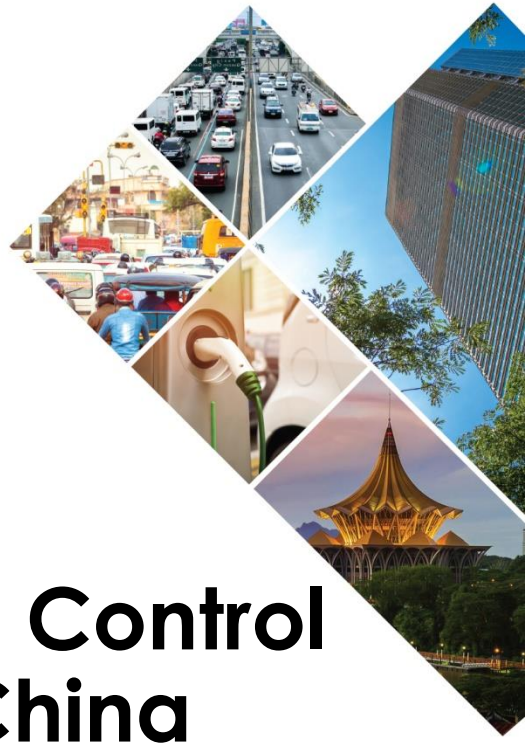
10th BAQ
Better Air Quality Conference
Kuching, Malaysia
14-16 Nov 2018
Borneo Convention Centre Kuching,
Sarawak, Malaysia



Coal-fired Power Plants Emission Control Pathways and Technologies in China

China Forum

Prof. Jiahai Yuan
NCEPU
15 Nov 2018

Coal power in China-technology advancement
中国煤电技术发展进程

- **The brief history of coal power development in China**

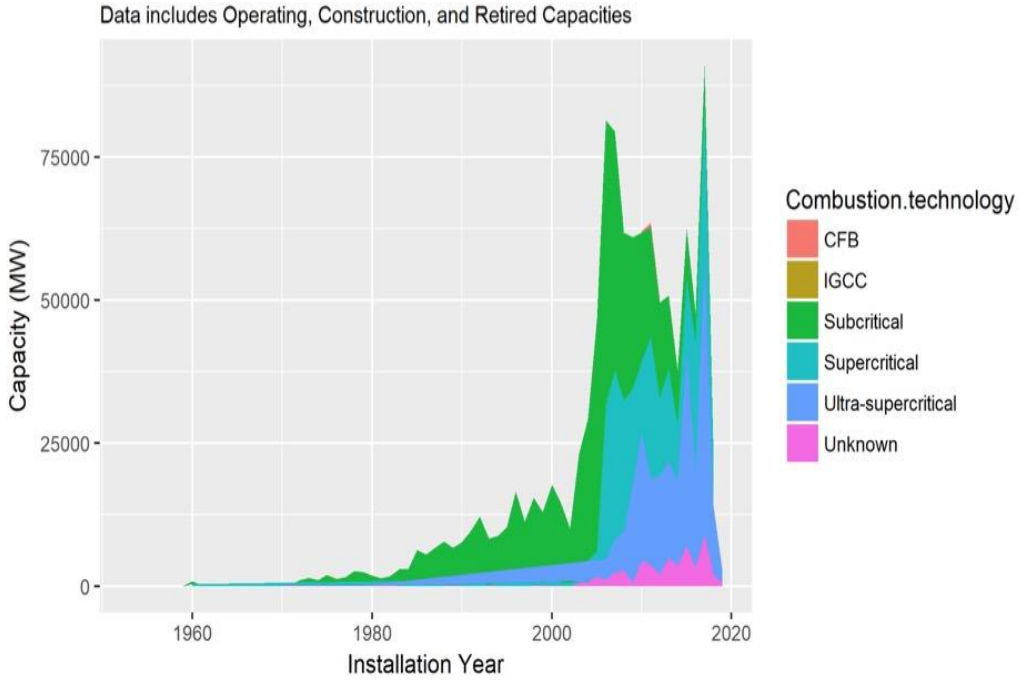
1967	• The first domestic 100 MW high voltage unit • 第一台国产10万千万高压机组在北京高井电厂投运
1972	• The first domestic 200 MW ultra high voltage unit • 第一台国产20万千万超高压机组在辽宁朝阳井电厂投运
1975	• The first domestic 300 MW SB unit • 第一台国产30万千万亚临界双水内冷汽轮机组投运
1989	• The first imported 600 MW SB unit • 第一台引进技术制造的60万千瓦亚临界机组投运
1992	• The first imported 600 MW SC unit • 第一台国外引进的60万千瓦超临界机组投运
2004	• The first domestic 600 MW SC unit • 第一台国产60万千瓦超临界机组在华能沁北电厂投运
2006	• The first imported 1000 MW USC unit • 第一台引进技术国内制造的100万千万超超临界机组投运
2007	• The first domestic 600 MW USC unit • 第一台国产60万千瓦超超临界机组在华能营口电厂投运
2015	• The first domestic 600/1000 MW twice-reheat USC unit • 第一台60万/100万千瓦二次再热超超临界机组投运

Coal power in China-efficiency gains
煤电效率提升

- Measure 1: build new high-parameter (SC and USC) units.
- 措施1：新建大容量、高参数（超临界、超超临界）煤电机组

Technology type: Sub-critical dominates in existing coal fleet.
煤电技术特征：亚临界机组占主导地位

Coal-generation capacity installations by boiler efficiency and year
不同效率煤电机组投运情况



Coal-fired power plant capacity by technology in 2016
2016年不同技术类型煤电机组情况

Technology	Capacity(MW)	Share(%)
Sub-critical	**497712**	**52.95**
Super-critical	226910	24.14
Ultra-super critical	170668	18.16
IGCC	250	0.03
CFB and Unknown	44334	4.72
total	939874	100

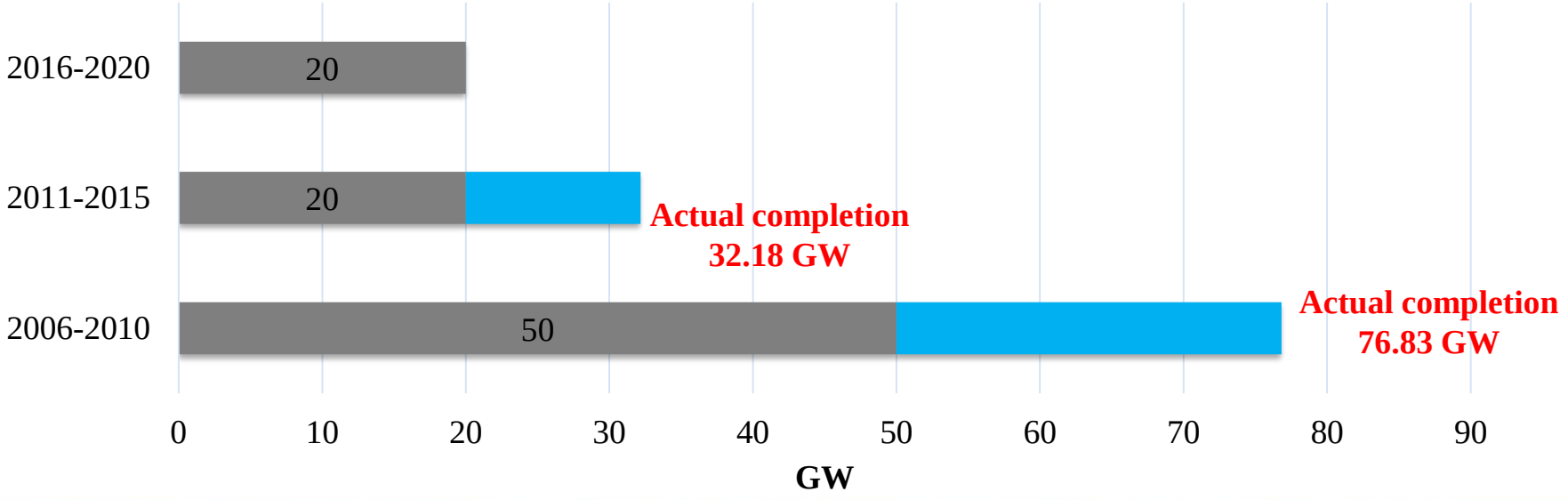
Source: CEC

Coal power in China-structural optimization
优化煤电结构

- Measure 2: shut down small and inefficient units (110GW).
- 措施2：关停小机组和落后机组（1.1亿千瓦）

Shut-down of small units is a key measure of technology advance in China's power sector.
中国电力行业技术进步的关键是关停小机组。
It is estimated that this measure alone has saved primary energy by 90 Mtce.
保守估计，该项措施可节约能源9000万吨标准煤。

Planning and actual completion of eliminating small thermal power units

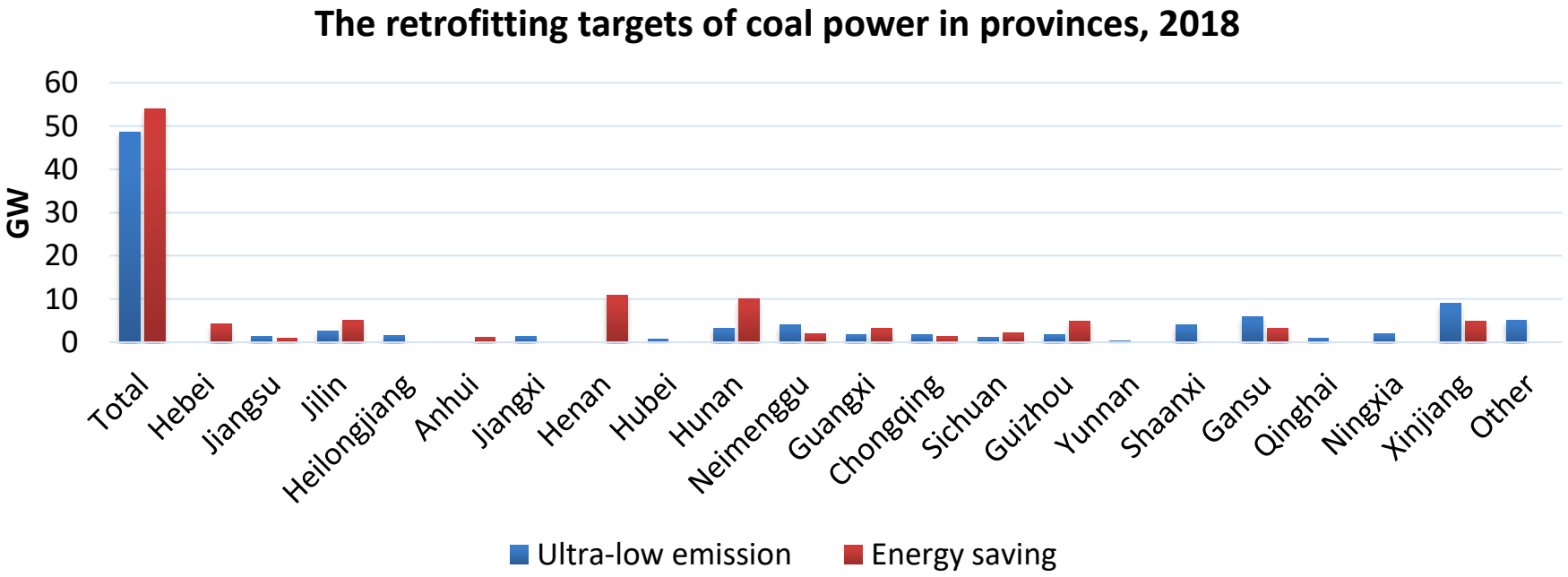


Source: CEC

Coal power in China-efficiency gains
煤电机组清洁高效改造

- Measure 3: retrofit existing units (>500GW).
- 措施3：现有机组清洁高效改造

The eastern, central and western regions will have completed the retrofitting of ultra-low emission by 2017, 2018 and 2020 respectively.
按照规划要求，东部、中部和西部地区分别要在2017、2018和2020年完成超低排放改造。

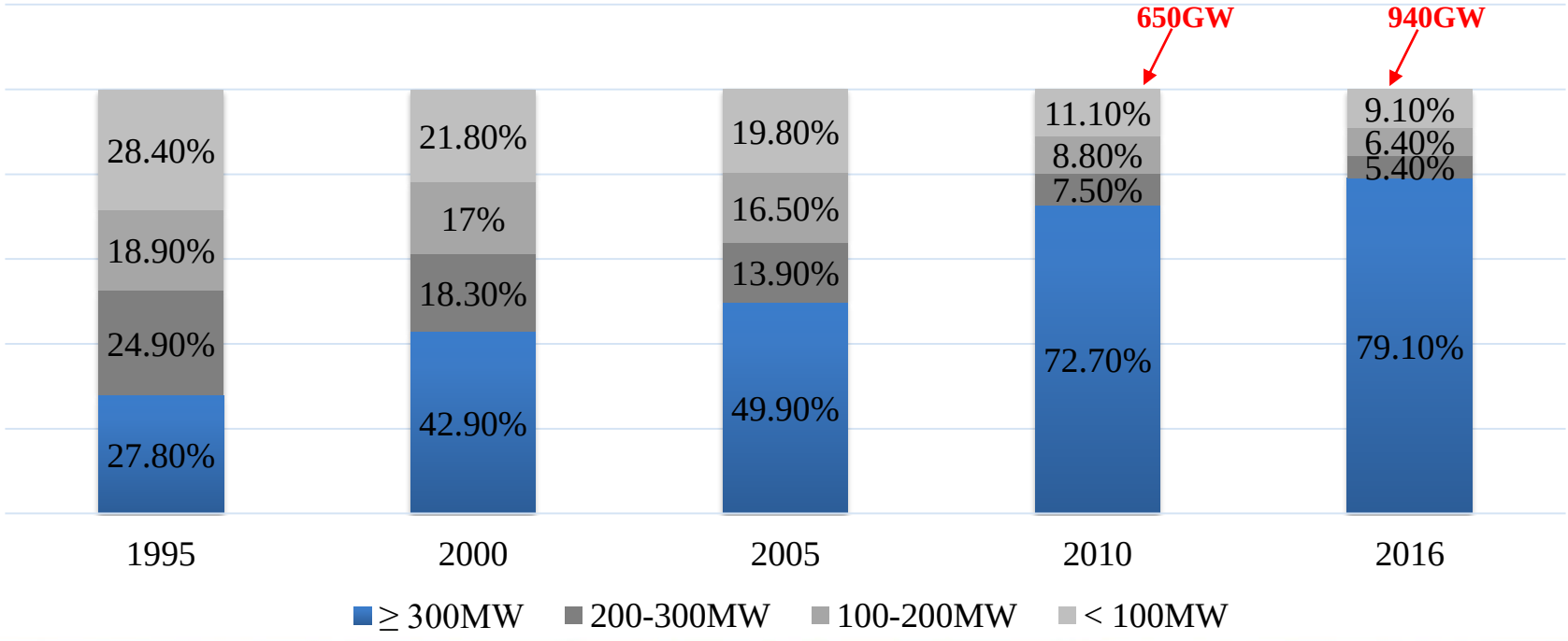


Source: CEC

Coal power in China-structural optimization
煤电结构优化

- The proportion of >300MW coal power units increased from 27.8% in 1995 to 79.1% in 2016 with 96 newly-built 1GW sized units.
- 通过新增百万千瓦等级机组96台，中国30万千万机组的比重从1995年的27.8%增加到2016年的79.1%。

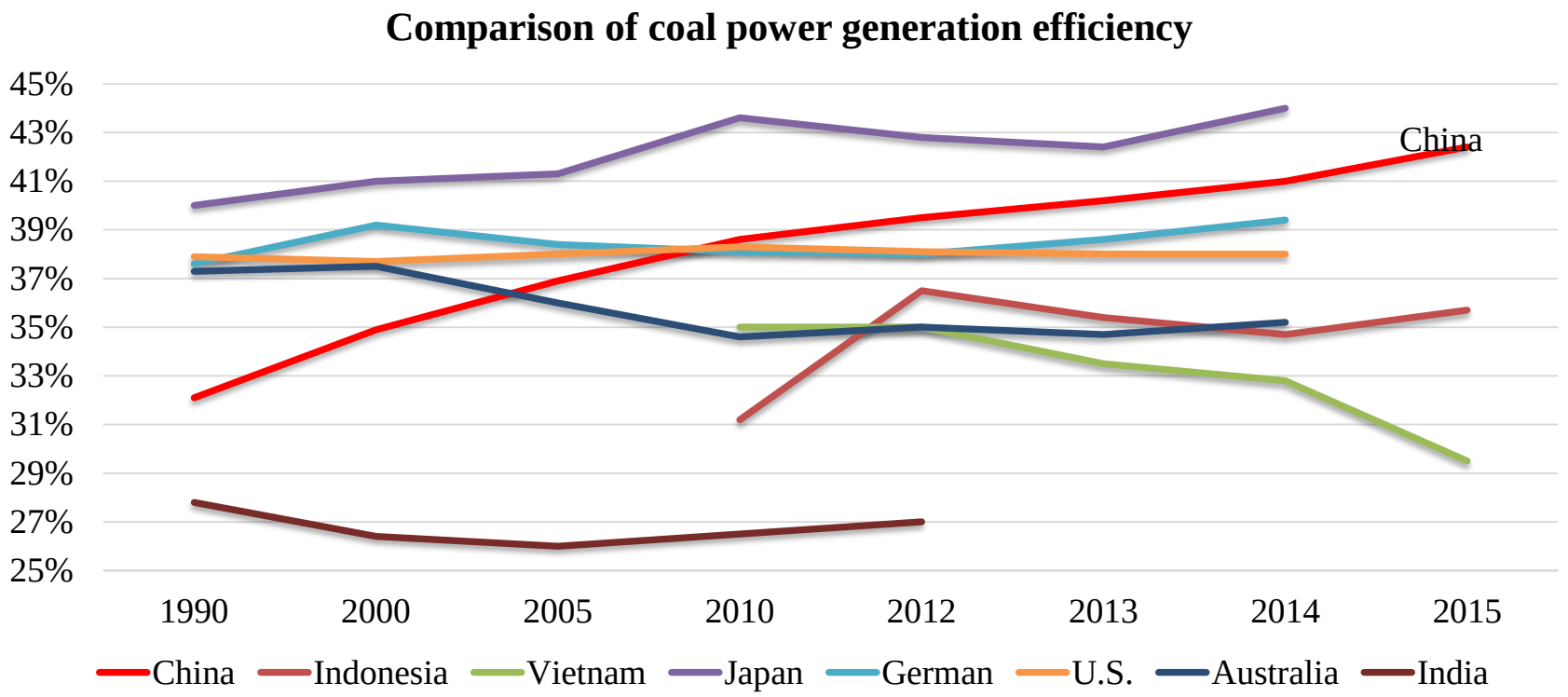
Proportion of coal power generating units with different grades in China



Source: CEC

Coal power in China: growing generating efficiency
发电效率持续提高

- Since 2010, China's coal power generating efficiency has been higher than that of Germany, the United States and other countries, only slightly lower than that of Japan.
- 自2010年以来，中国煤电发电效率已经超过了德国、美国等众多国家，仅比日本要低一点。



Source: CEC

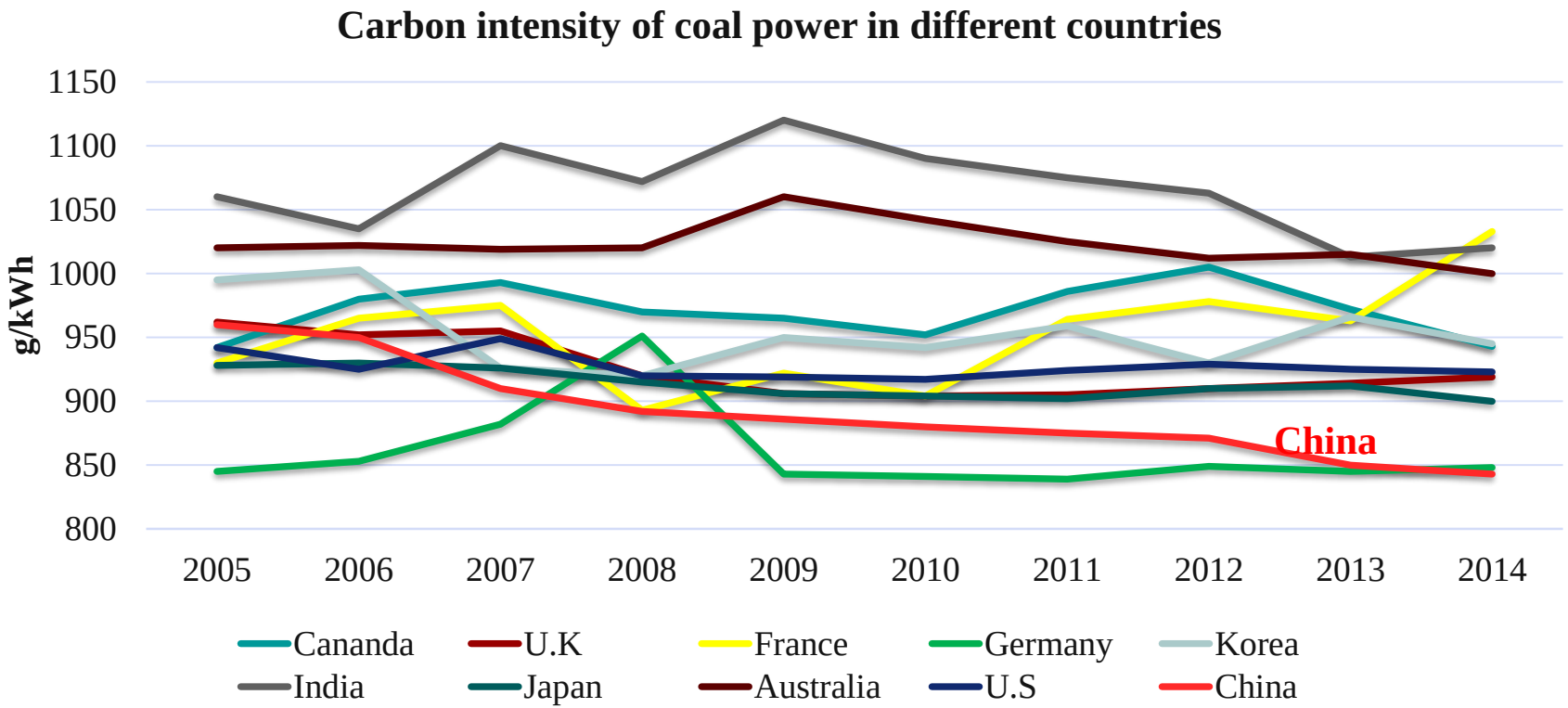
Coal power in China-typical units
典型煤电机组煤耗水平

Heat rate and CO_2 emission intensity of typical coal power units in China in 2016

Unit type	Coal consumption of power supply（gce/kWh）		CO_2 emission intensity (lignite)（gCO_2/kWh）		CO_2 emission intensity (bituminous)（gCO_2/kWh）	
	average	**advanced**	average	**advanced**	average	**advanced**
1000MW USC wet-cooling	285	**271**	834	**794**	789	**750**
1000MW USC air-cooling	300	**298**	878	**874**	830	**826**
600MW USC clamminess	289	**278**	846	**813**	800	**768**
600MW USC air-cooling	310	**298**	908	**873**	858	**825**
600MW SC wet-cooling	304	**292**	890	**856**	841	**809**
600MW SC air-cooling	321	**308**	940	**902**	888	**853**
600MW SBC wet-cooling	316	**303**	925	**887**	874	**839**
600MW SBC air-cooling	329	**322**	964	**943**	911	**891**
350MW SC wet-cooling	311	**306**	910	**896**	860	**847**
300MW SBC wet-cooling	325	**312**	952	**915**	900	**865**
300MW SBC air-cooling	340	**337**	996	**986**	941	**932**

Coal power in China-declined CO2 factor
煤电碳排放强度下降

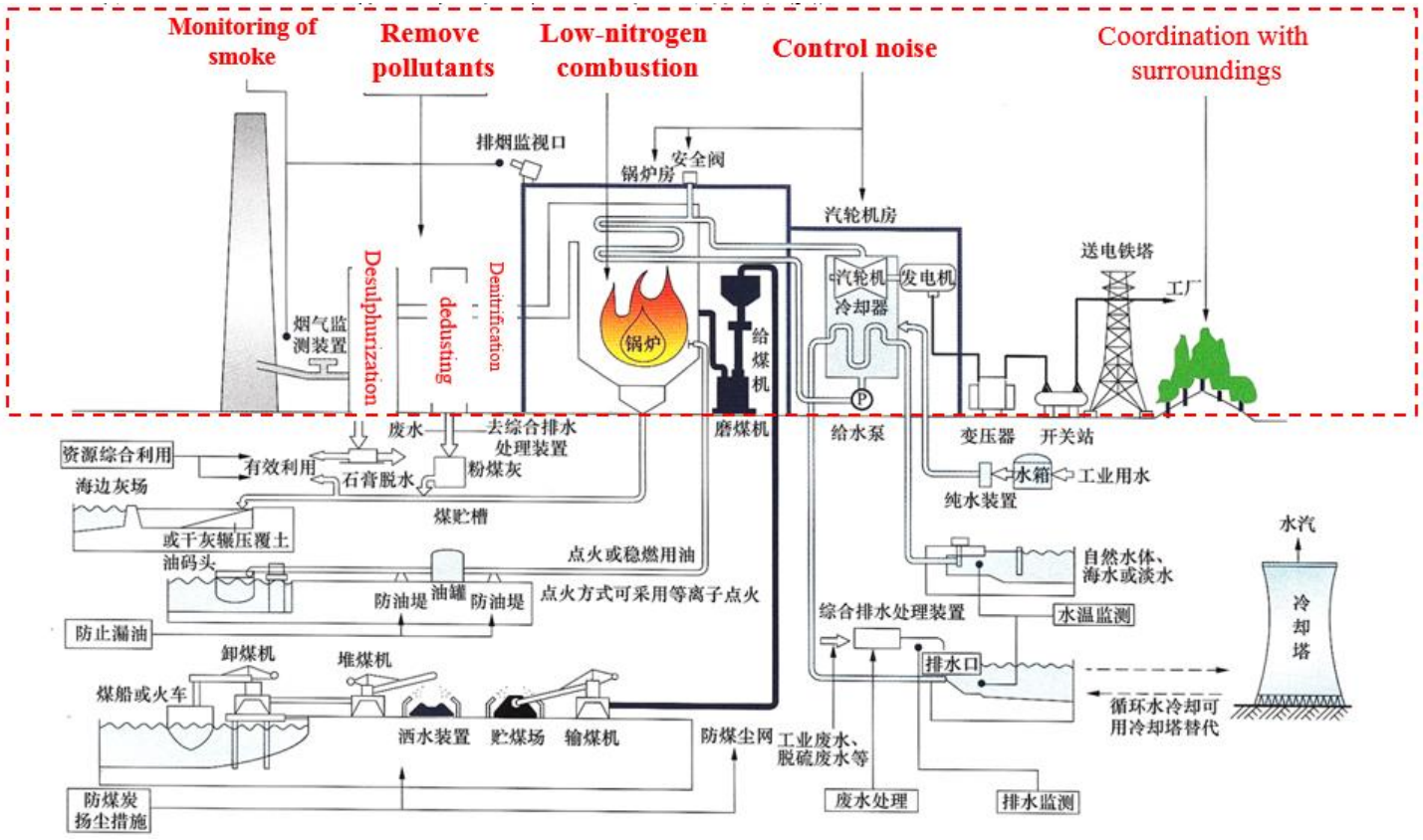
- In 2016, carbon intensity is approaching 822 g/kWh in China's thermal power sector.
- 2016年，中国火电碳排放强度已经降低为822 g/kWh。
- China's carbon emission performance is much better than that of the United States, Canada, Britain, France and other countries.
- 中国的碳减排绩效要优于美国、加拿大、巴西、法国等国家。



Source: CEC

Clean coal in China-whole process
燃煤电厂环境保护措施示意图

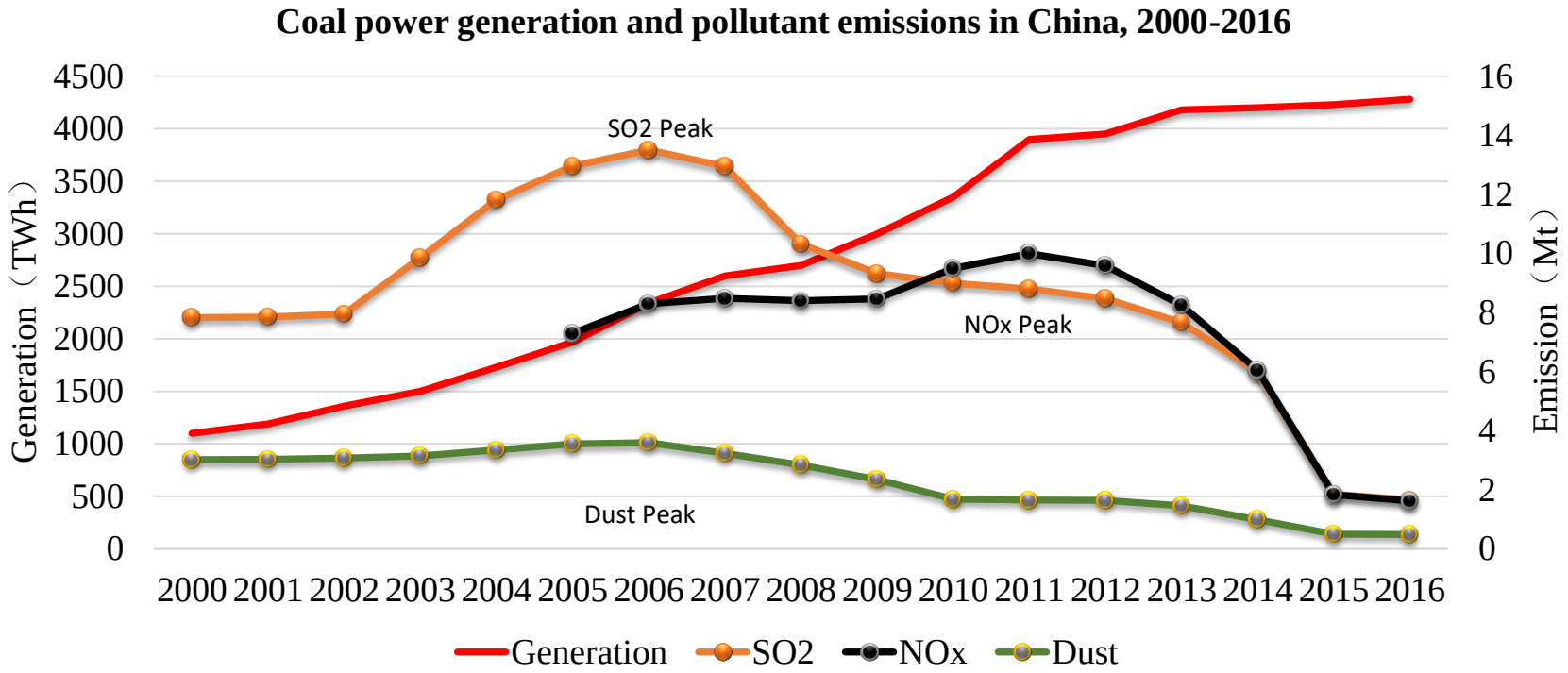
- China's coal power plants have achieved clean development in the whole process, in all directions (coal consumption, emission concentration, total control, supervision, statistics, etc.), and in all elements (gas, water, sound, dust, etc.).
- 中国燃煤电厂实现了全过程（从设计、施工、投运到关停）、全方位（供电煤耗、排放浓度、总量控制、监管、统计等）、全要素（气、水、声、渣等）的清洁化发展。



Source: CEC

Rapid decrease of pollutant emissions
污染物排放量迅速减少

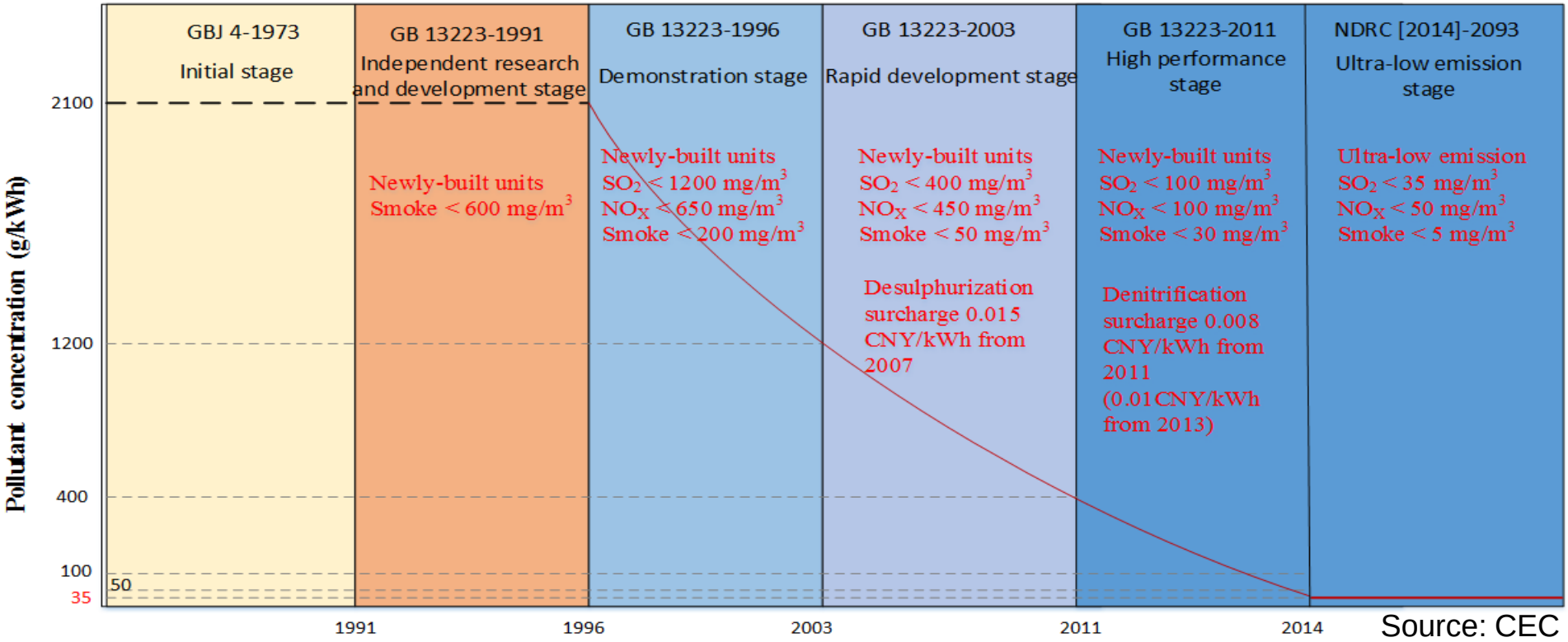
- From 1979 to 2016, thermal power generation increased by 17.5 times, smoke and dust emissions decreased by 94% from the peak of 6 million tons, SO_2 emissions decreased by 87% from the peak of 13.5 million tons, and NO_X emissions decreased by 85% from the peak of 10 million tons.
- 1979~2016年，火电发电量增长17.5倍，烟尘排放量比峰值600万吨下降了94%，二氧化硫排放量比峰值1350万吨下降了87%，氮氧化物排放量比峰值1000万吨左右下降了85%。



Source: CEC

The evolution of pollutant control standards
污染物排放标准演变

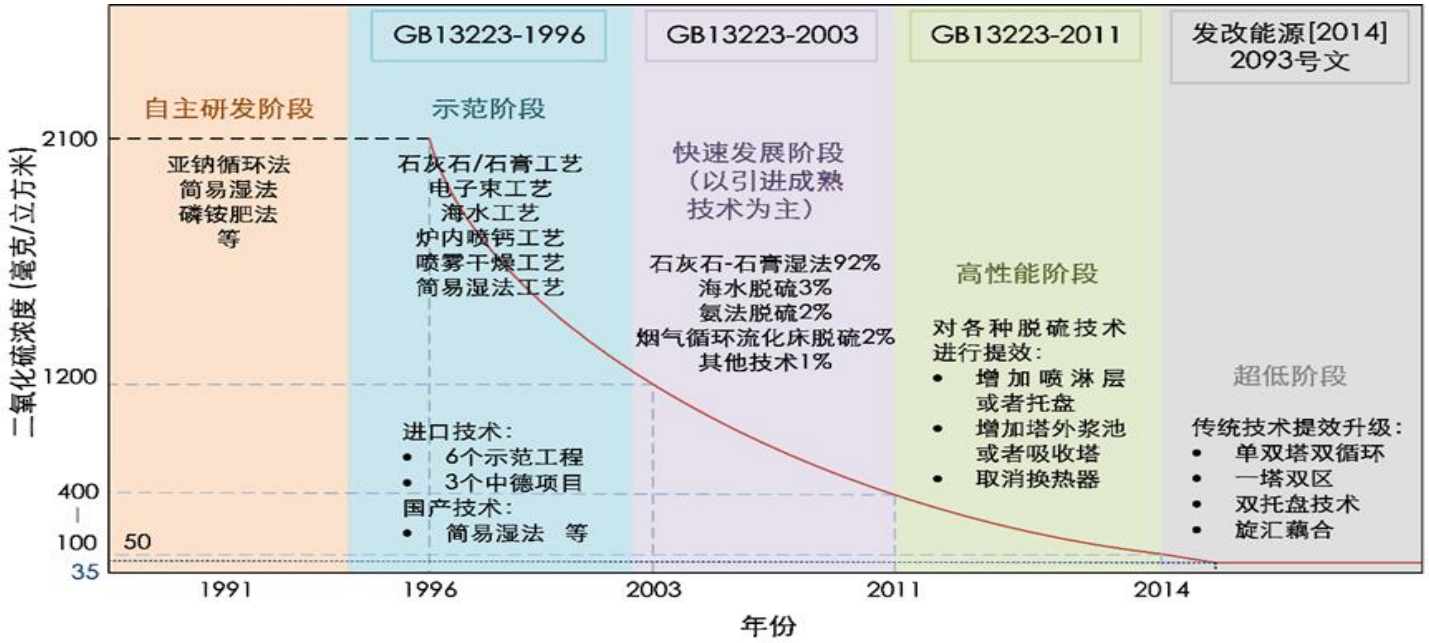
- China only began to introduce end-of-pipe treatment of pollutant in coal power since 1990s.
- 自20世纪90年代以来，中国才开始引入煤电污染物的终端处理。
- The standard became more stringent since 2000s. 2000年以来，环保标准越发严格。
- With current standard (ultra-low), coal power can be as clean as gas.
- 按照现行标准（超低排放），煤电可以像气电一样清洁。



Source: CEC

The evolution of desulfurization standards
煤电脱硫技术标准

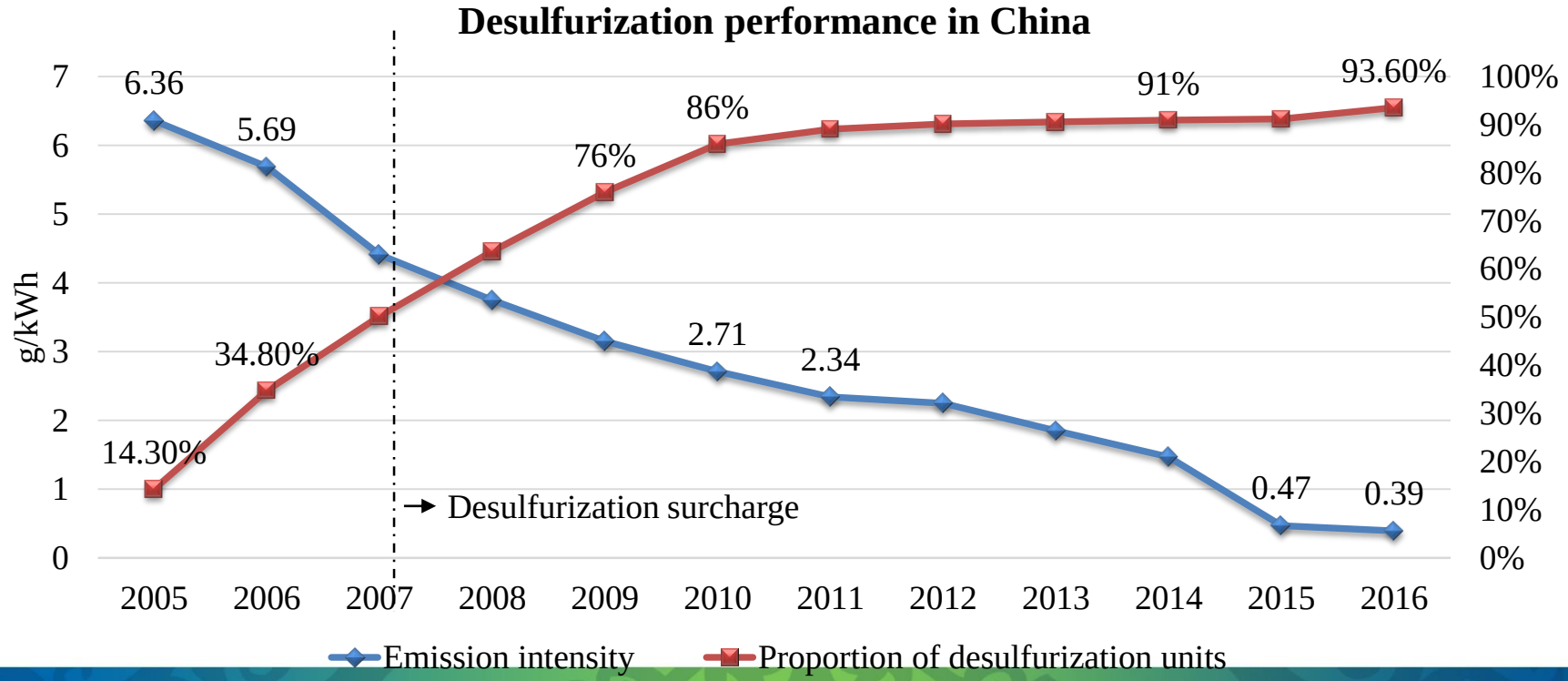
- China only began to introduce desulfurization technology since late 1990s.
  自20世纪80年代后期，中国开始研究烟气脱硫技术。
- In the 1990s, demonstration projects were carried out to lay the technical foundation for large-scale flue gas desulfurization.
  1990年之后，先后从国外引进了各种类型的烟气脱硫技术，开展了示范工程建设，为大规模开展烟气脱硫奠定技术基础。
- In the 21st century, the control of sulfur dioxide in power has entered the phase dominated by flue gas desulfurization.
  进入21世纪，电力二氧化硫控制步入以烟气脱硫为主的控制阶段。



Source: CEC

Pollutant control-decreased SO2 intensity
SO2排放强度降低

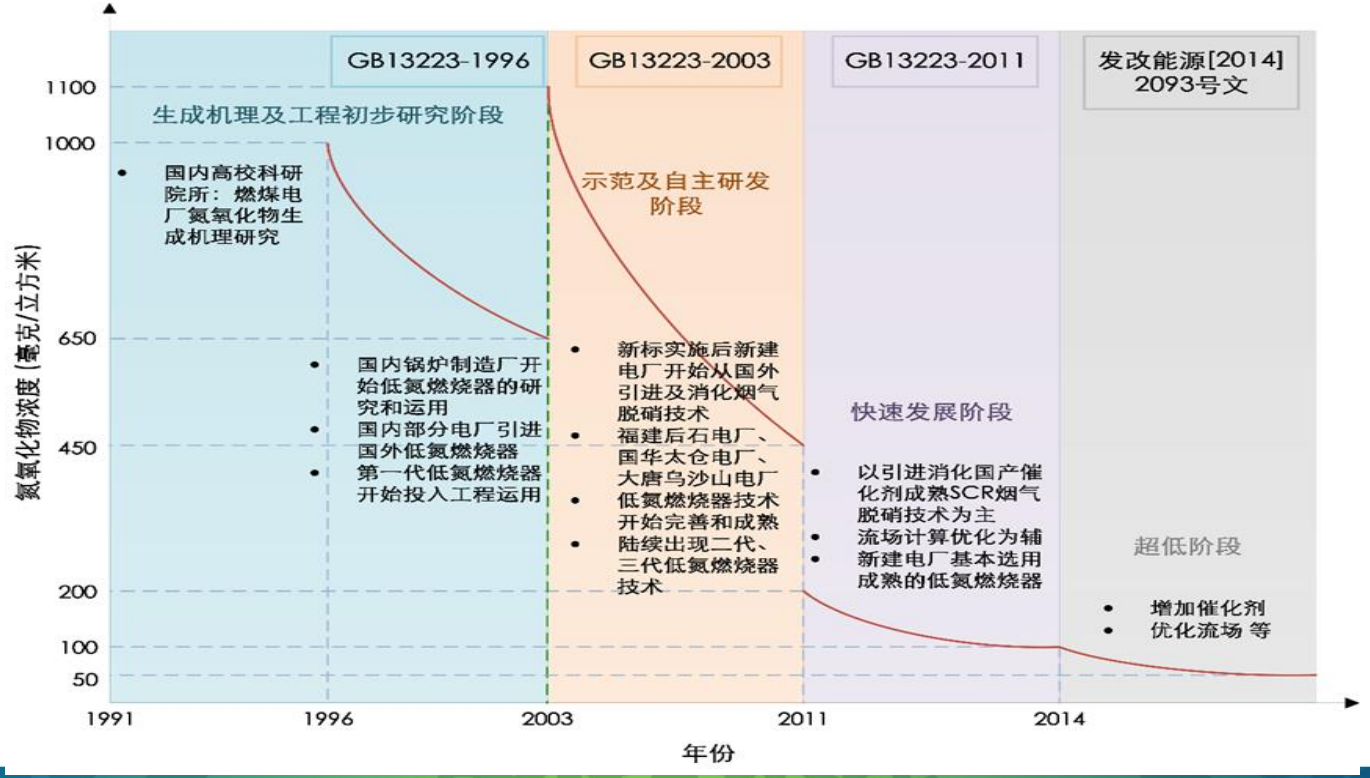
- China devoted to investing in 830 GW desulphurization facilities during 2005-2016.
  2005-2016年间，中国累计完成煤电机组脱硫改造8.3亿千瓦。
- The SO_2 emissions intensity decreased by 96.1%, from 10.11g/kWh in 1980 to 0.39g/kWh in 2016.
  目前，燃煤电厂脱硫效率大于97%，部分达99%以上。 SO_2排放绩效由1980年的10.11克/千瓦时降至2016年 的0.39克/千瓦时，下降96.1%。



Source: CEC

The evolution of denitrification standards
煤电脱硝技术标准

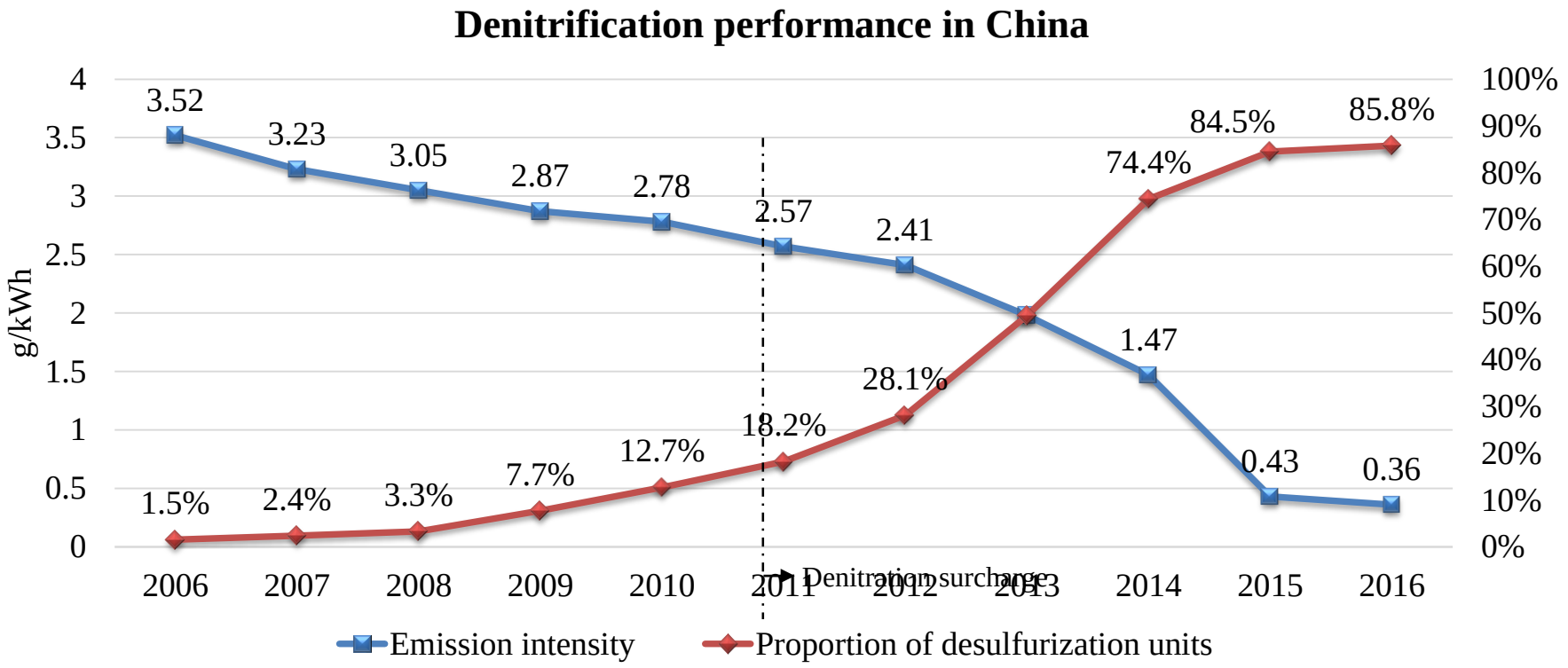
- China only began to introduce denitrification construction and retrofit in coal power since "12th –FYP" (2011-2015).
  "十二五"开始大规模烟气脱硝建设及改造。
- Conventional pulverized boilers basically adopt SCR technology, and some CFB boilers and very few conventional pulverized boilers adopt SNCR technology or SCR-SNCR technology.
  常规煤粉炉基本采用SCR技术，部分CFB锅炉及极少数常规煤粉炉采用SNCR技术或者SCR-SNCR技术。



Source: CEC

Pollutant control-decreased NOx intensity
煤电NOx强度降低

- China devoted to investing in 820GW denitrification facilities during 2011-2016.
  2011~2016年，累计新增脱硝机组8.2亿千瓦，年平均投运脱硝容量超过1亿千瓦。
- The NO_X emissions intensity decreased from 3.62 g/kWh in 2005 to 0.36 g/kWh in 2016.
  火电氮氧化物排放绩效由2005年的3.62克/千瓦时下降到2016年的0.36克/千瓦时。



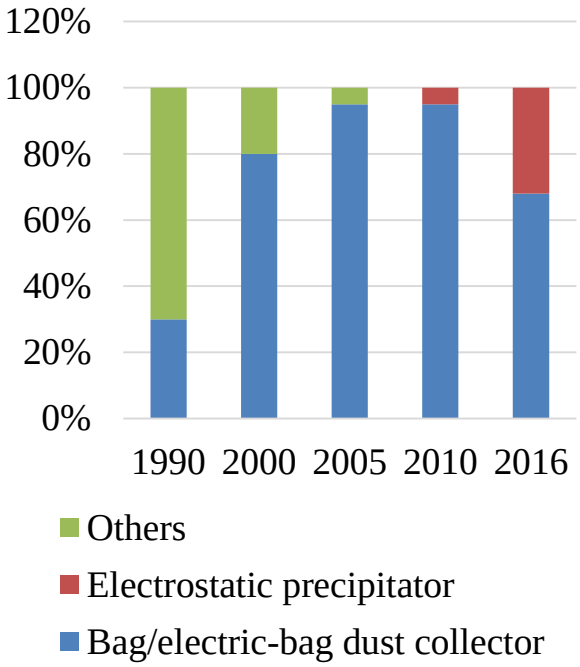
Source: CEC

Pollutant control-decreased dust intensity
煤电烟尘强度降低

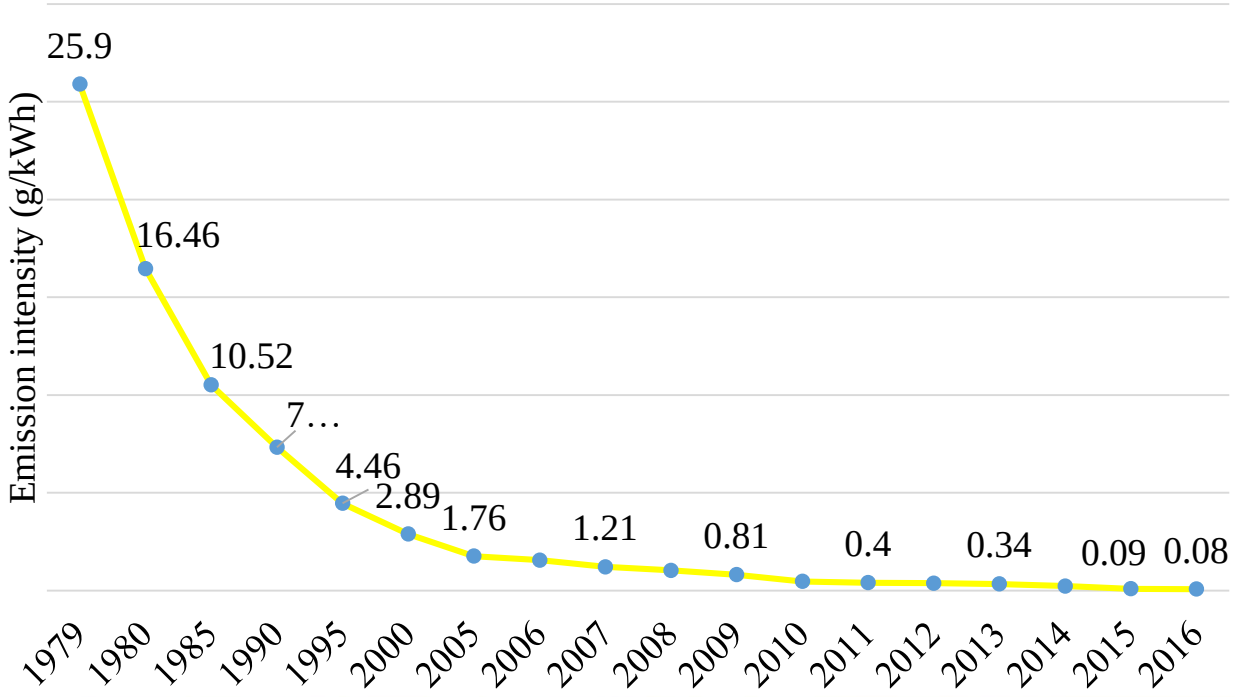
- The dust emissions intensity decreased by 99.7%, from 25.9g/kWh in 1979 to 0.08g/kWh in 2016.

烟尘排放绩效由1979年的25.9克/千瓦时下降到2016年的0.08克/千瓦时，下降99.7%。

Application of dust collector technology



Performance of thermal power dust emission



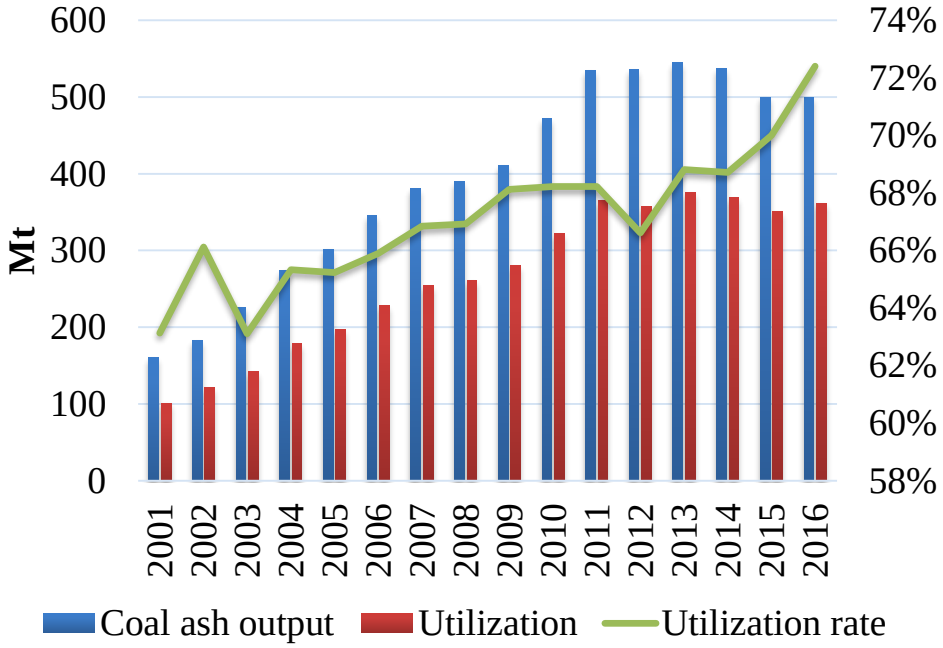
Source: CEC

Enhanced utilization of solid waste
固废回收利用

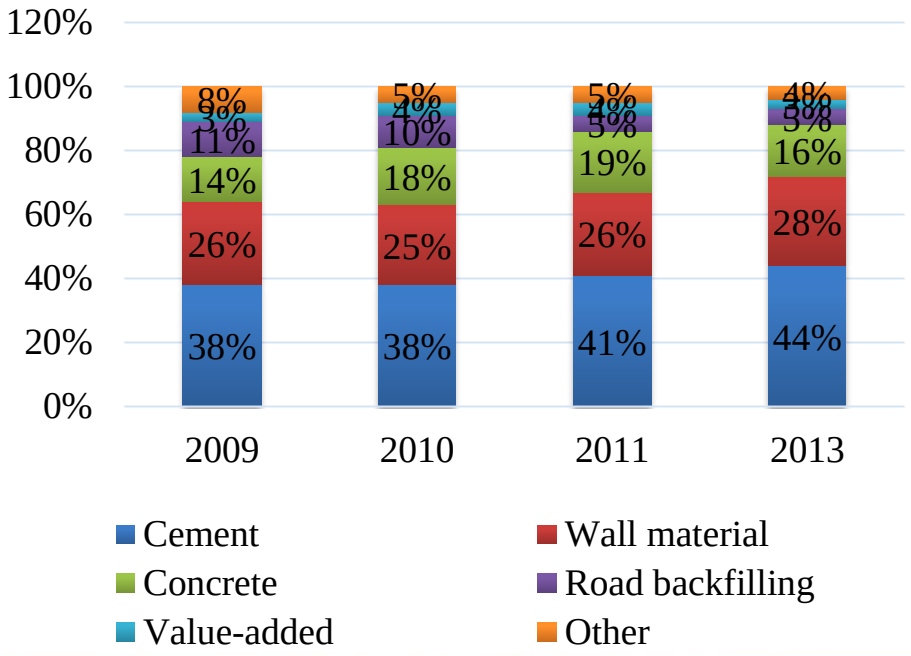
- Desulphurization gypsum and coal ash have been utilized in large quantities.
- In 2016, about 500Mt of coal ash was produced in coal power plants and its comprehensive utilization rate was about 72%, while about 72.5 Mt of desulfurized gypsum was produced, with a comprehensive utilization rate of 74%.

  2016年全国燃煤电厂产生粉煤灰约5亿吨，综合利用率约为72%；产生脱硫石膏约7250万吨，综合利用率约74%。

Utilization of coal ash in coal-fired power plants



Application of coal ash



Source: CEC

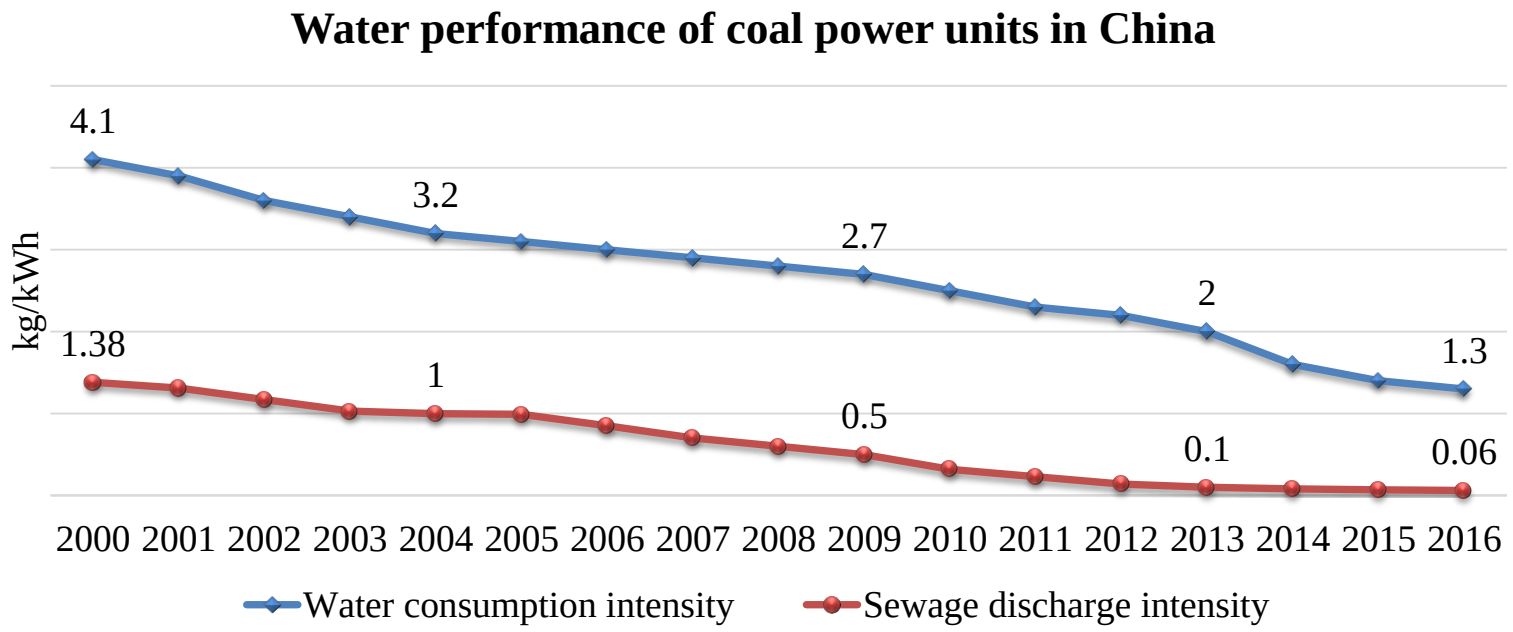
Reduced water consumption and water rate
耗水与废水排放逐年减少

- The water consumption intensity decreased by 68.3%, from 4.1kg/kWh in 2000 to 1.3kg/kWh in 2016.

火电单位发电水耗由2000年的4.1千克/千瓦时降至2016的年1.3千克/千瓦时，降幅达到68.3%。

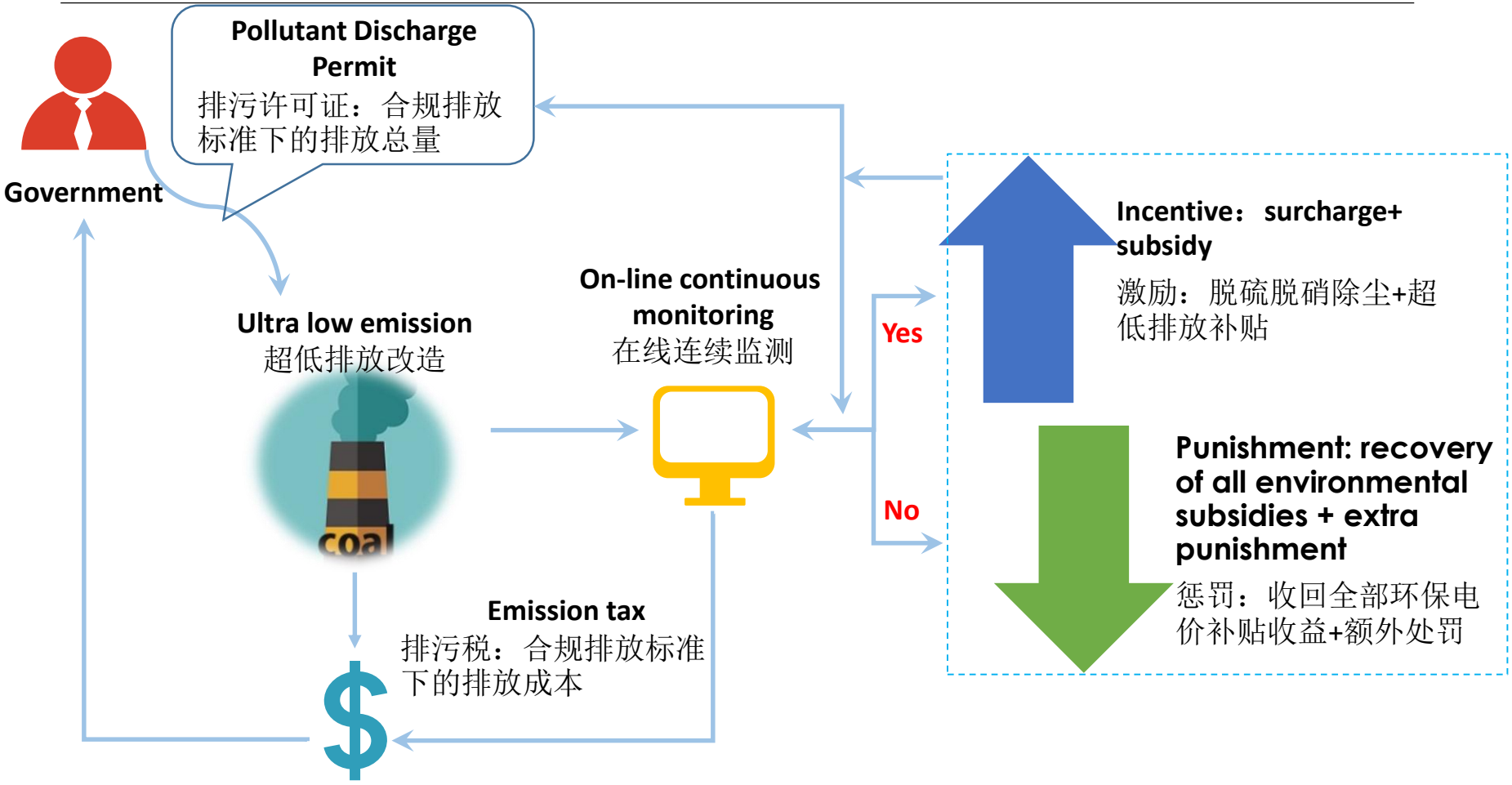
- The waste water intensity decreased by 95.7%, from 1.38kg/kWh in 2000 to 0.06kg/kWh in 2016.

废水排放绩效由2000年的1.38千克/千瓦时降至2016年的0.06千克/千瓦时，降低95.7%。



Source: CEC

Regulation system for emissions control
火电排放管控治理体系



Questions & Comments

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