

China's High Efficiency Coal-fired Power Generation

中国煤电高效发展

中国国家能源局

China NEA

Nov 29 2015

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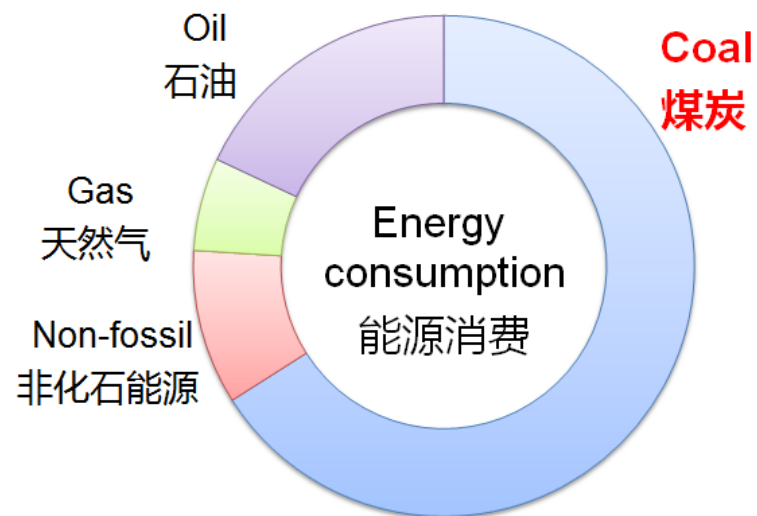
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China's energy structure

中国能源概况

- China is the largest energy consumer in the world.
中国是世界上最大的能源消费国。
- Coal is accounted for 70% of China's total energy consumption.
在中国能源消费结构中，煤炭占约70%。
- Petroleum and natural gas are needed to be imported from abroad. 60% of petroleum and 30% of natural gas are needed to be imported, respectively.
石油和天然气资源相对匮乏，需要大量进口。其中，石油对外依存度近60%，天然气超过30%。



Coal plays an important role in China's energy supply, coal also the important guarantee of China's energy security.

煤炭既是中国能源供应的重要支撑，也是中国能源安全的重要保障

China's energy structure

中国能源概况

- ❑ Coal production and consumption result in large amount of air、soil and water pollution, China is facing big challenge regarding to environmental protection.

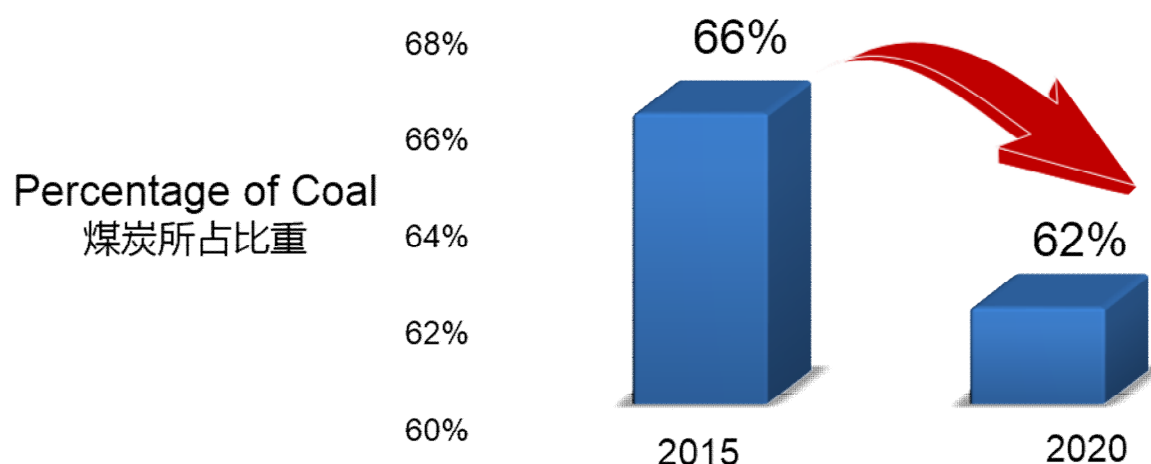
相比石油和天然气，煤炭的生产和消费过程中产生了大量的大气、土壤、水体污染，给中国的环境保护造成了严峻的挑战。

- ❑ China is devoting itself to increase the proportion of energy consumption of oil、gas and renewable energy sources, decrease the share of coal consumption.

目前，中国政府正致力于通过增加石油、天然气及其他可再生能源消费量，减少煤炭消费比重。

- ❑ China will consume **4800** million tons of converted coal equivalent by 2020. The share of coal consumption will be reduced to less than **62%**.

预计到2020年，中国能源消费总量将达到**48-50亿吨**标准煤，其中，煤炭占比将控制到**62%**以内。

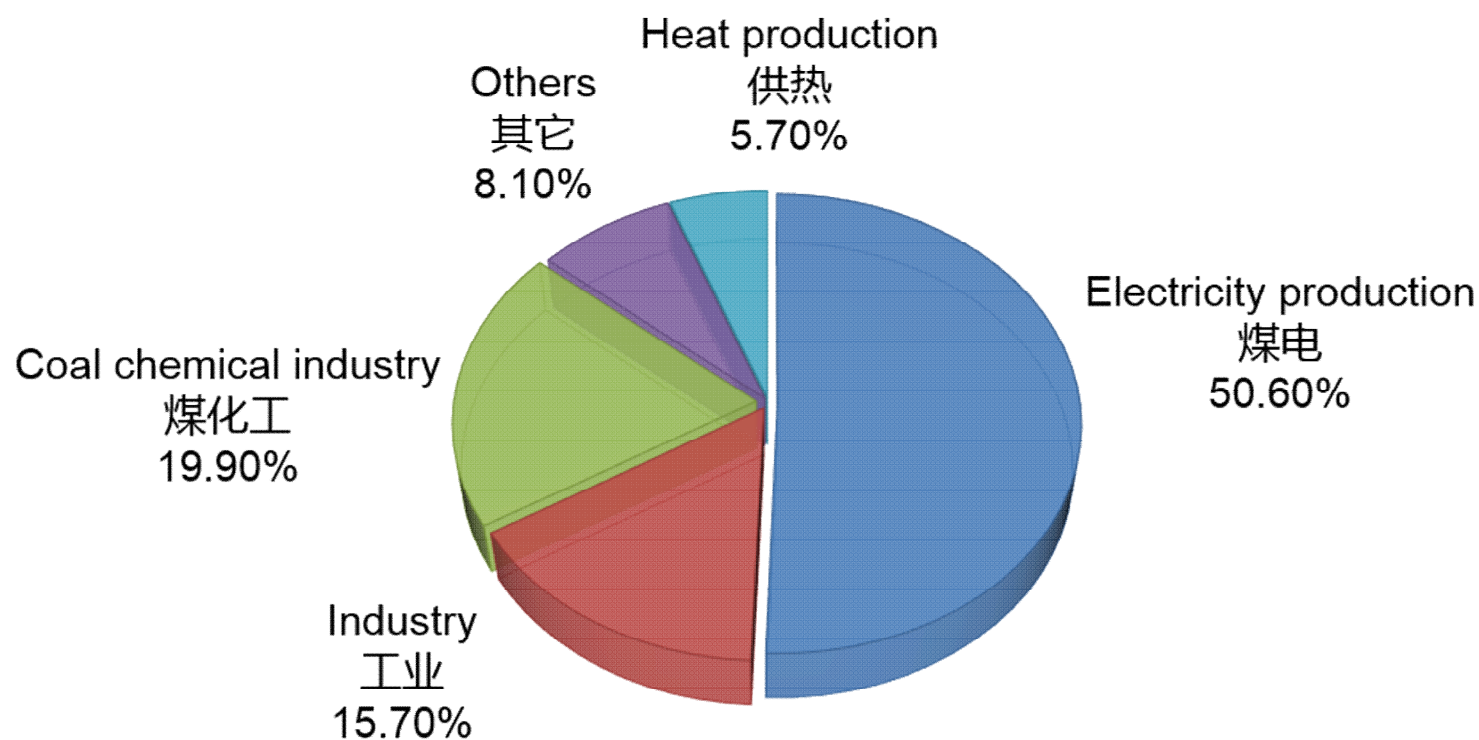


China's energy structure

中国能源概况

In China, electricity production is the main form of coal utilization, which accounted for approximately 50% of coal consumption.

燃煤发电是煤炭利用中最主要的形式，占中国煤炭消费的比重约50%。



Relevant policies of coal-fired power generation

煤电相关政策

China has issued series of policy documents of coal-fired power plants, these measures promote high-efficiency and clean utilization of coal.

中国政府连续出台了一系列的有关煤电的政策文件，有力促进了煤炭的清洁高效利用。



《Action plan of energy development strategy(2014-2020)》
《能源发展战略行动计划(2014-2020)》

《Action plan of energy saving, emission reduction, upgrading and retrofitting of coal-fired power plants(2014-2020)》
《煤电节能减排升级与改造行动计划(2014-2020)》

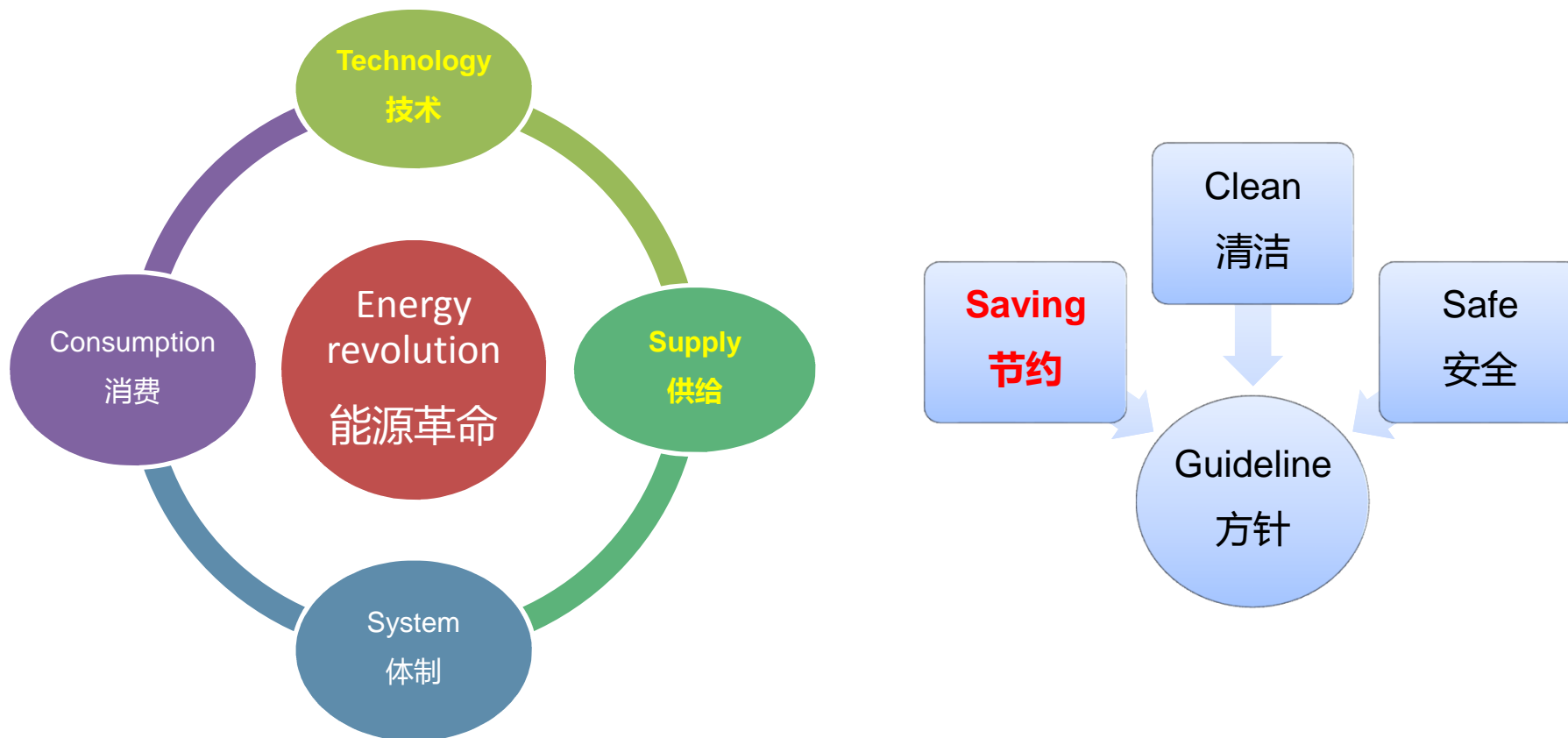
《 Interim measures for the administration of commerical coal quality 》
《商品煤质量管理暂行办法》

Relevant policies of coal-fired power generation

煤电相关政策

Action plan of energy development strategy(2014-2020)

能源发展战略行动计划 (2014-2020年)



Relevant policies of coal-fired power generation

煤电相关政策

Action plan of energy development strategy(2014-2020)

能源发展战略行动计划 (2014-2020年)

Develop clean and efficient coal-fired power generation
清洁高效发展煤电

Promote constructions of coal base channel
推进煤电大基地大通道建设

improve clean coal utilization level
提高煤炭清洁利用水平

Implement demonstration project of coal to oil and coal to gas
稳妥实施煤制油、煤制气示范工程

Primary energy consumption
一次能源消费总量

4.8×10^9
tce

2020

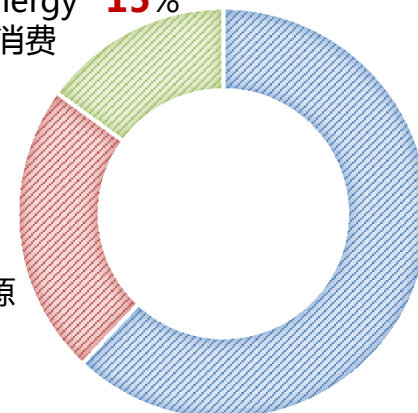
Coal consumption
煤炭消费总量

4.2×10^9
t

Non-fossil energy
非化石能源消费 15%

23%
Other fossil
其他化石能源

62%
Coal
煤炭

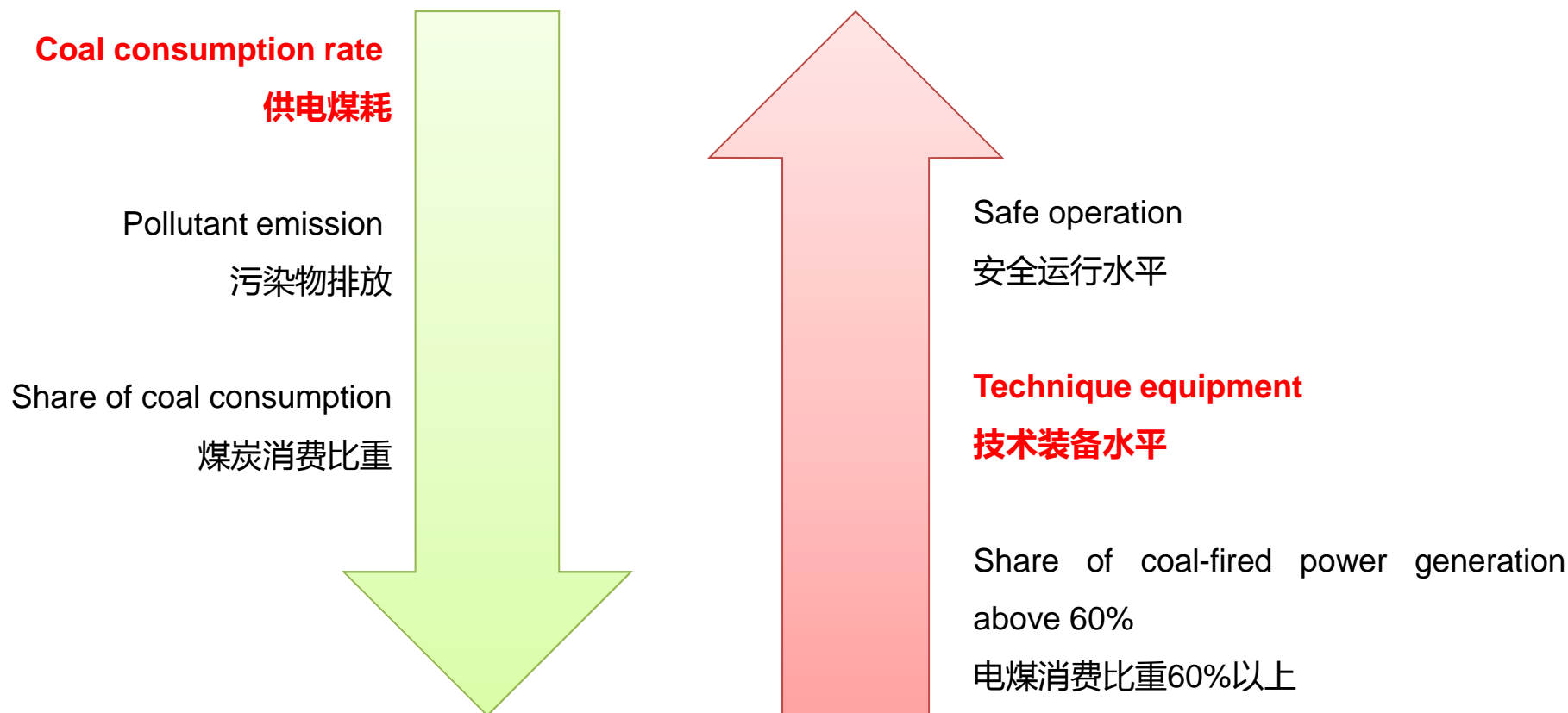


Relevant policies of coal-fired power generation

煤电相关政策

Action plan of energy saving, emission reduction, upgrading and retrofitting of coal-fired power plants (2014-2020)

煤电节能减排升级与改造行动计划 (2014-2020)

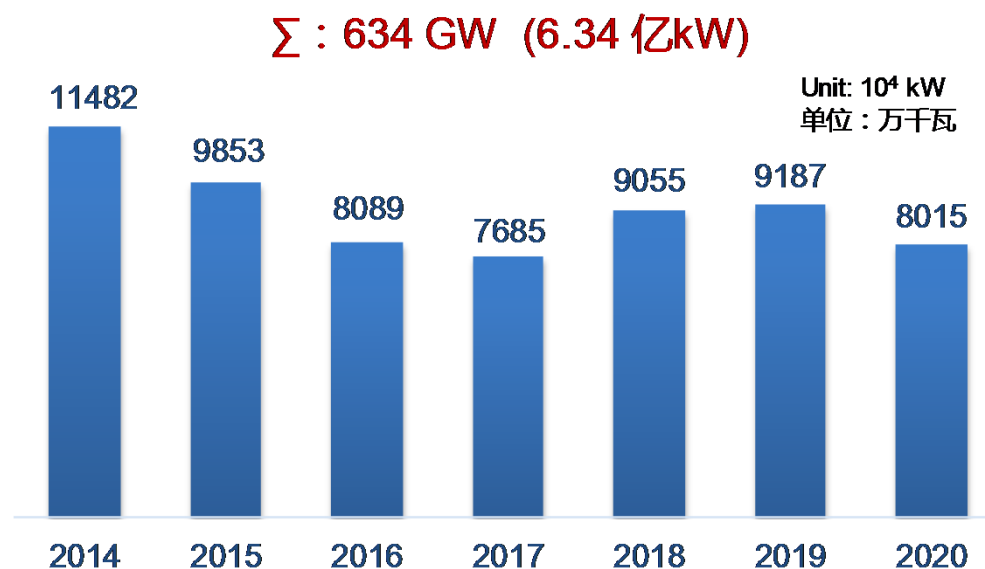


Relevant policies of coal-fired power generation

煤电相关政策

Action plan of energy saving, emission reduction, upgrading and retrofitting of coal-fired power plants (2014-2020)
煤电节能减排升级与改造行动计划 (2014-2020)

- new-built coal-fired power units : **300** g/kWh.
新建煤电机组 : **300**g/kWh。
- Existing coal-fired units : **310** g/kWh
现役煤电机组 : **310**g/kWh。
- Existing 600MW and above units : **300** g/kWh
现役60万千瓦及以上机组 : **300**g/kWh。



Reform plan of coal-fired power plants in 2014-2020
2014~2020年煤电机组分年改造计划



Coal consumption Target (煤炭消费量目标)

- **- 1.5 × 10⁸ t (-1.5 亿吨)**

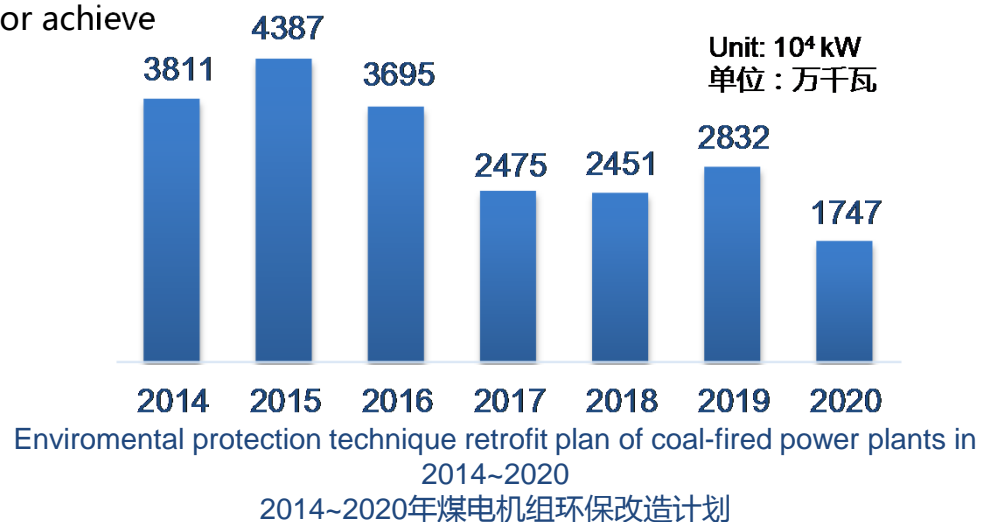
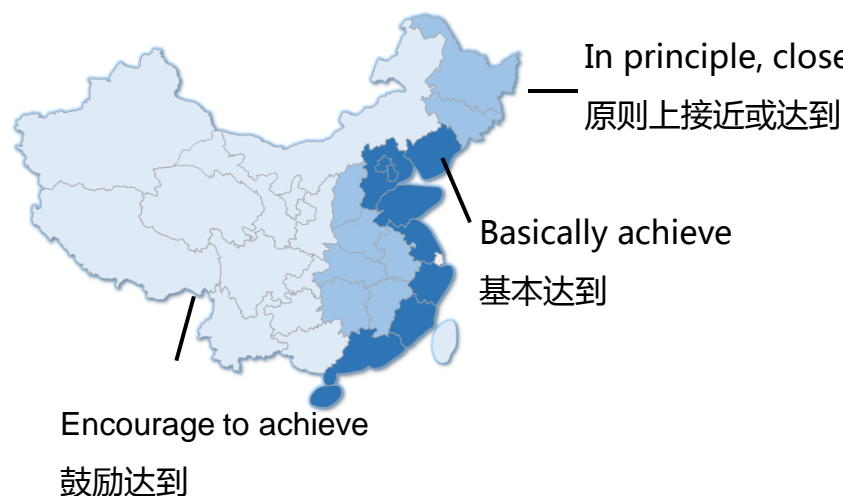
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Dust: 10mg/Nm³ SO₂: 35mg/Nm³ NO_x: 50mg/Nm³

Σ : 214 GW (2.14 亿kW)



Pollutant emission reduction target (污染物减排量目标)

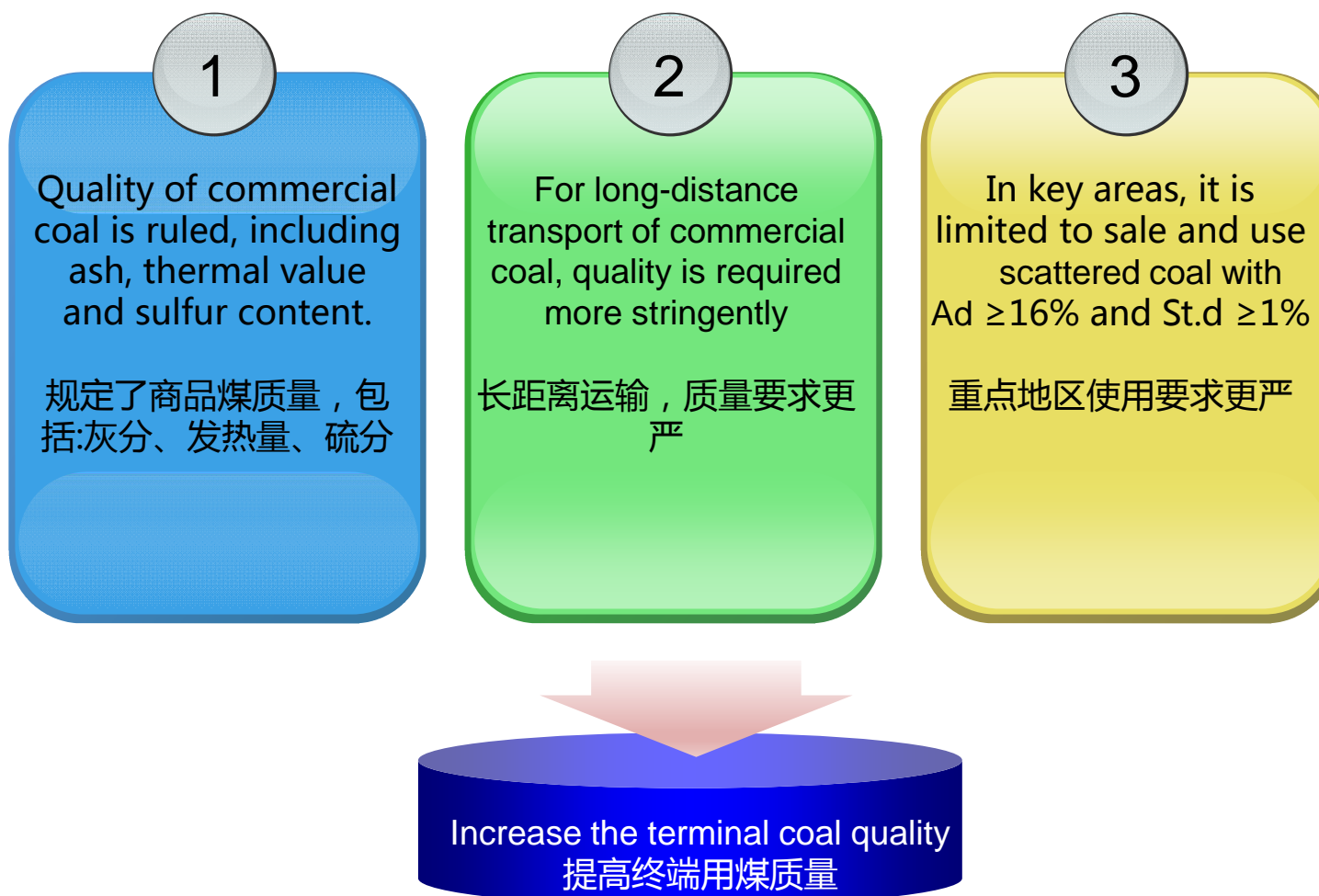
- **Dust(烟尘) : - 60%**
- **SO₂ : - 56.7%**
- **NO_x : - 46.9%**

Relevant policies of coal-fired power generation

煤电相关政策

《Interim measures for the administration of commercial coal quality》

《商品煤质量管理暂行办法》



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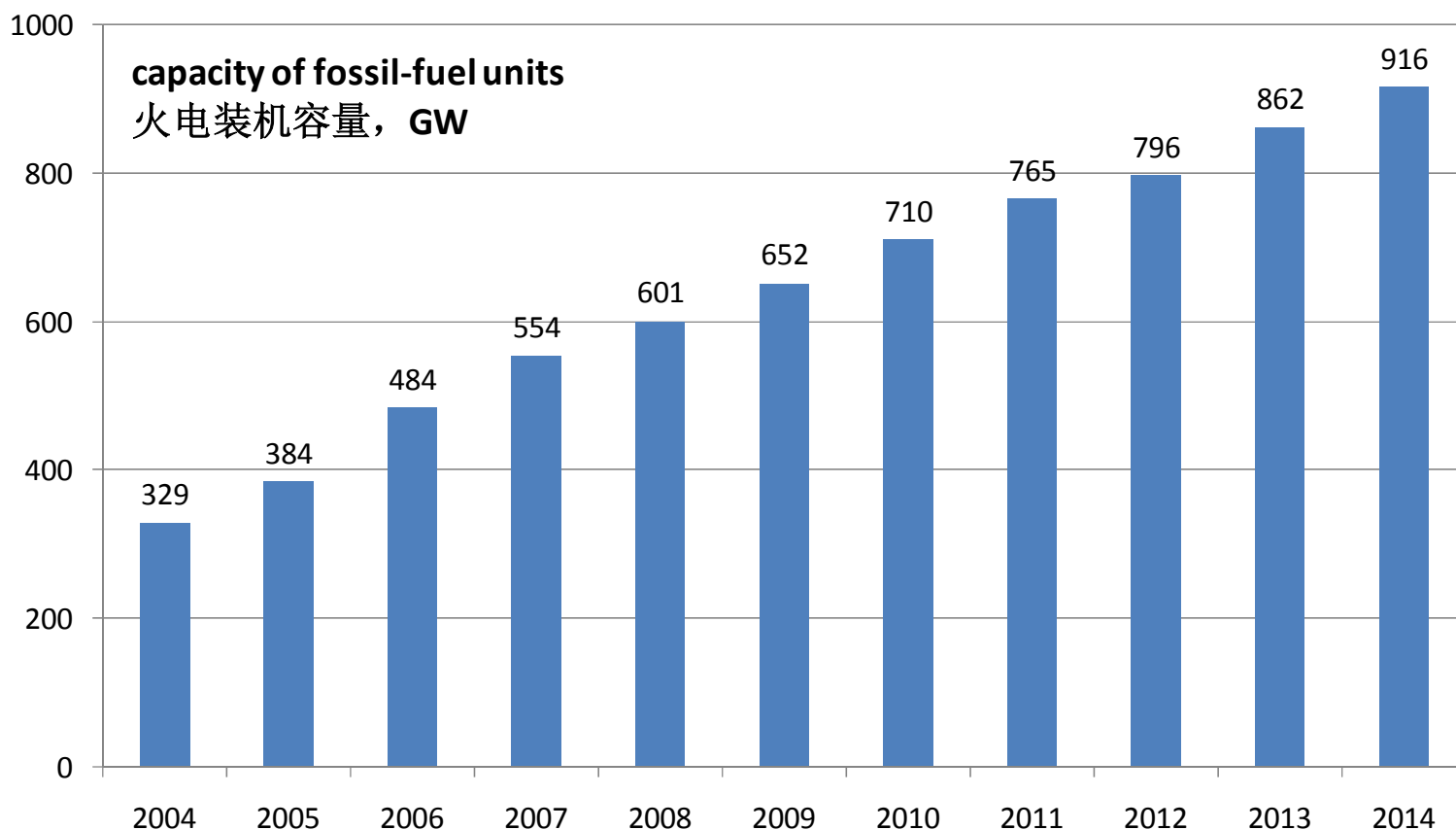
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Status of coal-fired power generation

中国煤电发展现状

Recent years, China's installed capacity of coal-fired power generation has been continuously increasing, and became the largest country of installed capacity in the world.

近年来，中国煤电装机持续增长，已经成为世界上煤电装机最大的国家。



China's installed capacity of fossil-fuel units and total coal consumption from 2004 to 2014

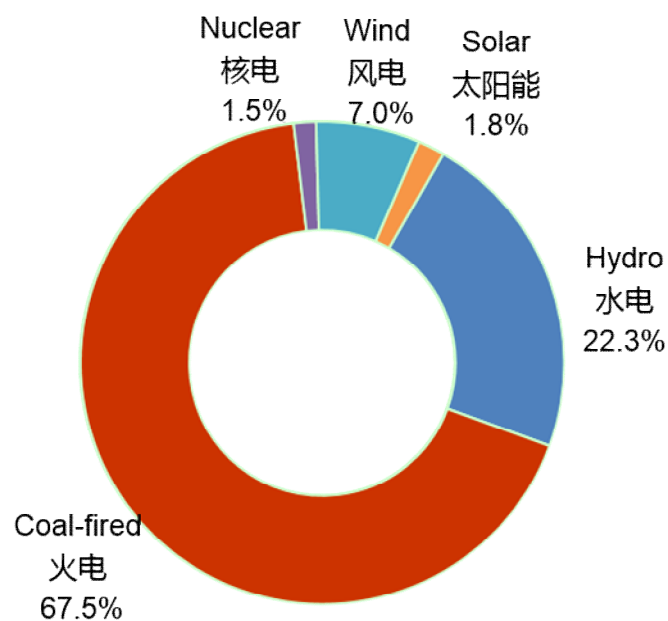
2004-2014 年中国电力装机及全国煤炭消费总量

Status of coal-fired power generation

中国煤电发展现状

Installed capacity in 2014 : 1360GW

2014年发电装机容量 : 13.60亿kW

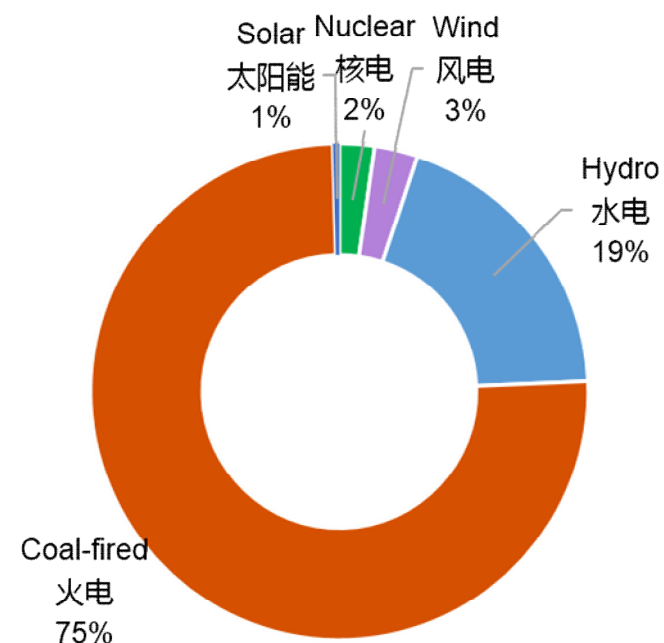


Structure of installed capacity in 2014

2014年全国装机构成

Electric production in 2014 : 5.4×10^{12} kWh

2014年发电量 : 5.4万亿kWh



Structure of electric production in 2014

2014年全国发电电量构成

Status of coal-fired power generation

中国煤电发展现状

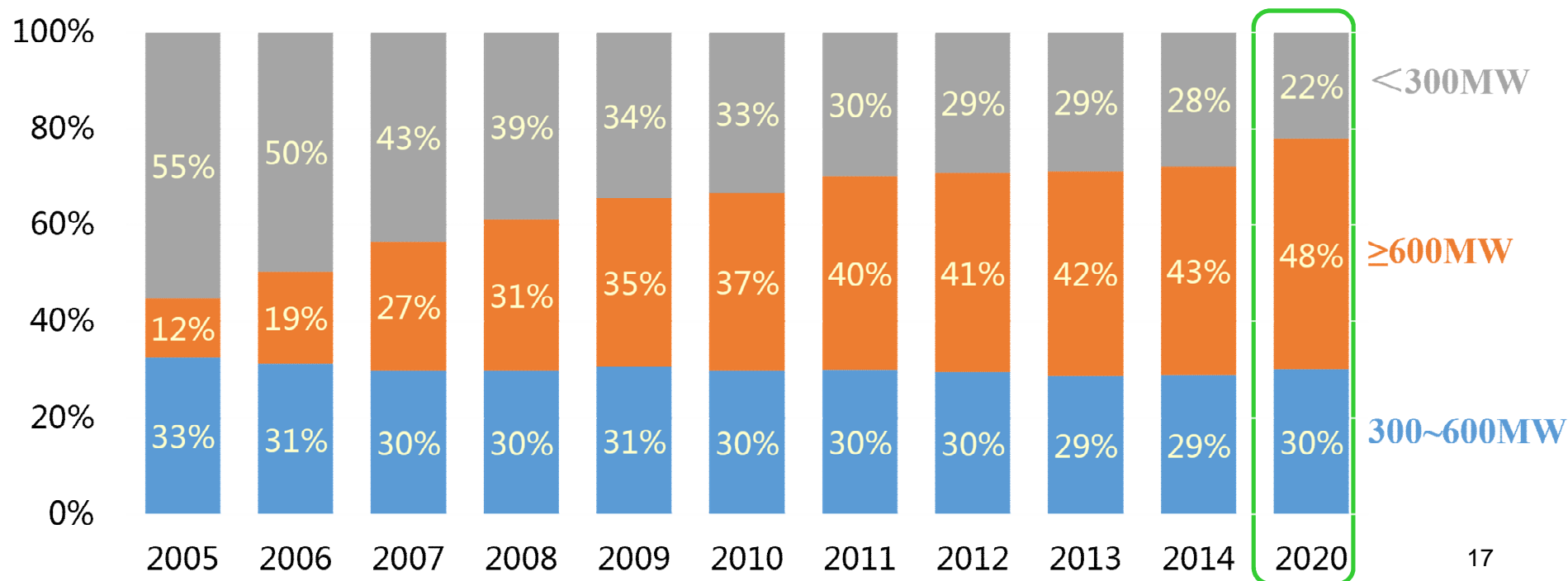
Optimization of coal-fired power structure 煤电结构优化

- The structure of China's fossil fuel power plants has been optimized by the continuous work of "Build large capacity units while shut down small ones".

近年来实施“上大压小”工作，不断淘汰落后产能，中国火电装机结构得到显著优化。

- By the end of 2014, the number of operating 600MW and above units has reached 561, among which 71 are 1000MW USB units. The total installed capacity amounted to 375.77 GW.

截至2014年底，在役600MW及以上机组561台，其中1000MW级机组71台，总容量约375.77 GW。



Status of coal-fired power generation

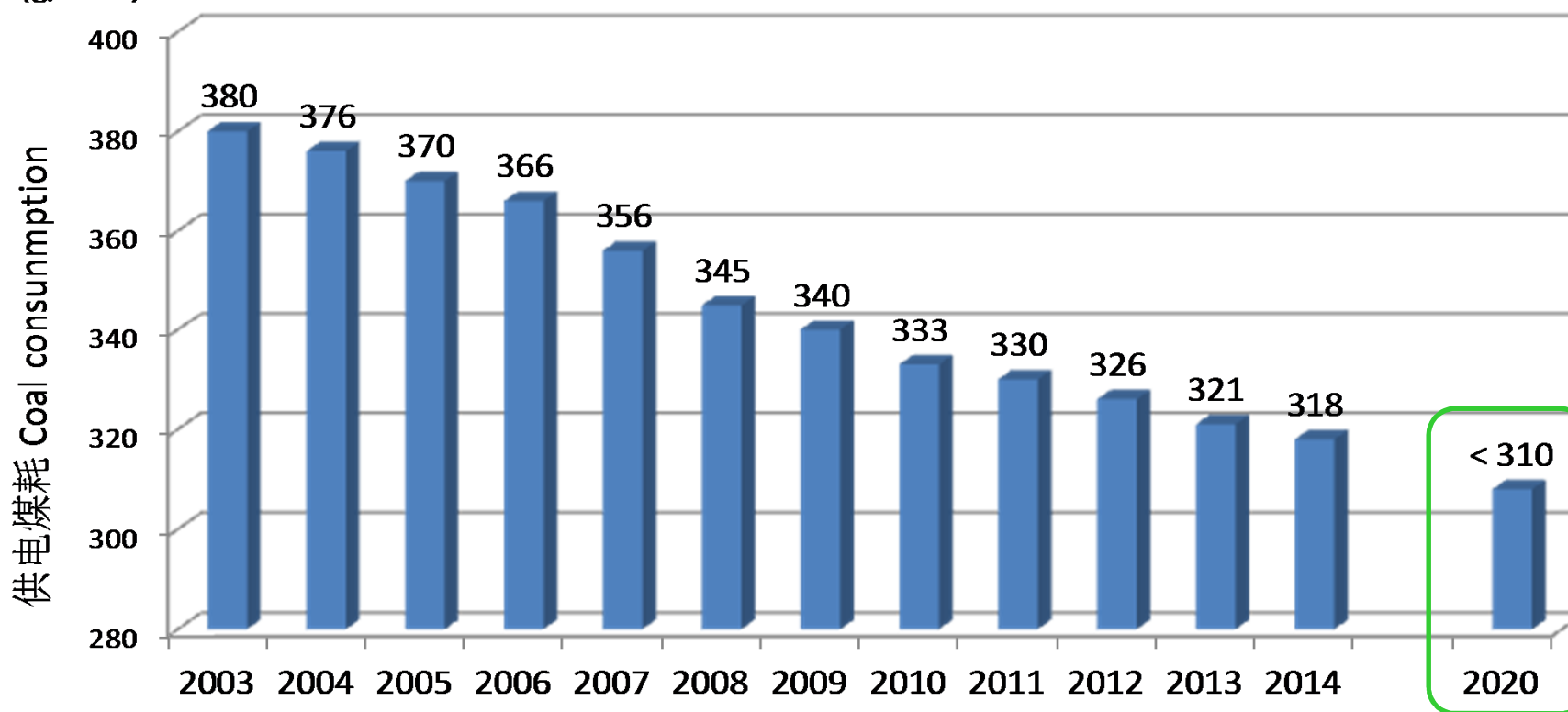
中国煤电发展现状

Development of coal-fired power generation technology 煤电效率提高

- Owing to the effective promoting technological optimization and upgrading of coal-fired power plants, the average coal consumption keeps decreasing.

由于积极推进煤电机组技术优化和升级，供电煤耗持续下降。

(g/kWh)



Annual average coal consumption for power supply by coal-fired units nationwide [Unit: g/(kw-h)]

中国煤电机组平均供电煤耗的逐年变化趋势

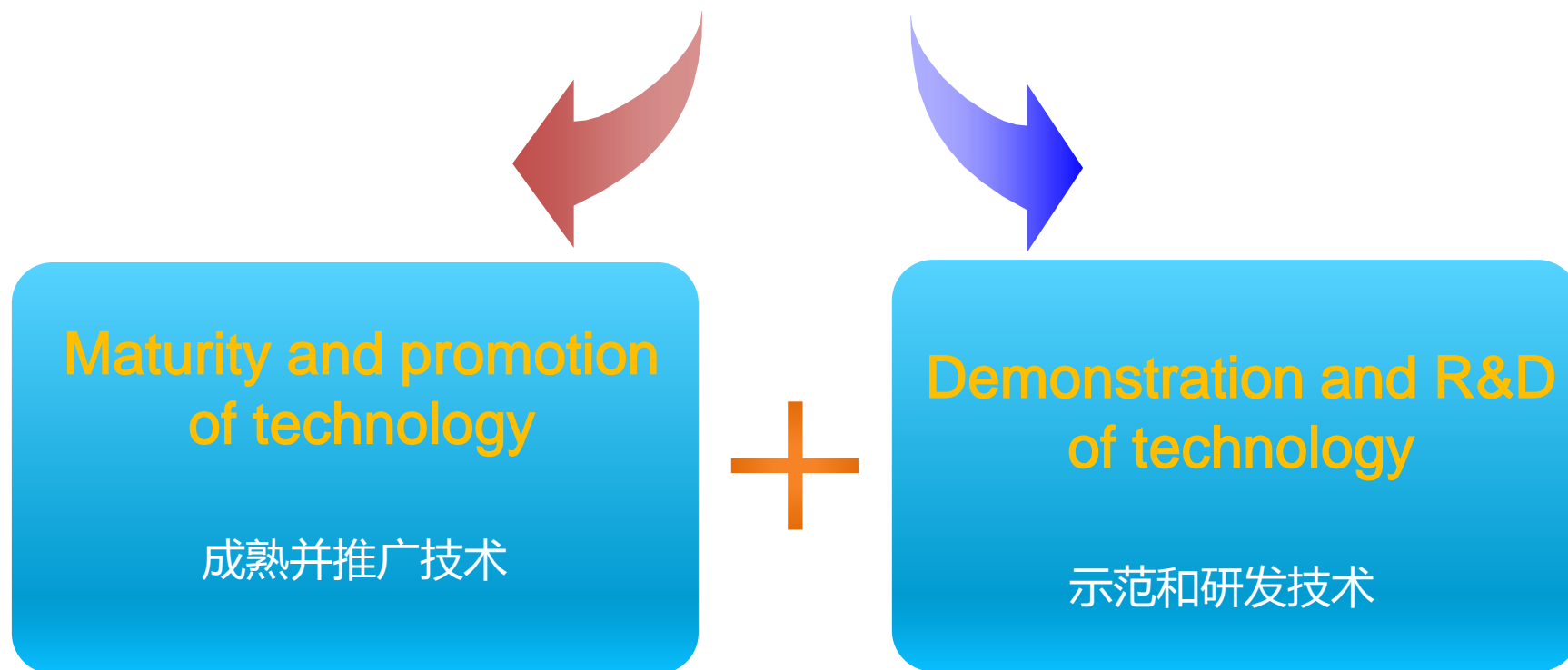
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Main technical routes

主要技术路线

Energy efficiency improvement and upgrading: Technology
燃煤清洁发电技术



Main technical routes

主要技术路线

Maturity and promotion of technology

成熟并推广技术

Energy efficiency improvement
and upgrading technology
煤电提效升级技术



Rise of steam parameters
提高机组蒸汽参数



Optimization of the heat regenerative system
优化回热系统



Cold end optimization of circulation water
循环水冷端优化



Optimization of four key pipings' design
优化四大管道设计



Recovery and utilization of flue gas waster heat;
increase of heat supply
烟气余热回收利用; 增加供热



Sealing system optimization for air preheater
优化空预器密封



Optimization of steam turbine flow path
汽轮机通流优化

Main technical routes

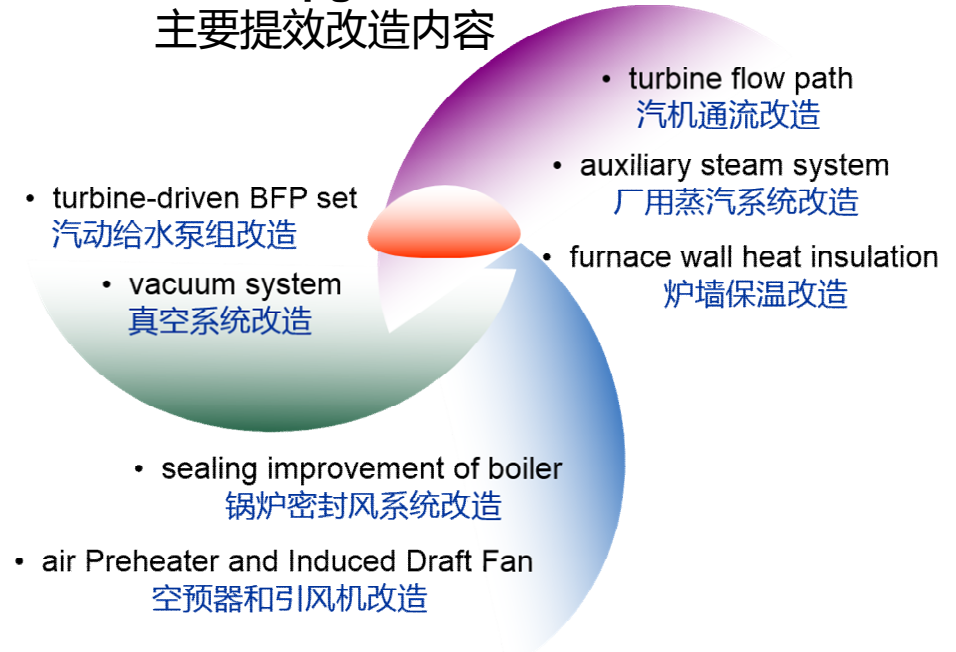
主要技术路线

Typical Project	案例
No. 2 Unit in Suizhong Power Plant	绥中电厂2号机组

- ❑ 800MW SC unit imported from Russia, put into operation in Sep. 2000
由俄罗斯引进800MW 超临界燃煤机组，2000年9月投入商业运行
- ❑ Retrofit work completed in Sep.2014
2014年9月完成升级改造



Main upgrades 主要提效改造内容



Main technical routes

主要技术路线

Typical Project	案例
No. 2 Unit in Suizhong Power Plant	绥中电厂2号机组

	Before 改造前	After 改造后	Improvement 改造后-改造前
Boiler efficiency in rated condition 额定工况锅炉效率(%)	92.11	94.67	2.56
Turbine heat rate in rated condition 额定工况汽轮机热耗率(kJ/kWh)	8414.31	7800.63	613.68
Auxiliary power rate in rated condition 额定工况发电厂用电率(%)	7.11	5.11	2.00
Coal consumption for power supply in rated (pure condensing) condition 额定、纯凝工况供电煤耗(g/kWh)	339.36	299.68	39.68

Main technical routes

主要技术路线

Demonstration and R&D of technology

示范和研发技术

□ USC power plant/double reheat 超超临界/二次再热

- Huaneng Anyuan:
2×660MW double reheat USC power plant put into operation, on 2015.06.27 and 2015.08.24, respectively.

2015年6月27日和8月24日，华能安源电厂1号、2号二次再热超超临界燃煤发电机组投产。

31MPa/600°C/620°C/620°C → 273 g/kWh



- Guodian Taizhou:
2×1000MW double reheat USC power plant, one put into operation in 2015. 9
2015年9月，国电泰州电厂3号二次再热超超临界燃煤发电机组投产。

31MPa/600°C/610°C/610°C → 266 g/kWh

Main technical routes

主要技术路线

Demonstration and R&D of technology

示范和研发技术

□ High-low location two axis STs arrangement 汽轮机高低位布置

- Shenneng: 1×1350MW double reheat USC power plant.
申能：1×1350MW，二次再热，超超临界
- Parameters : 31MPa/600°C/620°C/620°C
参数：31MPa/600°C/620°C/620°C



263 g/kWh

- By reducing the pipe length of steam and applying a lot of other energy-saving technologies, the net efficiency can be increased to as high as 46.7%
通过采用汽轮机高低位布置技术，可最大限度减少主蒸汽、再热蒸汽管道长度，减少散热损失及管道阻力，结合其它多项节能技术，预期机组净效率可高达46.7%。



Main technical routes

主要技术路线

Demonstration and R&D of technology

示范和研发技术

□ Deeply coupling ST & boiler 机炉深度耦合

- Power plant in Penglai of ZTE Electric Power Limited : 2×1000MW, double reheat, USC.
中兴蓬莱电厂：2×1000MW，二次再热，超超临界
- Parameters : 31MPa/600°C/620°C/620°C
参数：31MPa/600°C/620°C/620°C



260 g/kWh

- By reducing the difference in temperature in heat exchangers, applying flue gas-water heater、steam-air pre heater and low temperature, the net efficiency can be increased to as high as 47.2%.

通过采用机炉深度耦合技术，按照尽可能减少换热温差的原则，将锅炉尾部烟气热量与汽轮机抽汽热量统筹利用，设置烟气/给水加热器、蒸汽/空气预热器、低温省煤器等设备，预期机组净效率可高达47.2%。



Main technical routes

主要技术路线

Demonstration and R&D of technology

示范和研发技术

□ IGCC

Huaneng Tianjin IGCC demonstration project 华能天津IGCC示范电站



Commercial operation in 2012.12
2012年12月开始商业运行

- Capacity: 265MW
发电功率：265MW
- Power supply efficiency: 41%
供电效率：41%
- Coal consumption rate: 255.19g/kWh
发电煤耗：255.19g/kWh
- Efficiency of gasify furnace: 95%
气化炉热效率：95%
- Efficiency of cold gas: 84%
冷煤气效率：84%
- Carbon transformation rate: 99.2%
碳转化率：99.2%

In 2014, accumulated operating hours: 5500h; cumulative generation: 10.4×10^8 kWh
2014年累计运行超过5500小时，累计发电10.4亿千瓦时

Main technical routes

主要技术路线

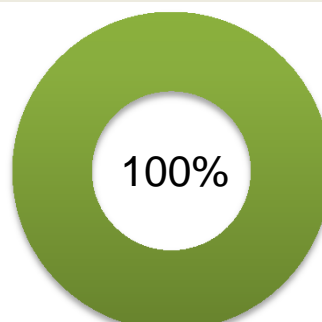
Pollution Emission Control 污染物排放



Power plants with dust removal devices%
安装除尘装置的机组%

Dust removal device
除尘装置

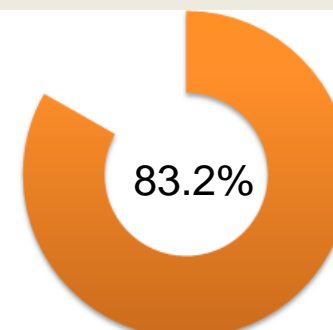
- ESP (99.30%~99.80%) 电除尘器
- ESP with high-frequency electric source/rotation electrode (99.30%~99.85%)
电除尘器+高频电源/旋转电极
- Low Low temperature ESP(99.82%~99.91%)
低低温电除尘器
- WESP (70%~80%) 湿式电除尘器



Power plants with desulfurizer%
安装脱硫装置的机组%

Desulfurizer
脱硫装置

- FGD with pallet (97.6%~98.8%)
托盘脱硫吸收系统
- FGD with Spin exchange coupling device(97.6%~98.8%)
旋汇耦合脱硫吸收系统
- FGD with double tower double cycle(98.5%~99.5%)
双塔双循环脱硫吸收系统



Power plants with SCR denitrification%
安装脱硝装置的机组%

Dust removal device
脱硝装置

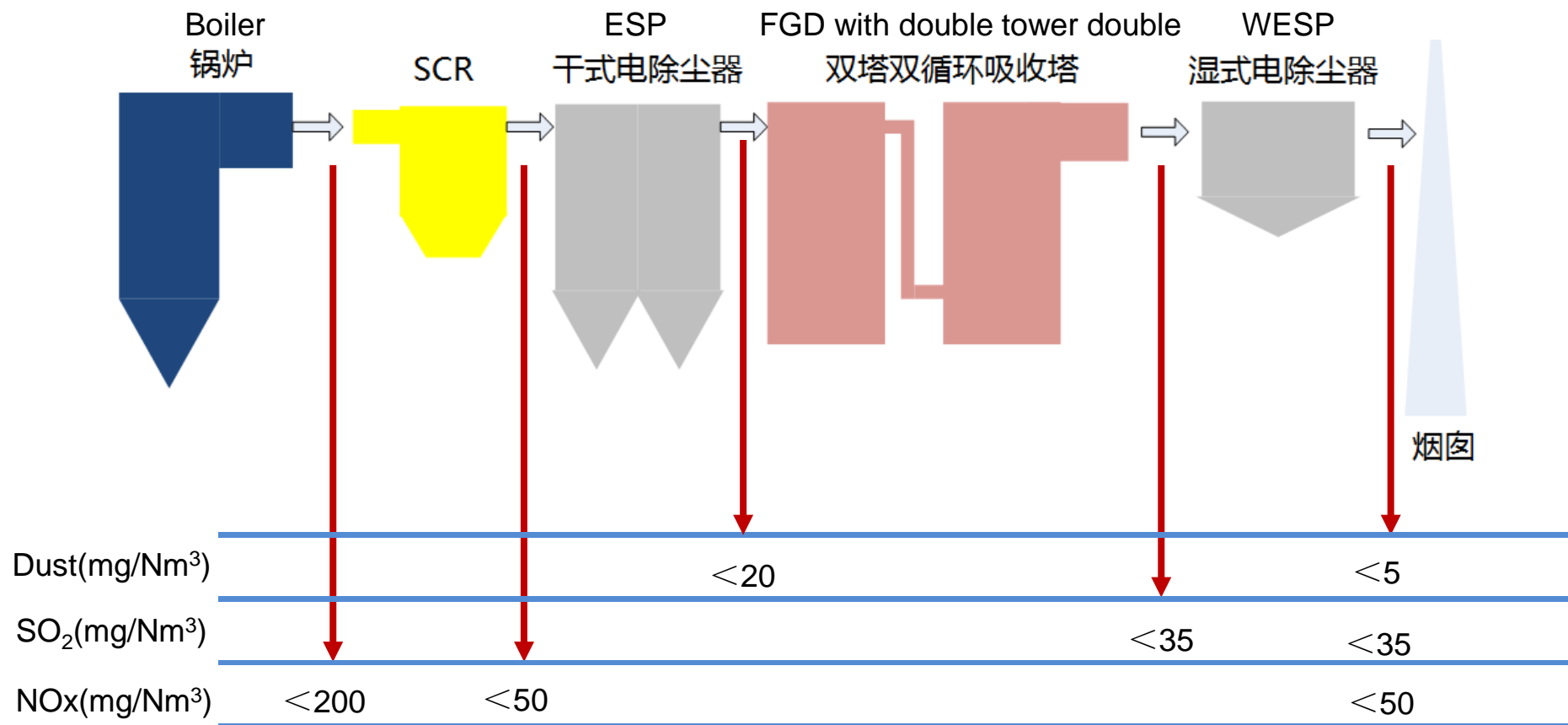
- LNB (< 120mg/Nm³)
低NO_x燃烧器
- SCR (80%~90%)
选择性催化还原系统

Main technical routes

主要技术路线

Pollution Emission Control 污染物排放

Ultra-low Emission Technical Routes of Coal-Fired Flue Gas 超低排放技术路线

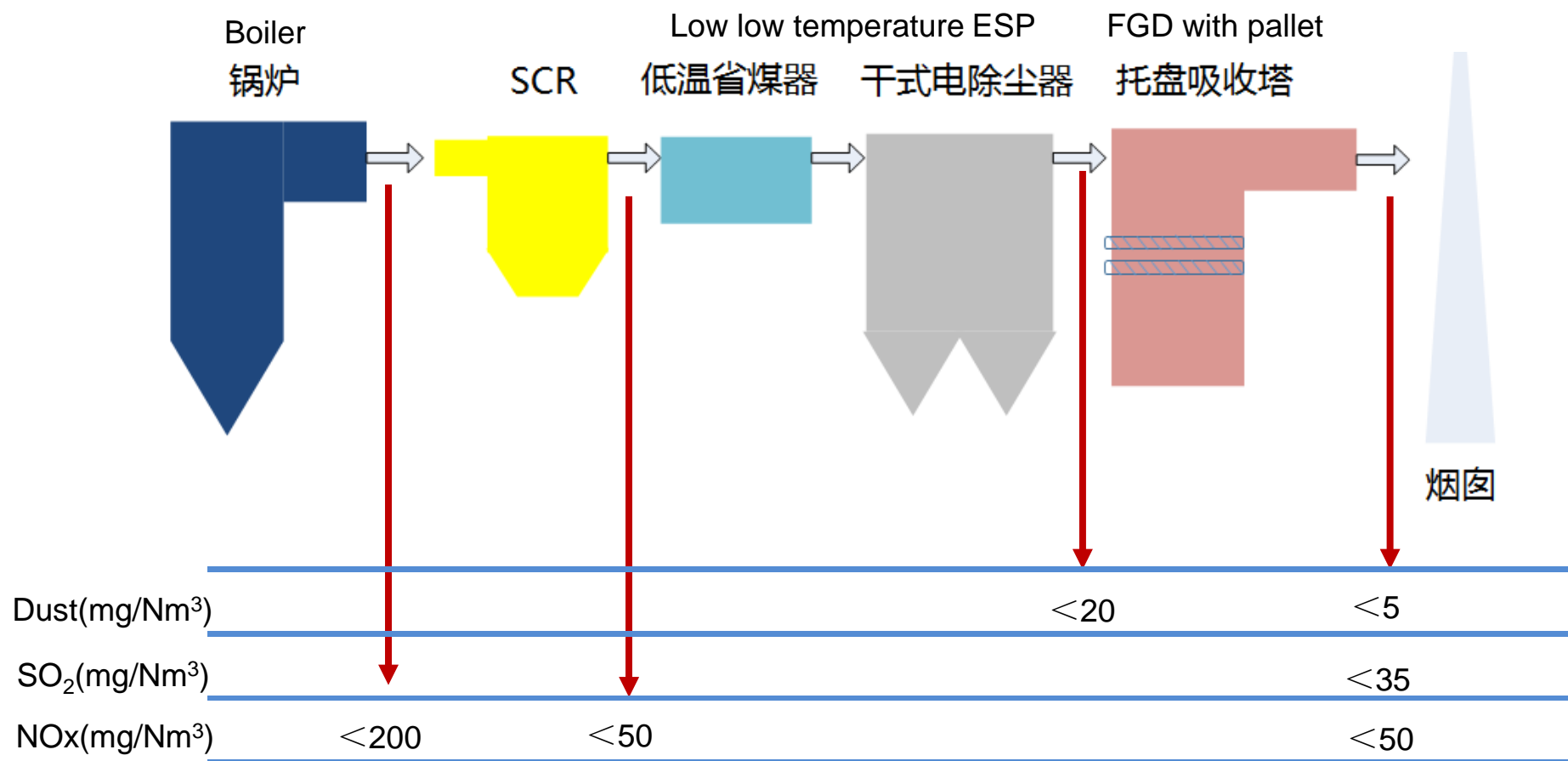


Main technical routes

主要技术路线

Pollution Emission Control 污染物排放

Ultra-low Emission Technical Routes of Coal-Fired Flue Gas 超低排放技术路线



Equipments manufacturing

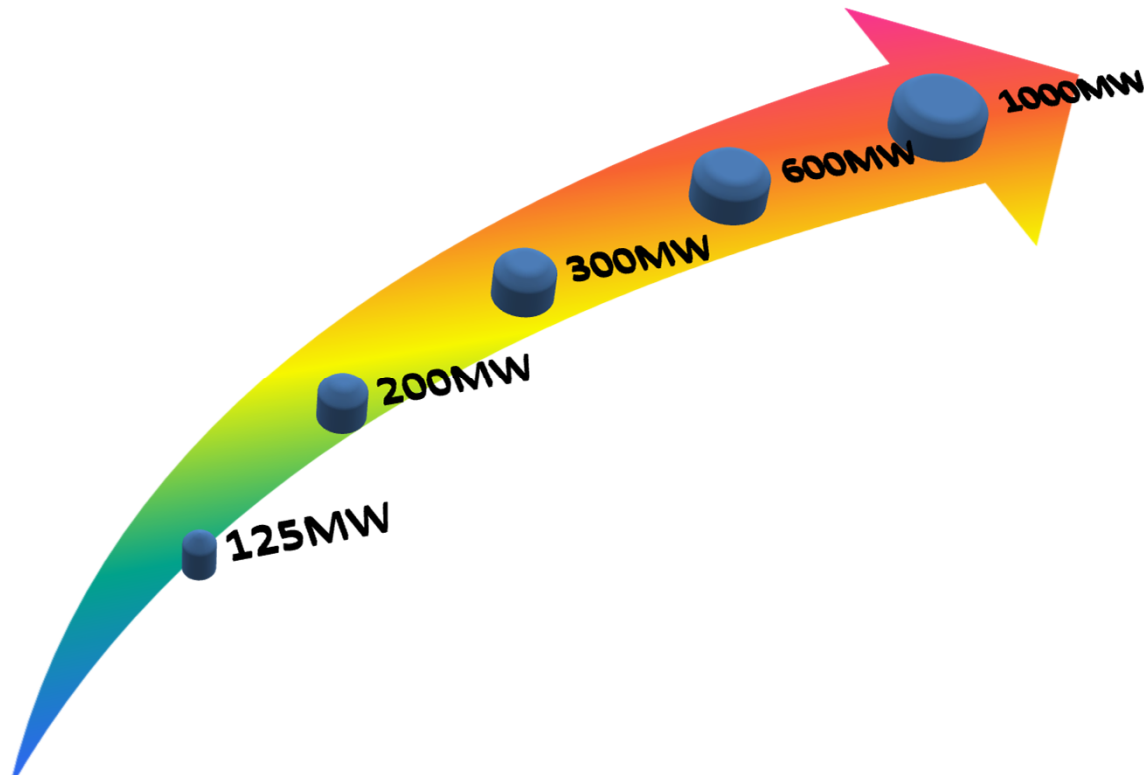
装备制造应用情况

In the past 20 years, China installed quite a lot of power generation units with different capacities and different parameters.

在过去的20年间，中国建设了一大批不同容量、不同参数的发电机组。

Today, China can manufacture almost all the equipments for coal-fired power plants except only a few core components.

除个别核心部件外，目前中国已基本具备了生产各类技术装备的能力。



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Prospective 未来工作方向

Enhance the generation efficiency of coal-fired power plant 提高煤电机组发电效率

- ❑ In principle, new-built coal-fired power generation projects should be 600MW or above USC units.

新建煤电项目原则上采用60万千瓦及以上超超临界机组

- ❑ The design value of coal consumption for power supply by 1000MW-level water-cooling and air cooling units should be no more than 282 g/KWh and 299 g/KWh, respectively.

100万千瓦级湿冷、空冷机组设计供电煤耗分别不高于282、299克/千瓦时

- ❑ The design value of coal consumption for power supply by 600MW-level water-cooling and air cooling units should be no more than 285 g/KWh and 302 g/KWh, respectively.

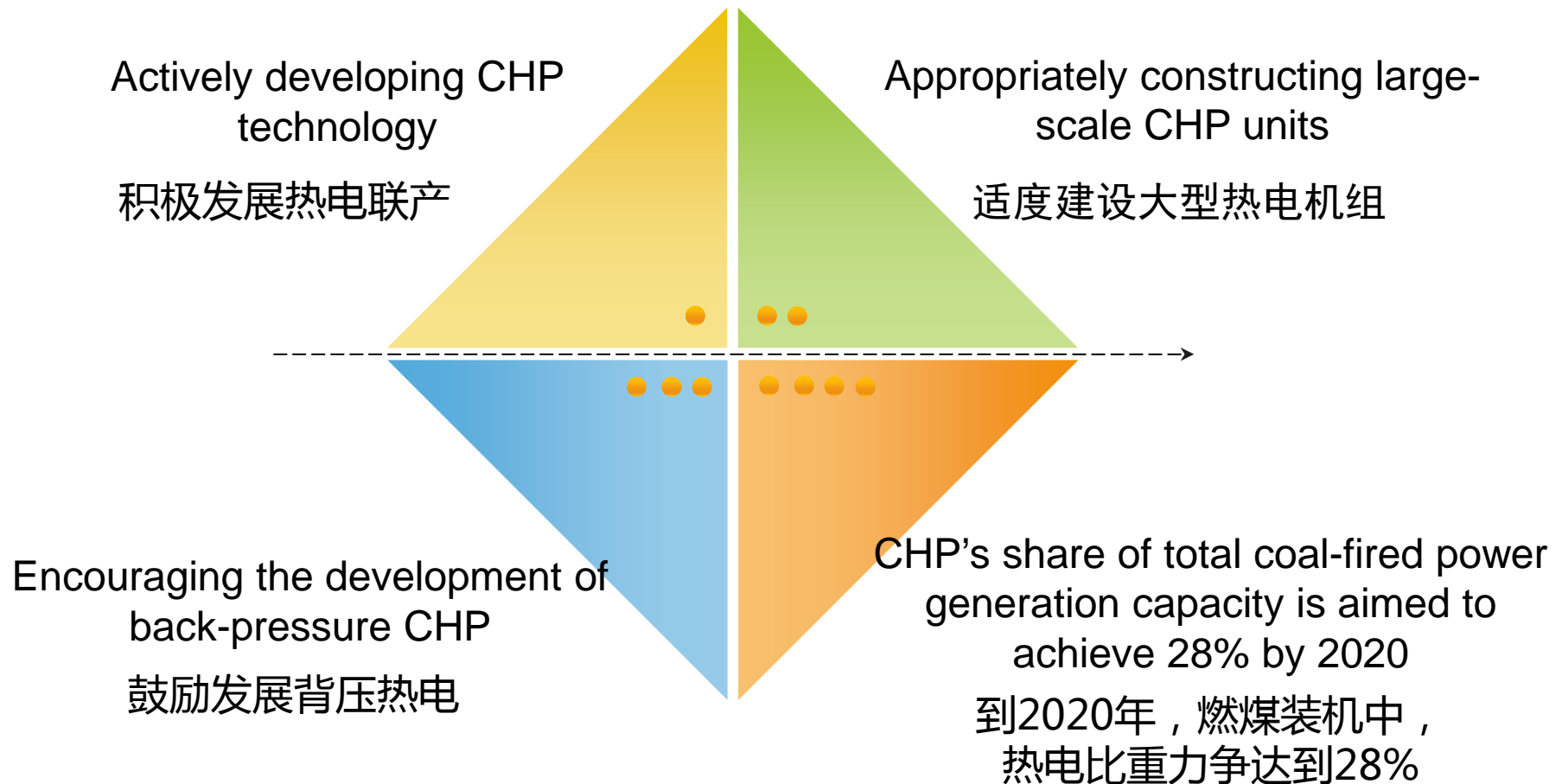
60万千瓦级湿冷、空冷机组分别不高于285、302克/千瓦时。

- ❑ In principle, heat supply units and CFB units which are burning low heat-value coal with the capacity of 300MW or above should be Supercritical units .

30万千瓦及以上供热机组和循环流化床低热值煤发电机组原则上采用超临界参数

Prospective 未来工作方向

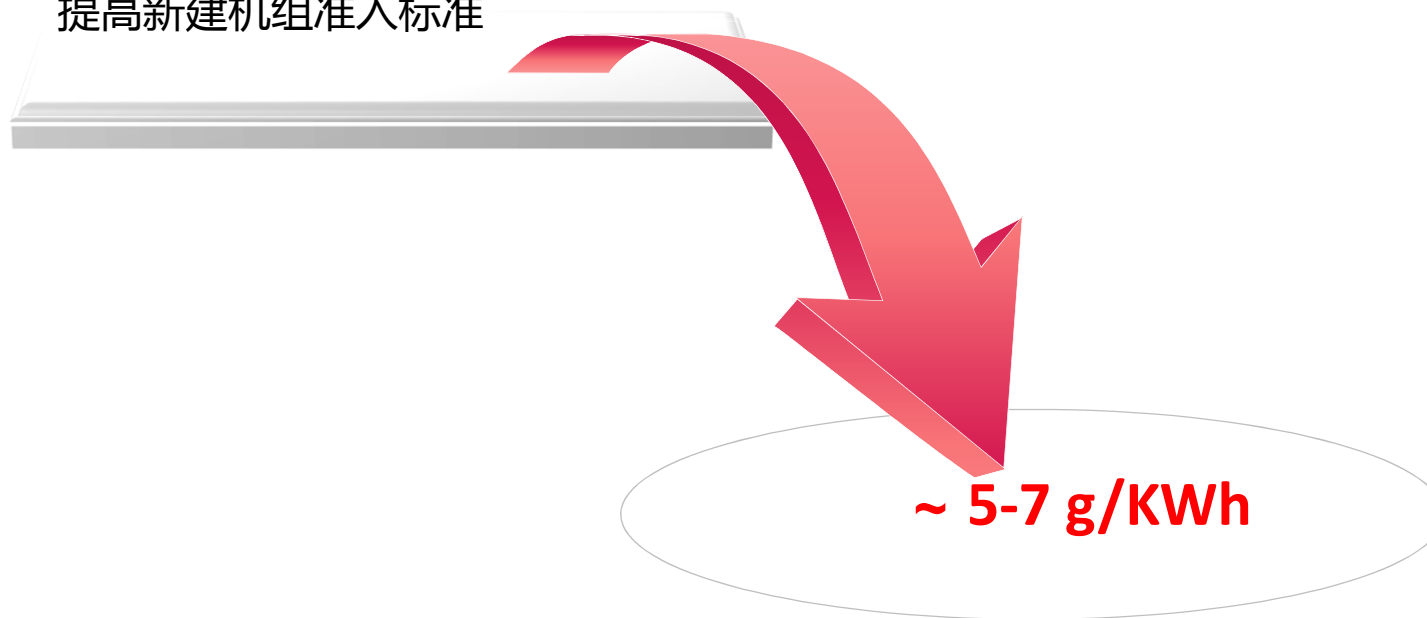
Enhance the generation efficiency of coal-fired power plant
提高煤电机组发电效率



Prospective 未来工作方向

Enhance the generation efficiency of coal-fired power plant
提高煤电机组发电效率

By raising access standards of new-built units
提高新建机组准入标准



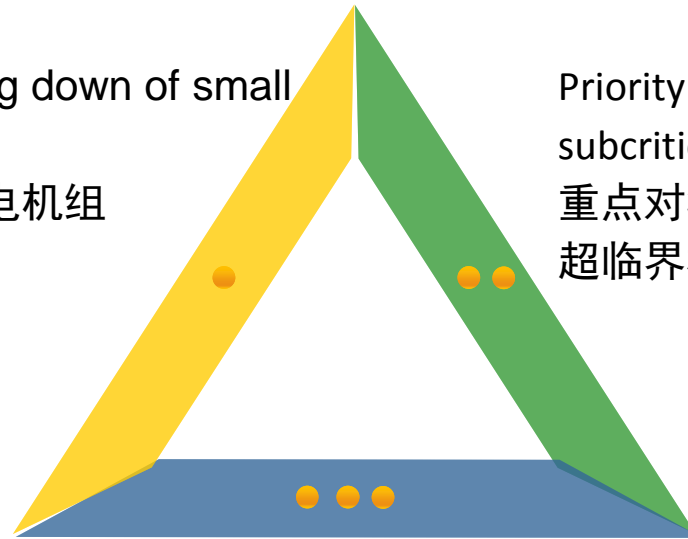
Average coal consumption for power supply nationwide is expected to decrease ~ 5-7 g/KWh
预计可实现全国平均供电煤耗降低~5-7克/千瓦时

Prospective 未来工作方向

Enhance the generation efficiency of coal-fired power plant
提高煤电机组发电效率

Accelerating the shutting down of small coal-fired unit
加快淘汰能耗高的小火电机组

Priority to upgrade 300MW and 600MW subcritical and supercritical units
重点对30万千瓦和60万千瓦等级亚临界、超临界机组实施提效改造



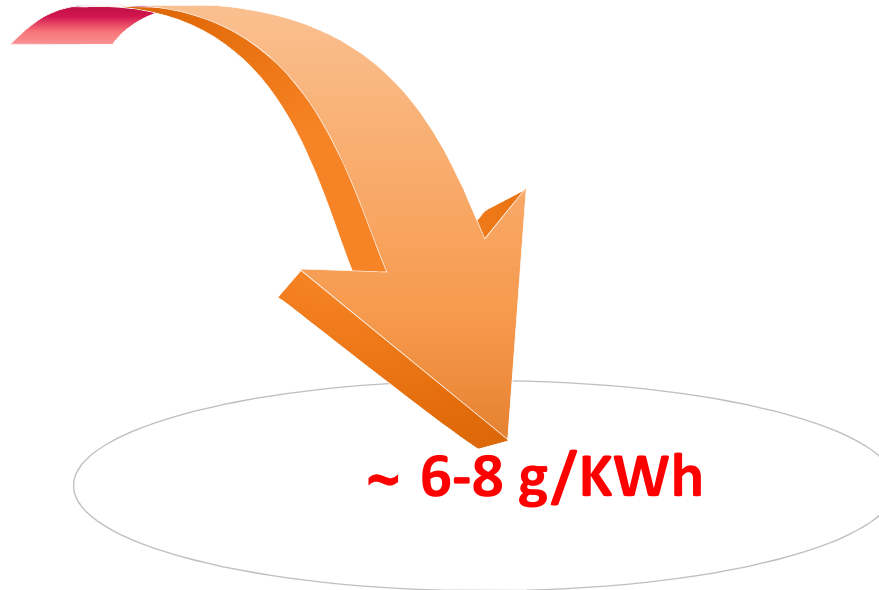
Retrofitting of condensing units $\leq 200\text{MW}$ should focus on heat supply retrofit, and back-pressure heat supply unit should be the priority selection.

20万千瓦级及以下纯凝机组重点实施供热改造，优先改造为背压式供热机组

Prospective 未来工作方向

Enhance the generation efficiency of coal-fired power plant
提高煤电机组发电效率

By energy efficiency upgrading of operating units
在役燃煤机组能效升级改造

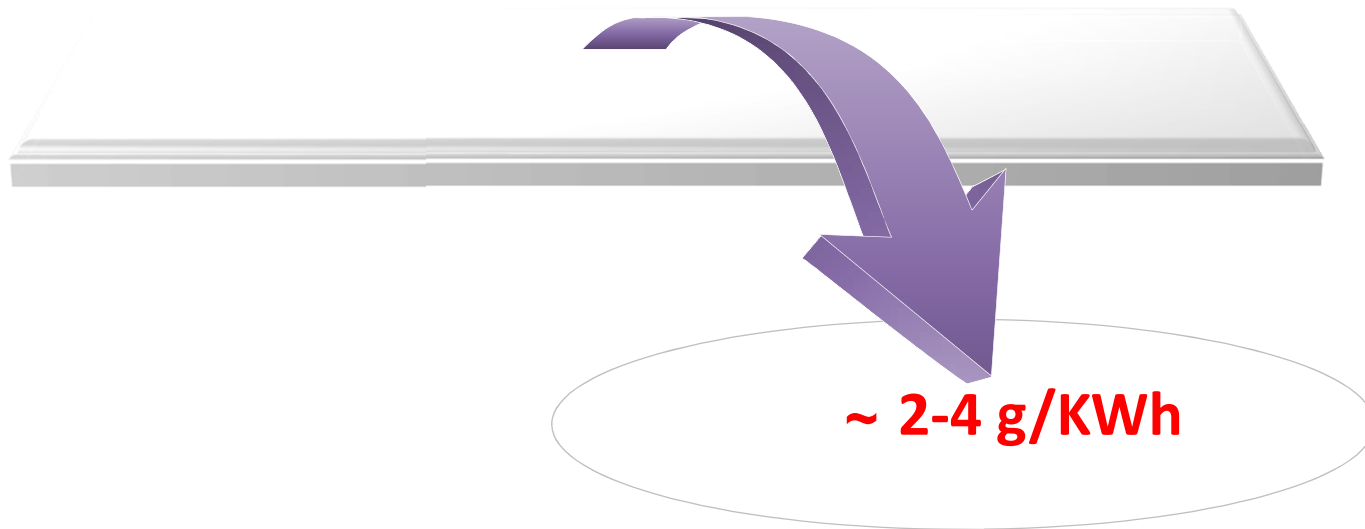


Average coal consumption for power supply nationwide is expected to decrease ~ 6-8 g/KWh
可实现全国平均供电煤耗降低~6-8克/千瓦时

Prospective 未来工作方向

Enhance the generation efficiency of coal-fired power plant
提高煤电机组发电效率

Implementing energy-saving dispatching in order to
improve the load rate of high-efficient coal-fired units
实施节能发电调度，提高高效煤电机组负荷率

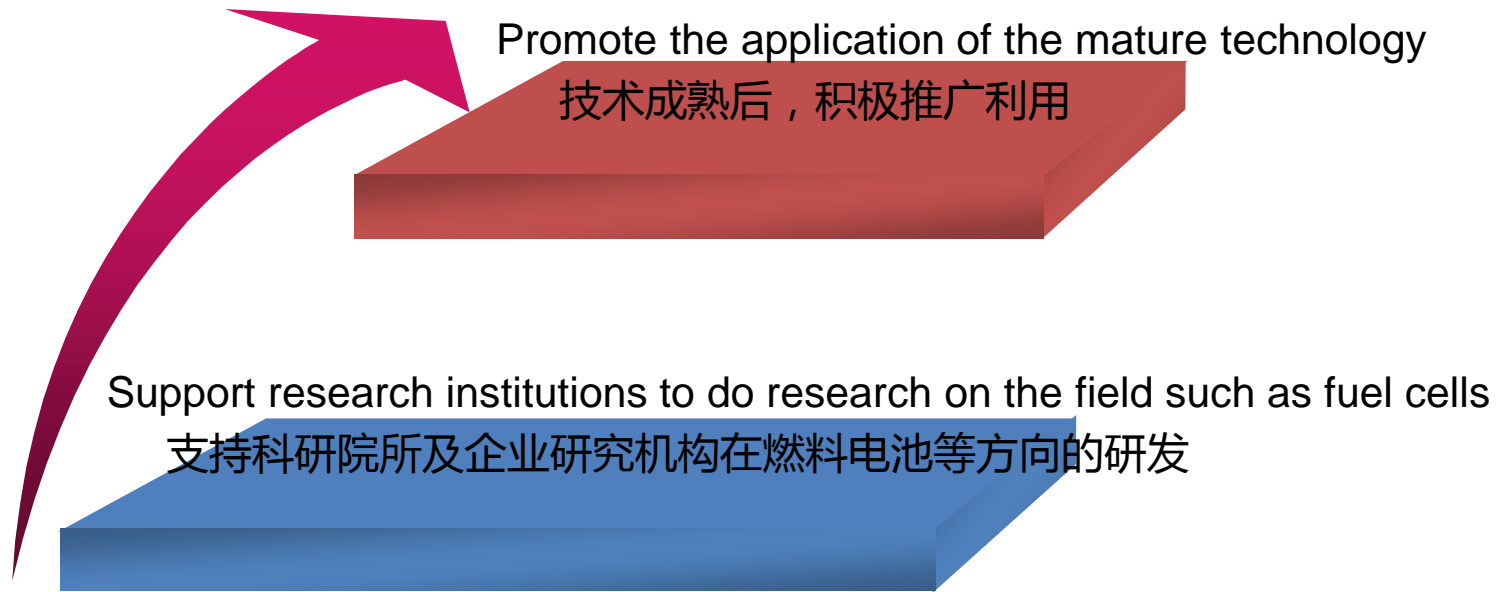


Average coal consumption for power supply nationwide is
expected to decrease ~ 2-4 g/KWh
可实现全国平均供电煤耗降低~2-4克/千瓦时

Prospective 未来工作方向

Support the research and application of efficient utilization methods of coal such as fuel cells

积极支持燃料电池等高效煤炭利用方式的研发和应用



Thanks for your attention!