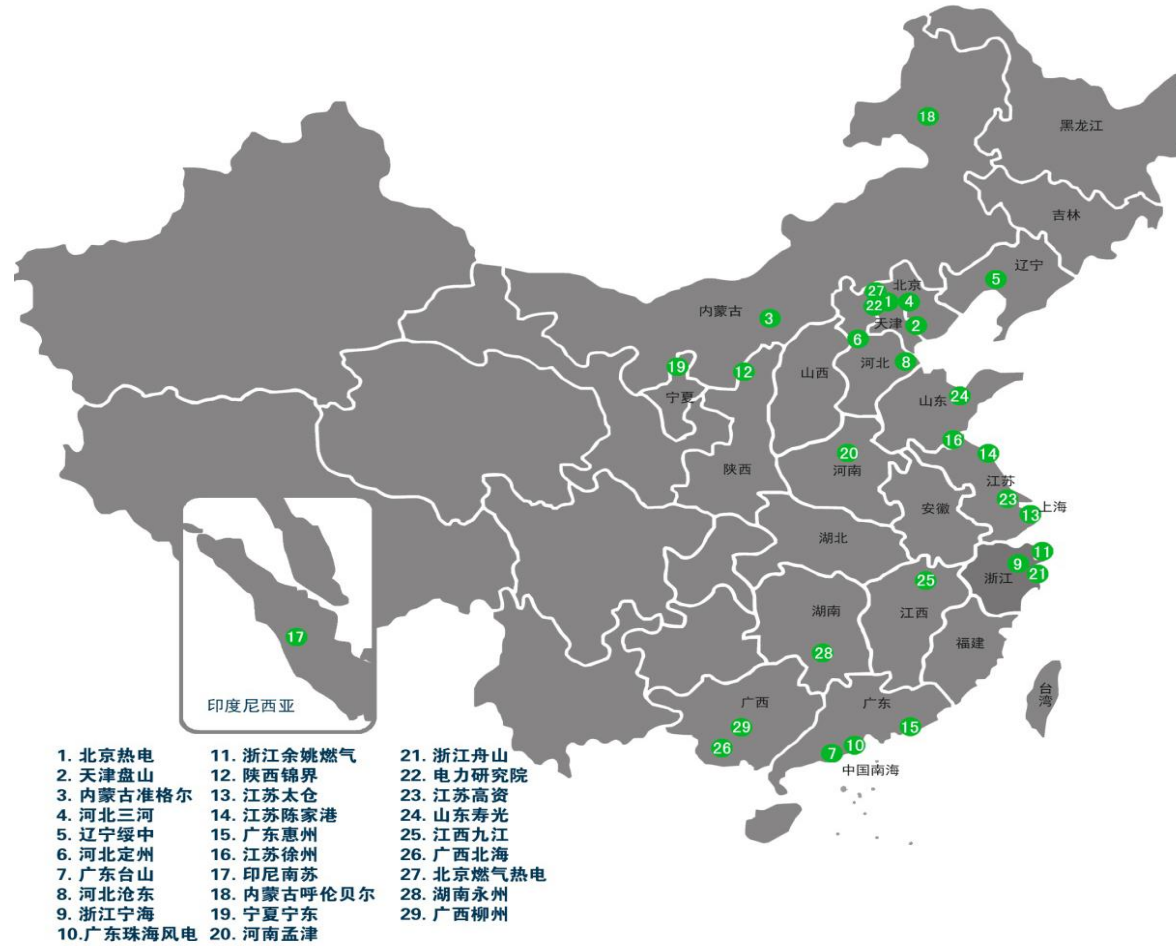
Part I Background of Near Zero Emissions

- Founded in March 1999, Shenhua Guohua Power is a wholly-owned subsidiary of Shenhua Group. Thanks to the advantages of the integrated resources of Shenhua Group in the aspects of coal, electricity, railway, harbor, shipping, it adopts the strategies of “Point-line-surface” and founds a series of high-efficiency, high-parameters and high-capacity power units at significant pitheads, harbors, traffic hubs and load centers.
- By the end of July 2014 , Guohua Power has 21 companies put into generation, 6 under construction, holding 36 independent enterprises with total assets reaching RMB140 billion. Nowadays, its operating power generation capacity is 34.80 million KW including 61 coal-fired units, 1 gas-fired unit (set) and 21 sets of wind turbines.



Part I Background of Near Zero Emissions

- **Distribution of controlled enterprises**
- Assets are distributed over 16 provinces, autonomous regions, directly-controlled municipalities in China and also indonesia.



Part I Background of Near Zero Emissions

Guohua Power has been adhering to “proactive environment protection, environment utmost” and constructs “clean, highly-efficient and beautiful power plants” guided by ecological progress.

In 2000, the first desulfurization facility was put into operation—Beijing Thermal Power

In 2004, the first 600MW desulfurization system was put into operation—in Taishan, Dingzhou.

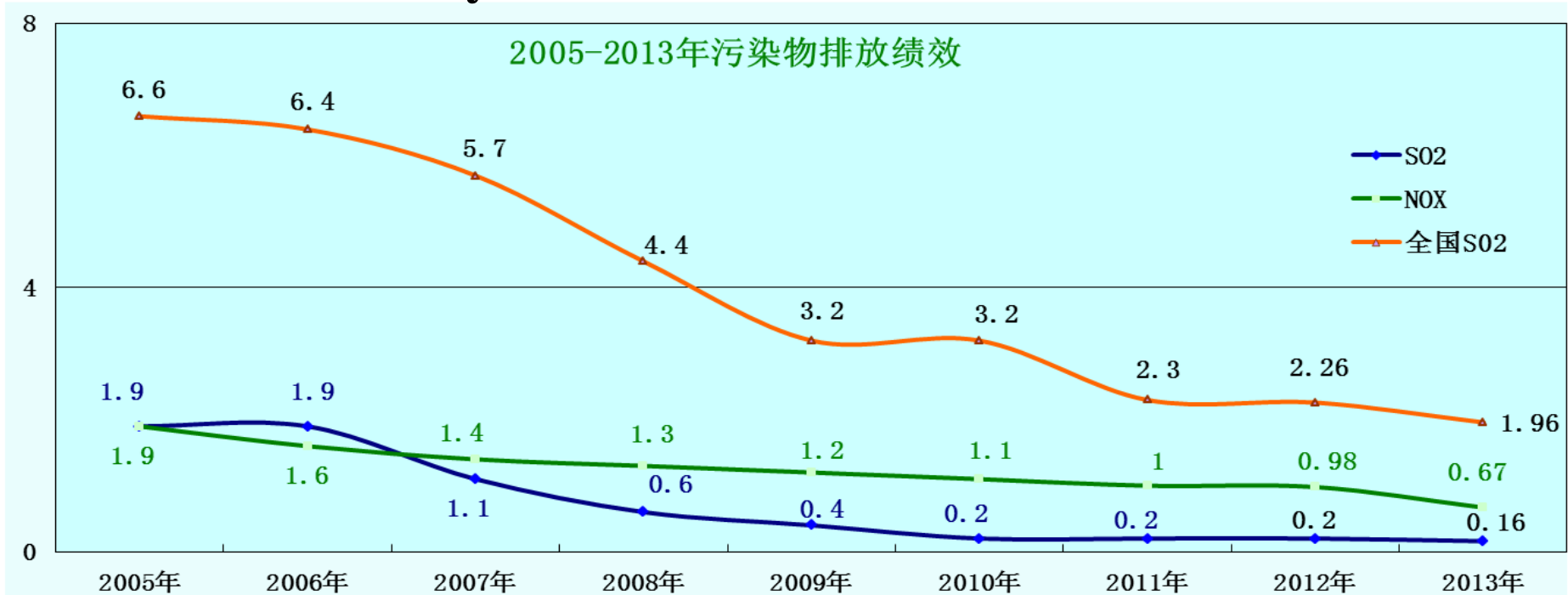
Four national No. 1 in environment protection and emission reduction

In 2006, the first desulfurization facility was put into operation—in Taicang

In 2011, the first million-kilowatt unit with exhaust fume cooling tower was put into operation—in Xuzhou

Part I Background of Near Zero Emissions

Key Environmental Indicators



- ☑ In 2013, the sulfur dioxide emission performance was 0.16g/kWh and nitrogen oxide emission performance was 0.67g/kWh, which were far lower than the national levels.
- ☑ As of July 2014, soot emission and sulfur dioxide emission performance were 0.05g/kWh and 0.12g/kWh respectively, a year-on-year decline of 25%; the nitrogen oxide emission performance has been 0.41g/kWh, a year-on-year decline of 55%. The domestic capacity of coal-fired denitrification units has reached 31,975,000 kilowatts, accounting for 95%.

Part I-Background of Near Zero Emission-Proposal of "Energy Revolution"

➤ **The fifth plenary session of the 17th CPC Central Committee and the Twelfth Five-Year Plan for energy development**

.....**focus on accelerating change of energy production and utilization methods**, enhance the strategy of giving priority to energy conservation , improve energy development and transformation as well as utilization efficiency , **control total energy consumption**, construct safe, stable, economical , clean and modern energy industrial system ,

➤ **Report at 18th Party Congress**

.....**promote energy production and consumption revolution, control total energy consumption** , enhance energy saving and consumption reducing , support energy-saving and low carbon industries and new energy, sustainable energy development and ensure national energy safety

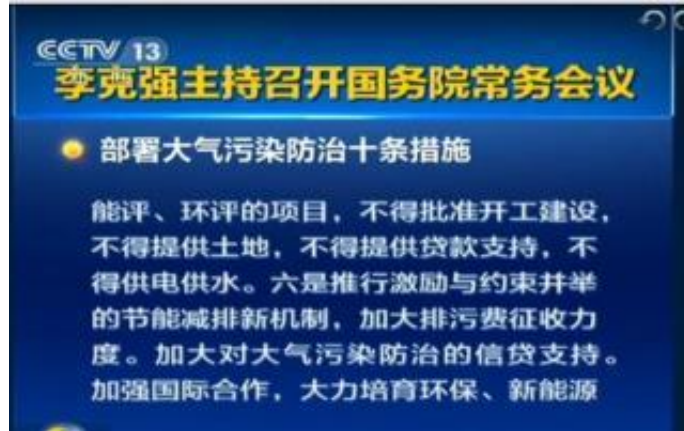
➤ **The Sixth Meeting of the Central Financial Work Leading Group (2014.06.13)**

.....once again **promote energy production and consumption revolution**, and further promoting, including: **energy consumption revolution, supply revolution, technical revolution and system revolution**



Part I Background of Near Zero Emissions

■ Actively promote air pollution control by the central government to local governments and all walks of life



Beijing, Tianjin,
Hebei, Shandong,
Shanxi, Inner
Mongolia

北京削减原
煤1300万吨

天津削减原
煤1000万吨

河北削减原
煤4000万吨

山东削减原
煤2000万吨

1. Intensive introduction of policies and measures like *Emission Standard of Air Pollutants for Thermal Power Plant*, *Air Pollution Prevention and Control Action Plan* and *Regulatory Measures on Environment Protection Price of Coal-fired Generating Units and Operation of Environment Protection Facilities*
2. *Liability Statement on Air Pollution Prevention and Control* has been signed by Ministry of Environmental Protection and 31 provinces (regions and cities)
3. Zhejiang proposes to implement natural gas emission standard for newly constructed units; by the end of 2017, reform the active **600,000**-kilowatts units as per the above-mentioned standard.

Part I Background of Near Zero Emissions

☑ **The coal industry is facing ever-increasingly strict environmental constraints**

① **Control of total energy consumption.** By 2017, the coal consumption accounting for the total consumption shall be reduced to be lower than 65%. Beijing-Tianjin-Hebei Region, Pearl River and Yangtze River deltas and other regions shall strive to achieve negative growth in total energy consumption.

② **The newly constructed projects in Beijing-Tianjin-Hebei Region, Pearl River and Yangtze River deltas and so on are prevented from constructing self-contained coal-fired power stations.** Coal consuming projects shall implement coal reduction and replacement policy. Except for heat and power cogeneration, it is forbidden to approve construction of new coal-fired generating projects; if the total capacity of multiple coal-fired generating units is over 300,000 kilowatts, it can be transformed into high parameter and large capacity coal-fired generating units as per principle of coal equivalent replacement.

Green and efficient energy production is the only road leading to energy revolution in China. In this century, the energy structure of "Coal-dominance" decides that for energy production revolution, we have to address scientific development, clean and low carbon utilization and conversion, fully utilize dual function of coal energy and resources, develop comprehensive optimization and utilization technology for coal grading and conversion so as to achieve the equivalent air pollution emission standard as that of natural gas turbine power generation, greatly improving proportion of coal for power generation and combined heat and power supply.

Part I Background of Near Zero Emissions

With further improvement in awareness of environment protection, Guohua Power has proposed “High quality green power generation plan” systematically for reforming the active units in terms of energy conservation, environment protection, increase in capacity, heat supply, noise reduction and so on, implements “Efficient and clean Near Zero Emission Projects” for newly constructed projects, sets up energy-saving and environment protection targets of “Efficient, clean, ecological and forward-looking”, pursues achieving natural gas emission standard for coal-fired power plants (soot concentration $\leq 5\text{mg}/\text{Nm}^3$, sulfur dioxide concentration $\leq 35\text{mg}/\text{Nm}^3$, nitrogen oxide concentration $\leq 50\text{mg}/\text{Nm}^3$) and is devoted to developing Guohua Power into an “Aspiring and responsible” power company with environment protection characteristics!



Part II Engineering Practice of Near Zero Emissions

Part II Engineering Practice of Near Zero Emissions

I. Clean and efficient Near Zero Emissions project

Guohua Power, upholding the banner of “Ecological progress” , taking “Beautiful power plant” as its guiding principle and taking the path of “cleanness and efficiency ” , further deepens research on double reheat, ultra-low back pressure, high efficiency desulfication, full load denitration, advanced coal conveying technology, hypersaline wastewater treatment, onsite and plant noise control, intensifies practices on sea water desalination, efficient desulfification, desulficated wastewater treatment and other special design projects and constantly converts independent innovation and technological achievements into competitiveness.

Guohua Power has started “Efficient and clean Near Zero Emissions projects” for new coal-fired generating units in 2013, with all newly constructed units achieving Near Zero Emissions. Moreover, it has first applied technical route of “Near Zero Emissions” to the newly constructed No. 4 unit of Guohua Zhoushan Power. Taking Shouguang, Jiujiang, Yongzhou projects as demonstration models, when the coal consumption of newly built million kilowatts units is lower than 270 g/kwh, it has achieved standard lower than national special emission limit and attained target of natural gas unit emission performance.



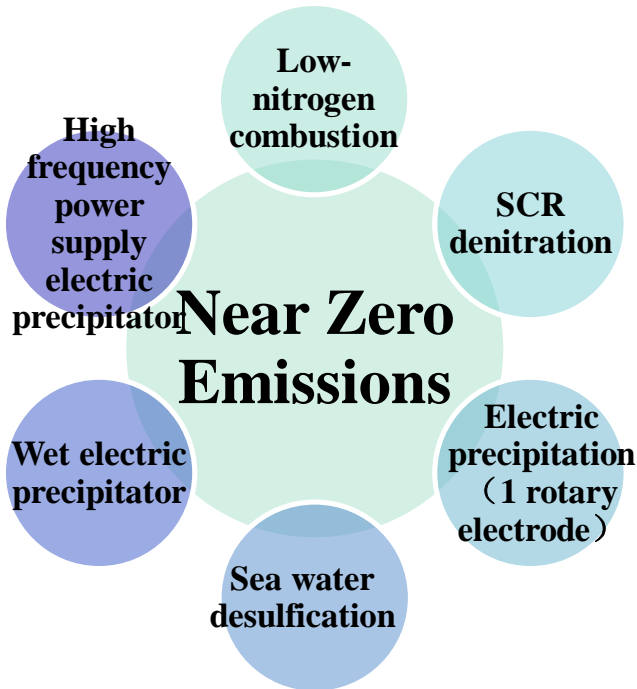
Part II Engineering Practice of Near Zero Emissions

II. Newly constructed project for No. 4 unit of Zhoushan Power

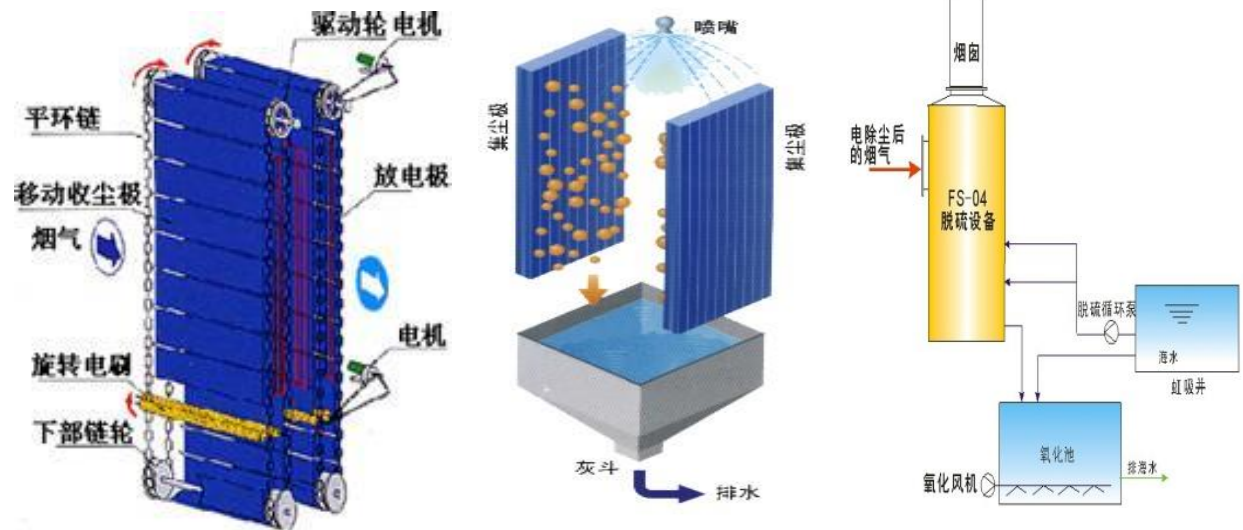
Shenhua Guohua (Zhoushan) Power Generation Co., Ltd. , located in Waishanju, Baiquan Town, Dinghai, is 16 km away from towndown, with a floor area of 967,323.66 square meters. At present, its capacity is 910MW. As the key project in "Ninth five year plan " , the company was founded in 1996 and No.1, 2, 3 units were put into operation in November 1997, March 2004 and October 2010 respectively. The fourth set of 350MW unit has passed 168 hours' test run on June 25 this year and has been put into operation.



III. No. 4 unit of Zhoushan Power----specific “Near Zero Emissions” technical measures



Overall technical route : low-nitrogen combustion+SCR+electric precipitation (4 conventional electrodes+1 rotary electrode) +high frequency power supply + wet electric precipitator+sea water desulfication.



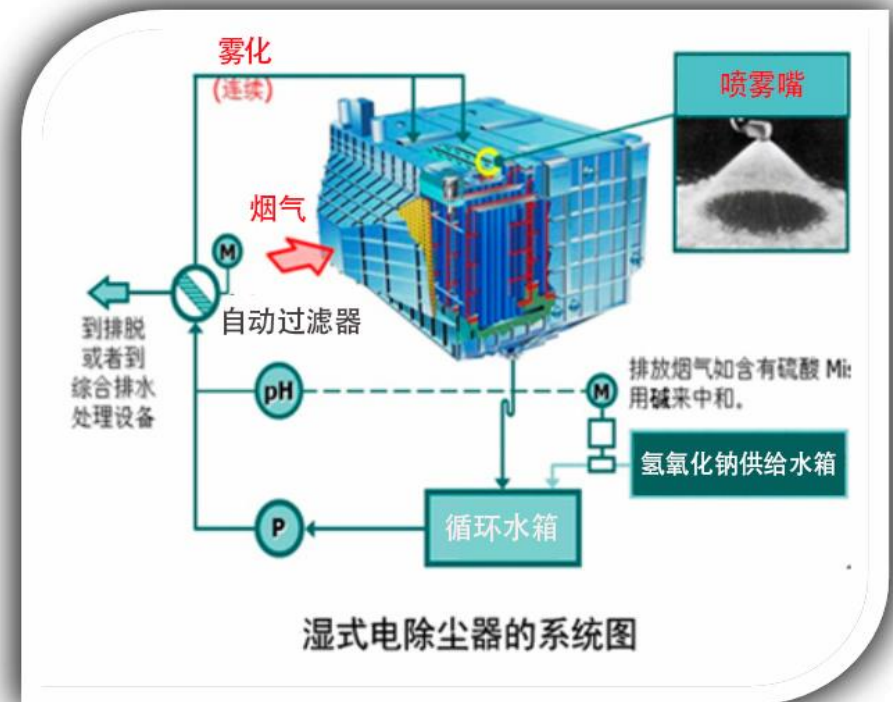
Part II Engineering Practice of Near Zero Emissions

Overall design plan for precipitation of Zhoushan No. 4 unit

Soot "Near Zero Emissions" requirements : $\leq 5\text{mg}/\text{Nm}^3$

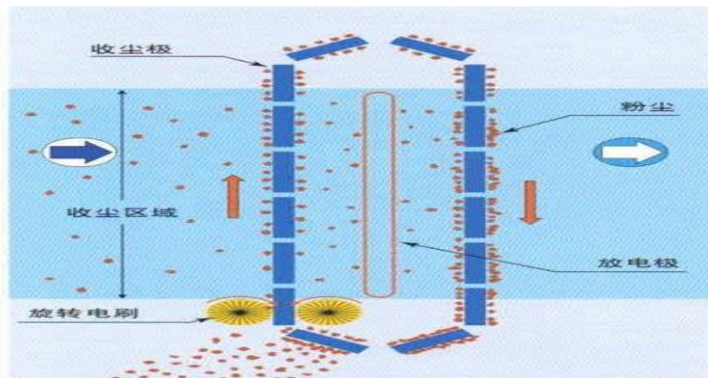
Technical solution : 5 electric field dry electro-static precipitator (4 electric field+1 rotary electrode electric field) + sea water desulfication + wet electro- static precipitator , all precipitators adopt high frequency power supply technology.

- Dry electro-static precipitator : design efficiency is 99.94% and guaranteed efficiency is 99.89% , outlet soot concentration $\leq 30\text{mg}/\text{Nm}^3$.
- Wet electro- static precipitator : design precipitation efficiency is 70% ; design value of inlet soot concentration is $16.5\text{mg}/\text{Nm}^3$, outlet soot concentration $\leq 5\text{mg}/\text{Nm}^3$.



Electric precipitation technical application--- rotary electrode

- Soot collecting mechanism is identical to conventional electric precipitator
- Advantages of rotary electrodes :
 1. Always keep the pole plate clean, prevent back corona, guarantee precipitator efficiency
 2. Change traditional rapping to brushing removal. Put the removal brush in non-soot collecting area to minimize reentrainment



Electric precipitation technical application---wet electric precipitation

Zhoushan No. 4 unit. One set of furnace is equipped with one set of double chamber single electric field wet electric precipitator ; wet electric precipitator inlet inlet soot concentration is calculated as per $16.5\text{mg}/\text{Nm}^3$, precipitation efficiency is $\geq 70\%$, outlet emission concentration is $\leq 5\text{mg}/\text{Nm}^3$; droplet removal rate is $\geq 70\%$, SO_3 removal rate is $\geq 60\%$, $\text{PM}_{2.5}$ removal rate is $\geq 60\%$.



Part II Engineering Practice of Near Zero Emissions

Actual effect for technical application of soot emission:

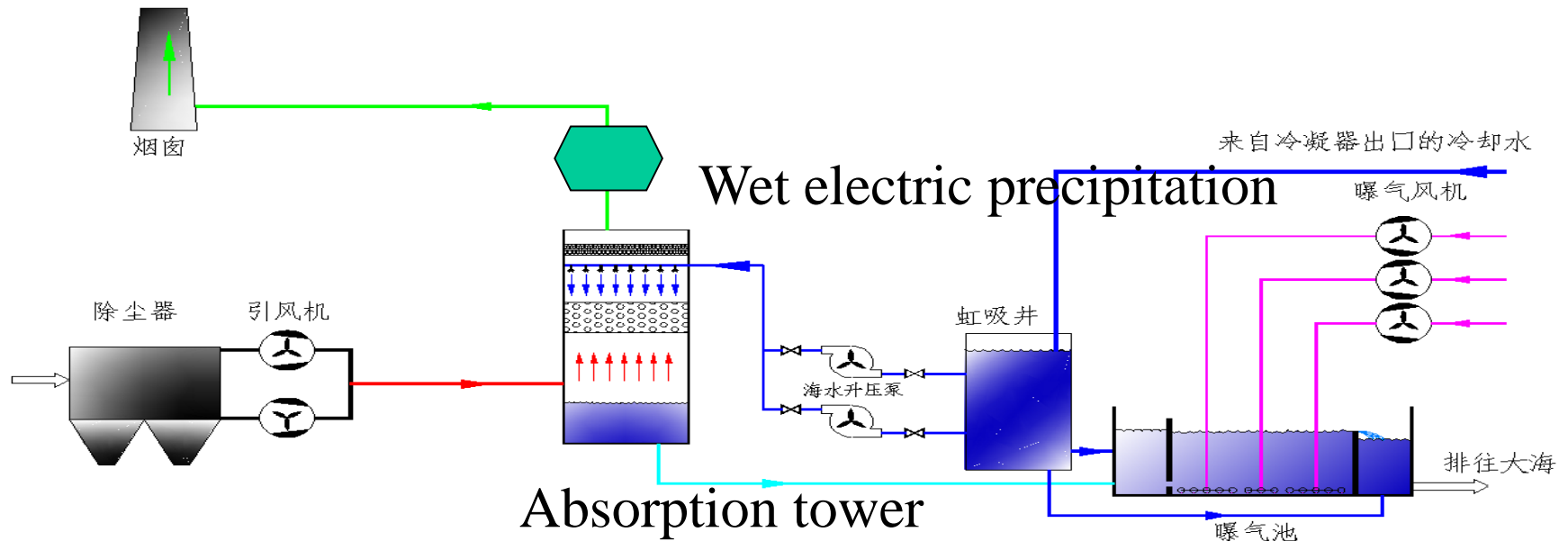
- Running measurement value of outlet soot concentration by electric precipitation is 16.53 mg/Nm^3 (DCS data) .
- Running measurement value of inlet soot concentration by wet electric precipitator is 10.3 mg/Nm^3 (DCS data) . Running measurement value of outlet soot concentration by wet electric precipitator is 2.46 mg/Nm^3 (Data from Zhejiang Province Environmental Monitoring) . The precipitation efficiency is 75.92% .
- Inlet droplet is 56.06 mg/Nm^3 , outlet 16.02 mg/Nm^3 , removal rate 71.39% .
- Inlet sulphur trioxide is 2.18 ppm , outlet 0.6 ppm , removal rate 71.9% .
- $\text{PM}_{2.5}$ inlet concentration is 1.7 mg/Nm^3 , outlet concentration 0.36 mg/Nm^3 , Removal rate is 78.66% (Data measured by Electric Power Research Institute of Zhejiang Electric Power Corporation) .



Part II Engineering Practice of Near Zero Emissions

Technical application of desulfurization---sea water desulfurization technology

Zhoushan No. 4 unit has fully utilized favorable coastal conditions , and adopting sea water desulfurization technology becomes the first sea water desulfurization project approved by Environmental Assessment Center of Ministry of Environmental Protection with desulfurization efficiency not lower than 98%, which is the important initiative for “Near Zero Emissions” of sulfur dioxide.



Process characteristics of sea water desulfication :

- Environment friendly : it doesn't need to add any chemical additives to the sea water and will not produce additional pollutants, realizing double attainment of soot and water discharge.
- Resources-saving : compared to limestone- gypsum method, it saves fresh water, avoids consumption and price increase of mineral resources like limestone, conforming to industry mode of cycling economy.
- Simplified process: simple process, fewer equipment, reliable operation
- Economical : power consumption rate of wet desulfication is 1.0 ~ 1.5% , power consumption rate of sea water desulfication is 0.7 ~ 1.2% , sea water desulfication has no limestone procurement and gypsum discharge costs.

Actual effect for technical application of SO₂ emission control

- After sea water desulfication SO₂ design value is less than 35mg/Nm³.
- At present, the actual operating value of SO₂ concentration is only 2.76mg/Nm³ (Data from Zhejiang Province Environmental Monitoring) , far lower than the design value .

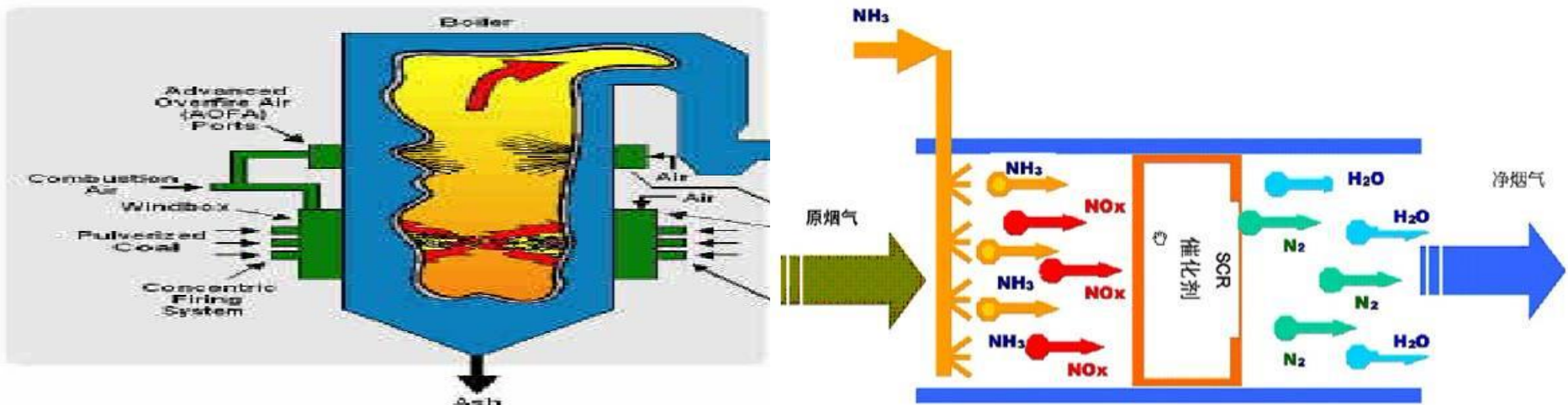


Part II Engineering Practice of Near Zero Emissions

Technical application of NO_x control

Overall technical solution : Technical application of ultra low-nitrogen combustion +SCR denitration unit. The configuration makes nitrogen oxide emission value of coal-fired Power Plant less than that of gas-fired power plant.

	Design value	Actual measured value
In-furnace low-nitrogen combustion	160mg/Nm ³ (75%-100% load) 200mg/Nm ³ (50%-75% load)	103 mg/Nm ³
SCRdenitration	Efficiency is not less than 80%	80.14%
Unit NO _x emission concentration	Guaranteed efficiency is less than 50mg/Nm ³	19.8 mg/Nm ³ (Data from Zhejiang Province Environmental Monitoring Center)



Part II Engineering Practice of Near Zero Emissions

IV. Near Zero Emissions costs---Zhoushan No. 4 unit investment analysis

■The costs for environment protection facilities of Zhoushan No. 4 unit is 140,030,000 Yuan , accounting for 9.87% of the dynamic investment of the project

■Where the direct costs of low-nitrogen combustor, wet precipitation , rotary electrode and so on for “ Near Zero Emissions” measures are 34.55 million Yuan, accounting for 2.44% of the dynamic investment of the project .

Item	Investment (10,000 Yuan)	Percentage in the dynamic investment of the project
Denitration unit system	3,273	2.31
Electro-static precipitator	2,797	1.97
Where : rotary electrode precipitator	559	0.39
Wet precipitator	2,063	1.45
NO. 0 high pressure heater	138	0.10
Low-nitrogen combustor	333	0.23
Capital contribution of Zhoushan Power	8,603	6.06
Sea water desulfication	5,400	3.81
Total	14,003	9.87

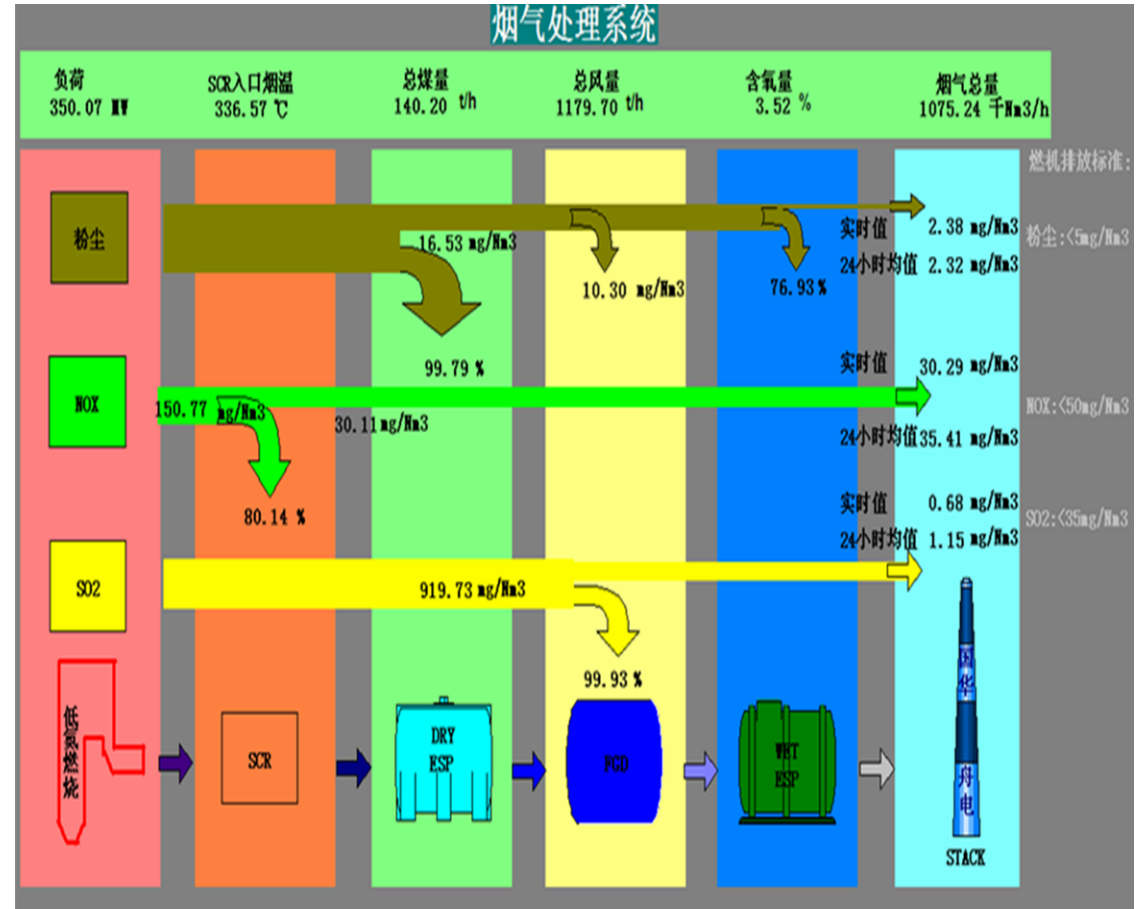
Note : sea water desulfication increases 5 million Yuan for “Near Zero Emissions”

Part III Achievements of Near Zero Emissions

I. Implementation effect of Near Zero Emissions---complete opening of “Near Zero Emissions” technical route

Air pollution emission table of
Zhoushan No. 4 unit during 168 hours' full
load test run

EP indicator	Soot	SO ₂	NO _x
	(mg/Nm ³)	(mg/Nm ³)	(mg/Nm ³)
18 days	2.12	1.77	24.21
19 days	2.1	1.54	23.49
20 days	2.28	1.91	23.49
21 days	1.82	1.04	23.22
22 days	2.17	1.33	32.57
23 days	2.41	1.52	31.64
24 days	2.08	1.73	23.75
Third party detection value	2.46	2.76	19.8
Limit emission standard of gas-fired unit	≤5	≤35	≤50



Part III Achievements of Near Zero Emissions

II. Near Zero Emissions emission reduction effect ---complete opening of “Near Zero Emissions” technical route

Compared to new national emission standard, to calculate as per annual 5,000 utilization hours, the emission reduction effect of Zhoushan No. 4 unit is as follows :

Index	Key limit (or advanced value)	Design value	Actual full load value	Emission reduction effect (tons/year)
Soot (mg/Nm ³)	≤20	≤5	≤3	91
SO ₂ (mg/Nm ³)	≤50	≤35	≤5	91
NO _x (mg/Nm ³)	≤100	≤50	≤35	303

Part III Achievements of Near Zero Emissions

III. Near Zero Emissions achievements---comparison table of environment protection data of six plants in China

Pollutant concentration Power plant	Soot concentration (mg/Nm ³)	SO ₂ concentration (mg/Nm ³)	NO _x concentration (mg/Nm ³)
Guohua Zhoushan No. 4 unit (350MW)	2.46	2.76	19.8
Guohua Sanhe No. 1 unit (350MW)	5.00	9.00	35.00
Zhejiang ** Power Plant No. * unit (1,000MW)	4.60	7.11	35.44
Zhejiang ** Power Plant No. * unit (1,000MW)	4.25	25.51	33.94
Guangdong ** Power Plant No. * unit (300MW)	3.00	20.00	35.00
Shanghai ** No. 3 Power Plant (1,000MW)	11.00	18.00	17.00

Part III Achievements of Near Zero Emissions

IV. Estimated Near Zero Emissions performance

Project	Actual emission of Zhoushan No. 4 unit	Actual emission of Sanhe No. 1 unit	Actual emission of natural gas unit in Yuyao	Natural gas unit emission standard
Soot emission concentration(mg/m ³)	2.5	5	0	5
Soot emission performance (g/kWh)	0.008	0.016	0	0.018
SO ₂ emission concentration(mg/m ³)	2.5	15	0	35
SO ₂ emission performance (g/kWh)	0.008	0.05	0	0.126
NO _x emission concentration(mg/m ³)	35	35	35	50
NO _x emission performance (g/kWh)	0.11	0.11	0.12	0.18

Part III Achievements of Near Zero Emissions

V. Expectations of Guohua Power Near Zero Emissions

S.N.	Indicator	Year					
		2013	2014	2015	2016	2017	
1	Guohua Power capacity (10,000 kilowatts)	3448	3600	3800	5500	6800	
2	Guohua Power coal consumption for power supply (g/kwh)	313	310	308	303	297	
3	Average emission concentration of soot (mg/standard cubic meters)	Active	20	18	16	13	8
		Newly constructed	--	5	5	5	5
		Average	20	17	15	10	6
4	Average emission concentration of SO ₂ (mg/standard cubic meters)	Active	43	41	37	33	28
		Newly constructed	--	27	27	27	27
		Average	43	40	36	30	27
5	Average emission concentration of NO _x (mg/standard cubic meters)	Active	187	88	70	60	50
		Newly constructed	--	40	40	40	40
		Average	187	86	67	53	45
6	Standard coal saved by transformed projects (10,000 tons)	--	--	6	60	120	

Through implementation of *High Quality Green Power Generation Plan* to quickly improve energy saving and environment protection level of active units, Guohua Power will break through resources and environment constraints so as to obtain broader operation and development space, and always be the leader of energy-saving and emission reduction in power industry and make contributions to constructing beautiful China !



*Pursue to be a responsible, world first-class enterprise
with Chinese characteristics*

