

双碳战略下中国煤电低碳化转型政策与行动

Low-carbon Transformation of China's Coal Power under the “Dual Carbon” Strategy: Policies and Actions

Dr. *YI Ye and Dr. BO Yu

Power Generation Engineering Consultancy Department
China Electric Power Planning and Engineering Institute

September 2, 2024

目录 CONTENTS

一 Introduction to Chinese Coal-fired Power Industry

二 Policies and Actions under the “Dual Carbon” Goals

三 Future of Chinese Coal-fired Power Industry

目录 CONTENTS

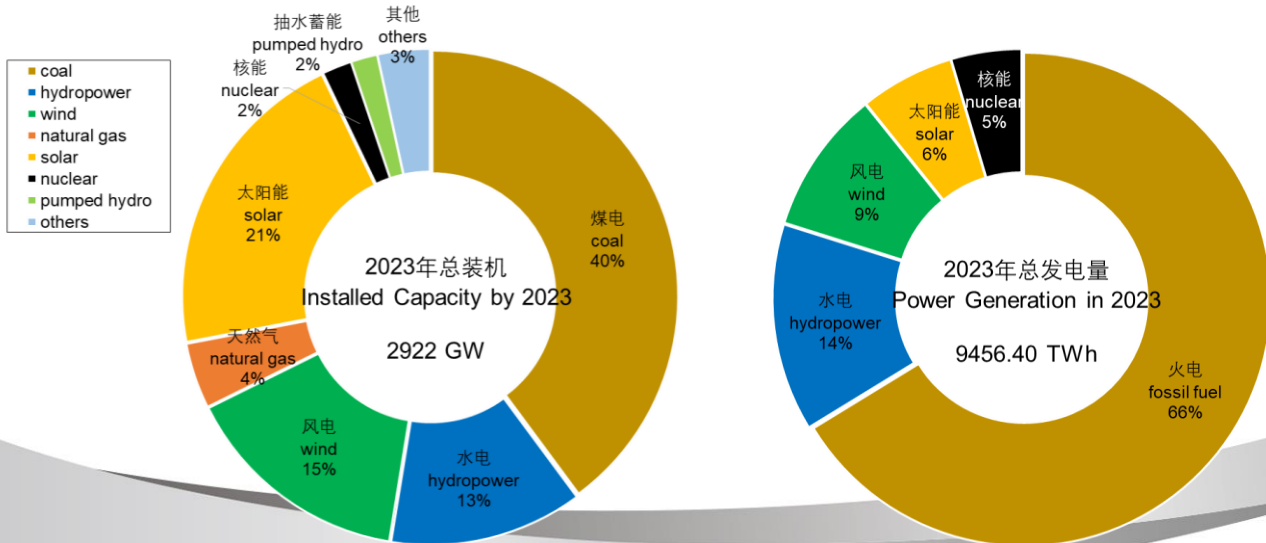
一 Introduction to Chinese Coal-fired Power Industry

二 Policies and Actions under the “Dual Carbon” Goals

三 Future of Chinese Coal-fired Power Industry

1. Coal-fired Power: installed capacity and power generation

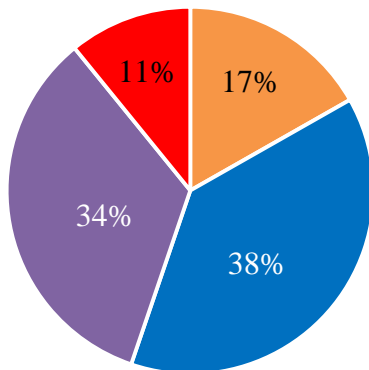
- 2023年煤电装机1165吉瓦，发电5379太瓦时。煤电装机占比、发电量占比逐年下降。2023年，煤电装机占比为39.9%，首次降低到40%以下（2014年为60.9%），煤电发电量占比57.9%（2014年为70.9%）。
- Coal-fired power: generated 5379 TWh electricity with a capacity of 1165 GW in 2023. Installed capacity share and power generation ratio are decreasing year by year, which fell from 60.9% and 70.9% to 39.9% (lowest in history) and 57.9% during 2014-2023.



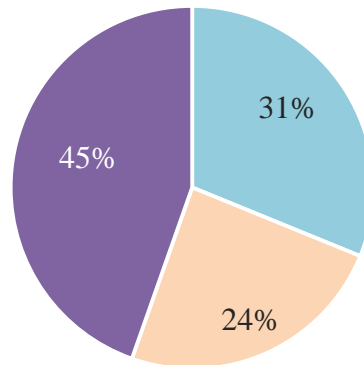
Installed Capacity (left) and Power Generation Mix (right) in 2023

1. Coal-fired Power: unit size and steam type

- 现役煤电机组：单机参数高，容量大。2023年超超临界和超临界机组占比合计69%；60万及以上机组占比55%。
- Coal Power Fleet in 2023: high efficiency and large-scale units take up more than half of the coal fleet.
 - Steam type: ultra-supercritical, 31%; supercritical, 24%; subcritical and below, 45%
 - Unit size: ≥ 1 GW, 17%; 600-1000 MW, 38%; 300-600 MW, 34%; < 300 MW, 11%



- 100万及以上 (≥ 1000 MW)
- 60-100万 (600-1000MW)
- 30-60万 (300-600MW)
- 30万以下 (< 300 MW)



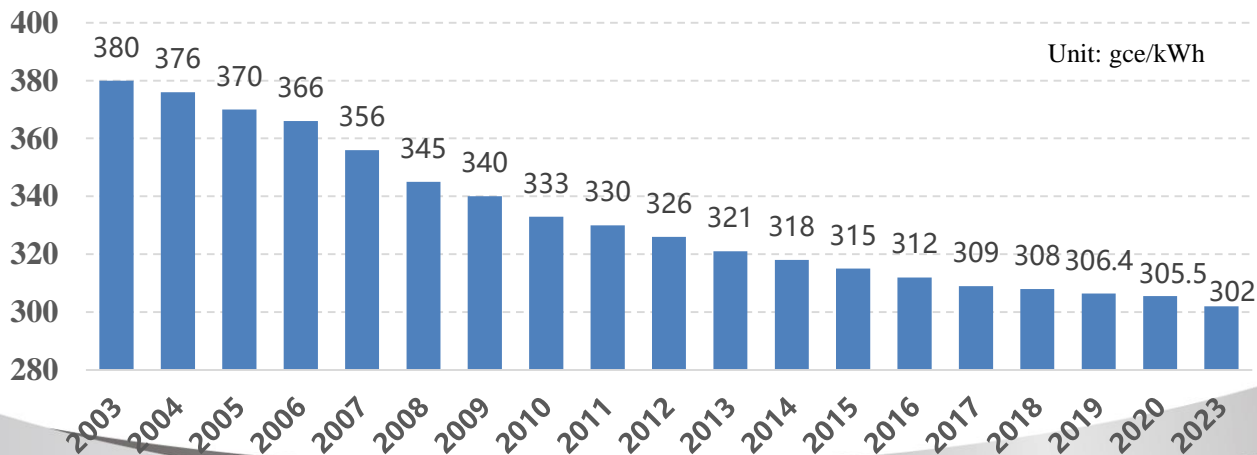
- 超超临界 Ultra-supercritical
- 超临界 Supercritical
- 亚临界及以下 Subcritical and below

煤电机组容量分类占比(左)、参数分类占比(右)

The Composition of China's Coal Power Fleet showing Unit Size(left) and Steam Type(right) in 2023

1. Coal-fired Power: low-emission

- 中国已建成全球最大清洁煤电供应体系。6000千瓦及以上电厂平均供电煤耗从2003年的380克标煤/千瓦时下降到2023年的302克标煤/千瓦时。
- **China has built the world's largest clean coal-fired power supply system.** The average coal consumption rate for power supply from plants with a capacity of over 6MW gradually declined from **380 gce/kWh** in 2003 to **302 gce/kWh** in 2023.

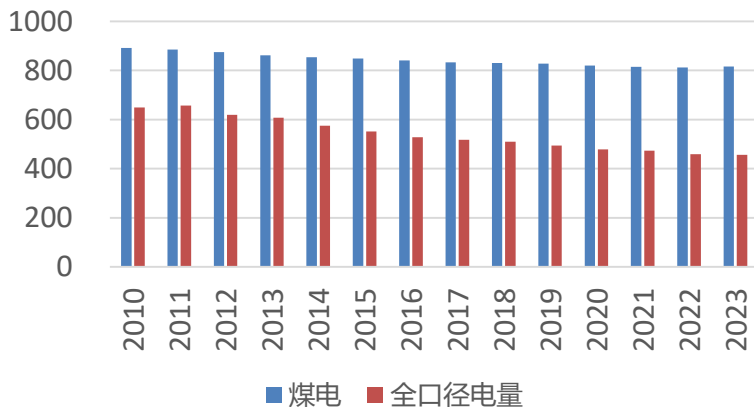


2003-2023年煤电平均供电煤耗
Average Coal Consumption Rate for Power Supply (2003-2023)

1. Coal-fired Power: low-emission

- 度电碳排放持续降低。但仅优于日本，次于欧美国家，仍有较大提升空间。
- The carbon emission factor is **decreasing over time**, however, it is still much higher than that of the Western countries and **needs improvement**.

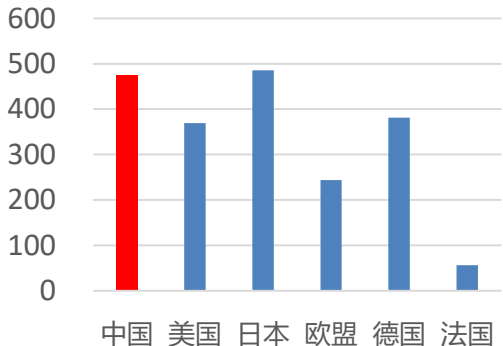
Unit: g-CO₂/kWh



Coal-fired Power Power Sector

煤电及全口径发电量度电碳排放
Carbon Emission Factor of the Coal-fired Power
and Power Sector

Unit: g-CO₂/kWh

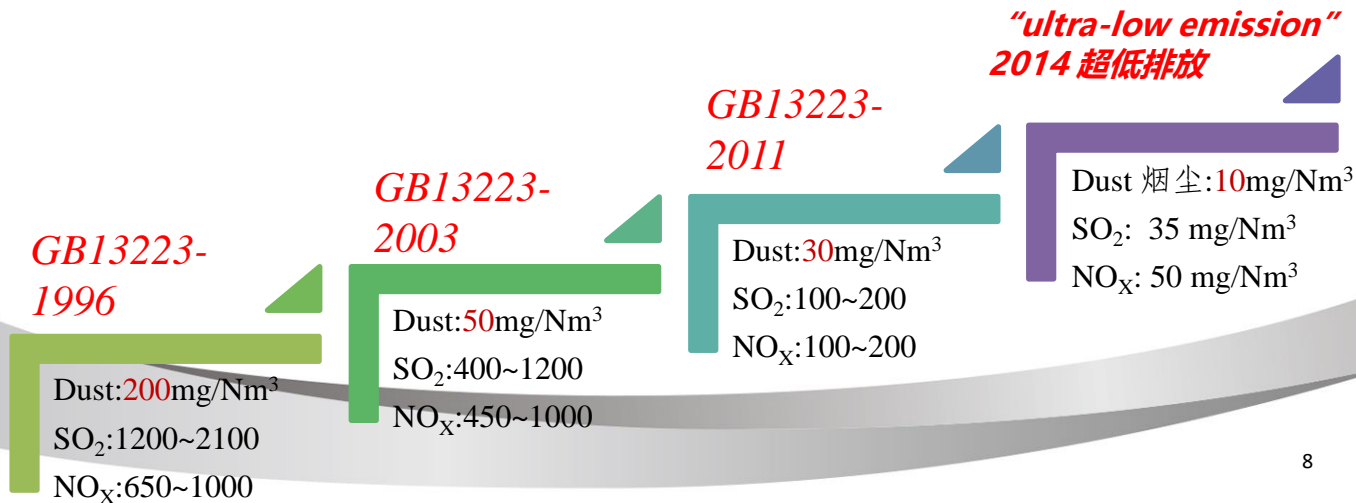


China U.S. Japan EU Germany France

各国全口径发电量度电碳排放比较
Comparison of Carbon Emission Factor of the
Power Sector

1. Coal-fired Power: low-emission

- 中国燃煤电厂超低排放标准已经是世界上最严格的排放标准。
- Emission standards for air pollutants from coal-fired power plants have been tightened over the years. China's ultra-low emission standards are one of the most rigorous in the world.
- 2023年烟尘、二氧化硫、NO_x排放分别为0.017g/kWh、0.083g/kWh、0.133g/kWh，比2014年分别下降95%、95.5%、93%。
- In 2023, emissions of dust, SO₂, and NO_x were 0.017g/kWh, 0.083g/kWh, and 0.133g/kWh, respectively, which was 95%, 95.5%, and 93% lower than that of 2014.



目录 CONTENTS

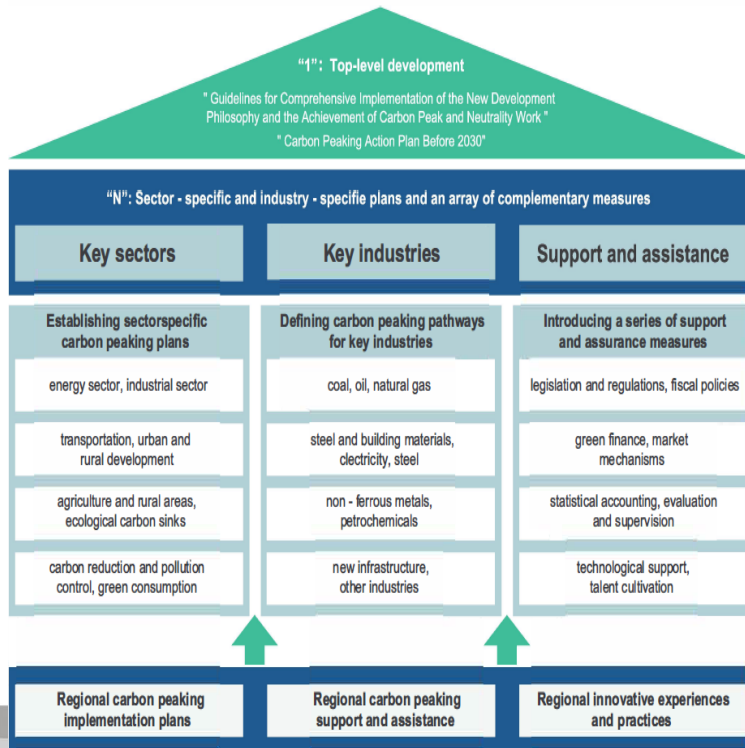
一 Introduction to Chinese Coal-fired Power Industry

二 Policies and Actions under the “Dual Carbon” Goals

三 Future of Chinese Coal-fired Power Industry

2. Policies on Achieving the “Dual Carbon” Goals

- 双碳目标：2030年前尽早达峰，2060年实现碳中和
- Dual Carbon Goals: to peak China’s carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060
- 为达成双碳目标，中国构建起目标明确、措施有力的碳达峰碳中和 “1+N”政策体系。
- Dual Carbon Goals: has established a clear and robust **"1+N" policy framework** to gradually achieve the dual carbon goals.
- The "1" refers to the *"Guidelines for Comprehensive Implementation of New Development Philosophy and the Achievement of Carbon Peaking and Carbon Neutrality Work"* (2021) and the *"Action Plan for Carbon Peaking Before 2030"* (2021) issued at the national level, which are the top-level designs of the entire policy system.
- The "N" represents the ministry-level implementation plans for carbon peaking in key sectors and industries, as well as a series of supporting and assistance measures.



- 在2021年10月公布的《2030年前碳达峰行动方案》中，明确提出了“能源绿色低碳转型行动”。该行动包含了6个方面：推进煤炭消费替代和转型升级、大力发展新能源、因地制宜开发水电、积极安全有序发展核电、合理调控油气消费和加快建设新型电力系统。
- China has clearly proposed 6 actions related to the green and low-carbon energy transformation in the "*Action Plan for Carbon Peaking Before 2030*" issued in Oct. 2021, which includes:
 - ① **Advancing the substitution and transformational upgrading of coal consumption.** Strictly and reasonably control the growth of coal consumption; strictly control the addition of new coal power projects, orderly phase out outdated coal power units, accelerate the energy-saving and flexibility transformation of existing units, promote heating transformation, and drive the transformation of coal power towards both basic guarantee and system regulation power sources. Promote the reduction and limitation of coal use in key coal-consuming industries.
 - ② **Vigorously develop new energy sources.**
 - ③ **Develop hydropower according to local conditions.**
 - ④ **Actively, safely, and orderly develop nuclear power.**
 - ⑤ **Reasonably regulate the consumption of oil and gas.**
 - ⑥ **Accelerating the construction of a new type of power system.**

2. Action Plan for Low-carbon Retrofit and Construction of Coal-fired Power Plants

- 2024年7月，国家发展和改革委员会和国家能源局印发了《煤电低碳化改造建设行动方案（2024-2027年）》，统筹推进存量煤电机组低碳化改造和新上煤电机组低碳化建设，以提升煤炭清洁高效利用水平，加快构建清洁低碳安全高效的新型能源体系，助力实现碳达峰碳中和目标。
- In July of 2024, the National Development and Reform Commission (NRDC) and National Energy Administration (NEA) jointly released the “*Action Plan for Low-carbon Retrofit and Construction of Coal-fired Power Plants*” (2024-2027) to promote and guide the low-carbon retrofit of existing coal fleet and newly construction of coal power plants.

国家发展和改革委员会 国家能源局文件

发改环资〔2024〕894号

国家发展改革委 国家能源局关于印发 《煤电低碳化改造建设行动方案 (2024—2027年)》的通知

为全面贯彻党的二十大精神，认真落实党中央、国务院决策部署，加大节能降碳工作力度，统筹推进存量煤电机组低碳化改造和新上煤电机组低碳化建设，加快构建清洁低碳安全高效的新型能源体系，助力实现碳达峰碳中和目标，国家发展改革委、国家能源局制定了《煤电低碳化改造建设行动方案（2024—2027年）》。

— 1 —

2. Action Plan for Low-carbon Retrofit and Construction of Coal-fired Power Plants: targets

- 《煤电低碳化改造建设行动方案》目标：
 - 到2025年，首批煤电低碳化改造建设项目全部开工；度电碳排放相较2023年同类机组平均碳排放水平降低20%左右，显著低于现役先进煤电机组
 - 到2027年，建造和运行成本显著下降；度电碳排放相较2023年同类机组平均碳排放水平降低50%左右，接近天然气发电机组碳排放水平
- **Targets** of “Action Plan for Low-carbon Retrofit and Construction of Coal-fired Power Plants”:

By 2025

- Start Construction of the first batch of retrofitted projects
- The carbon intensity of these retrofitted plants should be 20% lower than that of the average of the same level

By 2027

- Significant cost reduction
- The carbon intensity of these retrofitted plants should be 50% lower than that of the average of the same level, approaching that of the gas-fired power plants

2. Action Plan for Low-carbon Retrofit and Construction of Coal-fired Power Plants: three measures

- 《煤电低碳化改造建设行动方案》改造和建设方式：
 - 生物质掺烧。改造后煤电机组应具备掺烧10%以上生物质燃料能力
 - 绿氨掺烧。改造后煤电机组应具备掺烧10%以上绿氨燃料能力
 - 碳捕集利用与封存。CO₂高效驱油、CO₂加氢制甲醇、CO₂地质封存。
- **Three measures** encouraged in “*Action Plan for Low-carbon Retrofit and Construction of Coal-fired Power Plants*”

Biomass Co-firing

- Full use of agricultural and forestry residues, psammophyte, energy plants, etc.
- Retrofitted plant should be able to co-fire 10% or more biomass with coal

Ammonia Co-firing

- Produce green ammonia with surplus renewable electricity
- Retrofitted plant should be able to co-fire 10% or more ammonia with coal

CCUS

- Capture CO₂ after coal combustion
- CO₂ utilization and storage: CO₂ Enhanced Oil Recovery, methanol production, storage in a suitable location, etc..

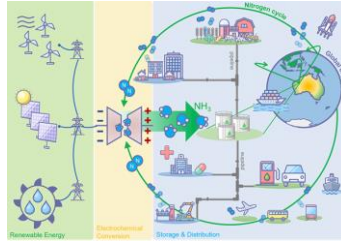
2. Action Plan for Low-carbon Retrofit and Construction of Coal-fired Power Plants: requirements for plant location

- **项目布局** 优先支持在可再生能源资源富集、绿色电力需求旺盛、经济承受能力强、地质条件适宜的地区实施煤电低碳化工程建设项目。优先支持采用多种技术路线耦合的项目建设。
- **Location of selected projects:** to locate in **well-developed** areas or areas that has **abundant renewable resources, high green electricity needs, or suitable geographical conditions.** Programs carrying on various retrofitting methods are preferred and encouraged.



**Biomass
Co-firing**

Stable long-term access to agricultural and forestry residues, psammophyte, energy plants, or other biomass resources



**Ammonia
Co-firing**

Reliable ammonia resources, including abundant renewable resources to produce green ammonia



CCUS

Significant CO₂ consumption or suitable locations for CO₂ storage

2. Action Plan for Low-carbon Retrofit and Construction of Coal-fired Power Plants: requirements for plant

- **机组条件** 实施低碳化改造建设的煤电机组应满足预期**剩余使用寿命长、综合经济性好**等基本条件，新上煤电机组须为**已纳入国家规划**内建设项目。
- **Plant Condition:** select existing plants which has a **long remaining lifetime and good financial behavior** or newly built plants that are **already included in the national construction plan.**
- **降碳效果** 2025年建成项目度电碳排放应显著低于自身改造前水平或显著优于现役先进水平，并较 2023 年同类煤电机组平均碳排放水平降低 **20%**左右。2027年建成项目，度电碳排放应较 2023 年同类机组平均降低 **50%**左右、接近天然气发电机组碳排放水平。同等条件下，优先支持度电碳排放更低、技术经济性更好的项目。
- **Carbon Reduction Level:** the carbon intensity of selected projects should be 20% lower than that of the same level plant before retrofit by 2025. The carbon intensity of selected projects should be 50% lower than that of the same level plant before retrofit by 2027. Projects having **less carbon emission and better financial behavior** are prioritized.

2. Action Plan for Low-carbon Retrofit and Construction of Coal-fired Power Plants: supporting measures

- **保障措施**
加大资金支持力度、强化政策支撑保障、优化电网运行调度、加强技术创新应用。
- **Four Supporting Measures**



2. Application of Co-firing Biomass

• 典型项目

采用气化耦合：湖北华电襄阳电厂6号机组；采用直燃耦合：华能日照电厂4号机组。

• Typical projects:



湖北华电襄阳电厂耦合生物质发电项目
Xiangyang Project in Hubei

- ❑ Co-firing: gasified biomass
- ❑ Electrical Power of Unit 6: 600 MW
Biomass: 10.8 MW
- ❑ Co-firing ratio: 1.68%
- ❑ Annual CO₂ emission reduction: ~50,000 t
- ❑ Start Operation: Sep. 2018



华能日照电厂耦合生物质发电项目
Rizhao Project in Shandong

- ❑ Co-firing: direct combustion of biomass
- ❑ Electrical Power of Unit 4: 680 MW
Biomass: 34 MW
- ❑ Co-firing ratio: 5%
- ❑ Annual CO₂ emission reduction: ~140,000 t
- ❑ Start Operation: Nov. 2022

2. Application of Co-firing Ammonia

• 典型项目

皖能铜陵电厂300MW机组掺氨燃烧项目、神华台山电厂600MW机组掺氨燃烧项目。

• Typical projects:



皖能铜陵电厂300MW机组掺氨燃烧项目
Tongling Project in Anhui

- ❑ Maximum ratio of co-firing ammonia: 35% with a load below 100 MW
- ❑ Burn-up of ammonia: 99.99%
- ❑ Combustion Type: pure ammonia
- ❑ Start Operation: Jun. 2022



神华台山电厂600MW机组掺氨燃烧项目
Taishan Project in Guangdong

- ❑ Maximum ratio of co-firing ammonia: 20% under various loads
- ❑ Burn-up of ammonia: 99.99%
- ❑ Combustion Type: ammonia-coal co-firing
- ❑ Start Operation: Dec. 2023

2. Application of CCUS

• Typical projects:

华能北京热电厂
CO₂捕集示范项目

Beijing CHP power plant,
CO₂ capture demo project

Start Operation: July 2008
2008年7月投运

Capacity: 3000 t/a
规模: 3000 吨/年

华能石洞口二厂
CO₂捕集示范项目

Shidongkou 2nd power
plant, CO₂ capture project

Start Operation: Dec. 2009
2009年12月投运

Capacity: 120,000 t/a
规模: 120,000 吨/年

国电投重庆双槐电厂
CO₂捕集示范项目

Chongqing ShuangHuai,
CO₂ capture demonstration

Start Operation: Jan. 2010
2010年1月投运

Capacity: 10,000 t/a
规模: 10,000 吨/年

大唐高井热电厂
CO₂捕集项目

Datang Gaojing CHP power
plant, CO₂ capture project

Start Operation: 2014
2014年投运

Capacity: 1,500 t/a
规模: 1,500 吨/年

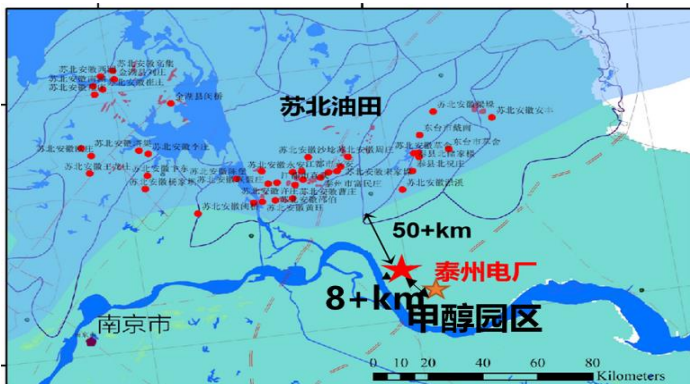


2. Application of CCUS

• 典型项目

国家能源泰州电厂CCUS项目(50万吨/年, 目前亚洲最大)、华能正宁电厂CCUS项目。

• Typical projects:



国家能源泰州电厂CCUS项目
CCUS Project in Taizhou Power Plant

华能正宁电厂CCUS项目
CCUS Project in Zhengning Power Plant

- ❑ Carbon Capture Capacity: 500,000 t/a (largest in Asia)
- ❑ CO₂ Capture: post-combustion
- ❑ CO₂ Utilization: EOR (20,000t/month), other industrial uses
- ❑ Start Operation: Jun. 2023

- ❑ Carbon Capture Capacity: 1,500,000 t/a
- ❑ CO₂ Capture: post-combustion
- ❑ CO₂ Utilization: EOR
- ❑ Start Operation: 2025

2. Application of CCUS

- **典型项目**

国华锦界电厂捕集与封存全流程示范项目、中海油恩平15-1油田群CO₂封存项目。

- **Typical projects:**



国华锦界电厂捕集与封存全流程示范项目
CCUS Project in Jinjie Power Plant



中海油恩平15-1油田群CO₂封存项目
Enping CO₂ Storage Project in Oil Field

- ❑ Carbon Capture Capacity: 150,000 t/a
- ❑ CO₂ Capture: post-combustion
- ❑ CO₂ Utilization: EOR, other industrial use
- ❑ Start Operation: Jan. 2021

- ❑ Carbon Capture Capacity: 300,000 t/a
- ❑ Carbon Storage Capacity : 1.46 Mt
- ❑ CO₂ Storage: Saline Aquifer
- ❑ Start Operation: Aug. 2021

目录 CONTENTS

一 Introduction to Chinese Coal-fired Power Industry

二 Policies and Actions under the “Dual Carbon” Goals

三 Future of Chinese Coal-fired Power Industry

3. Future Development of Chinese Coal-fired Power

- 将严格控制煤电规模，并保留一定规模煤电，以确保电力供应安全。China will **strictly control the scale of coal power** and retain a certain scale of coal power to ensure the security of the power supply.
- 将持续关停落后煤电机组。China will continue to **phase out outdated coal-fired power units**. Since 2011, China has shut down over 100 GW of coal-fired power units with high carbon emissions.
- 将持续减少煤电发电量，煤电年利用小时数将持续大幅下降。China will continue to **reduce the electricity generation from coal power**, and the annual utilization hours of coal power will continue to decline significantly. In 2023, the annual utilization hours of coal power were 4,466 hours, and it is expected to drop to 4,100 hours in 2025, 3,500 hours in 2030, and around 1,500 hours by 2060.
- 将持续提高煤电机组的调峰能力和快速变负荷能力。China will continue to **enhance the peak-shaving and rapid load-following capabilities** of coal-fired power units, aiming to achieve operational flexibility similar to gas turbines. It is to widen the regulatory room for adjusting renewable energy consumption and further improve its utilization level.
- 将持续降低煤电机组碳排放水平。China will continue reducing the carbon emission of coal-fired power units by 1) **improving the unit efficiency** to reduce coal consumption, 2) **co-firing with zero-carbon-emission fuels** such as biomass, and 3) **adopting carbon capture, utilization, and storage (CCUS) technologies**. China will implement carbon emission reductions for coal-fired power in a prudent and orderly way, through short-term demonstrations and long-term large-scale applications based on feasible and realistic conditions.

THANKS

感谢您的聆听

ご清聴ありがとうございます



地址：北京市西城区安德路65号 邮政编码：100120
电话：010-58388230 传真：010-82086966 邮箱：info@eppei.com
No.65 Ande Road,Xicheng District,Beijing,100120
Tel: 010-58388230 Fax: 82086966 E-mail: info@eppei.com
www.eppei.com