中国能源转型及发电能效提升

China’s Experience on Energy Transition and Energy Efficiency Enhancement in Electricity Generation

中国国家能源局电力司
Department of Electric Power, National Energy Administration, China
2025.04

目录 Contents

第1部分 中国能源转型及发电能效提升概况

Part I

Current Status of China's Energy Transition and Energy Efficiency Enhancement in Electricity Generation

- **中国的“四个革命、一个合作”能源安全新战略**：能源消费革命、供给革命、技术革命、体制革命和全方位加强国际合作

China′ s New Energy Security Strategy: aiming at revolutionizing consumption, supply, technology, and institutions, while strengthening all-round international cooperation.

- 中国将力争2030年前实现**碳达峰**、2060年前实现**碳中和**

China will try to **peak carbon emissions by 2030** and achieve **carbon neutrality by 2060.**

- 中国将加快规划建设**新型能源体系**：清洁低碳、安全高效

China is promoting the construction of a **new energy system**: clean, low-carbon, safe, efficient.

- 中国将加快构建**新型电力系统**：清洁低碳、安全充裕、经济高效、供需协同、灵活智能

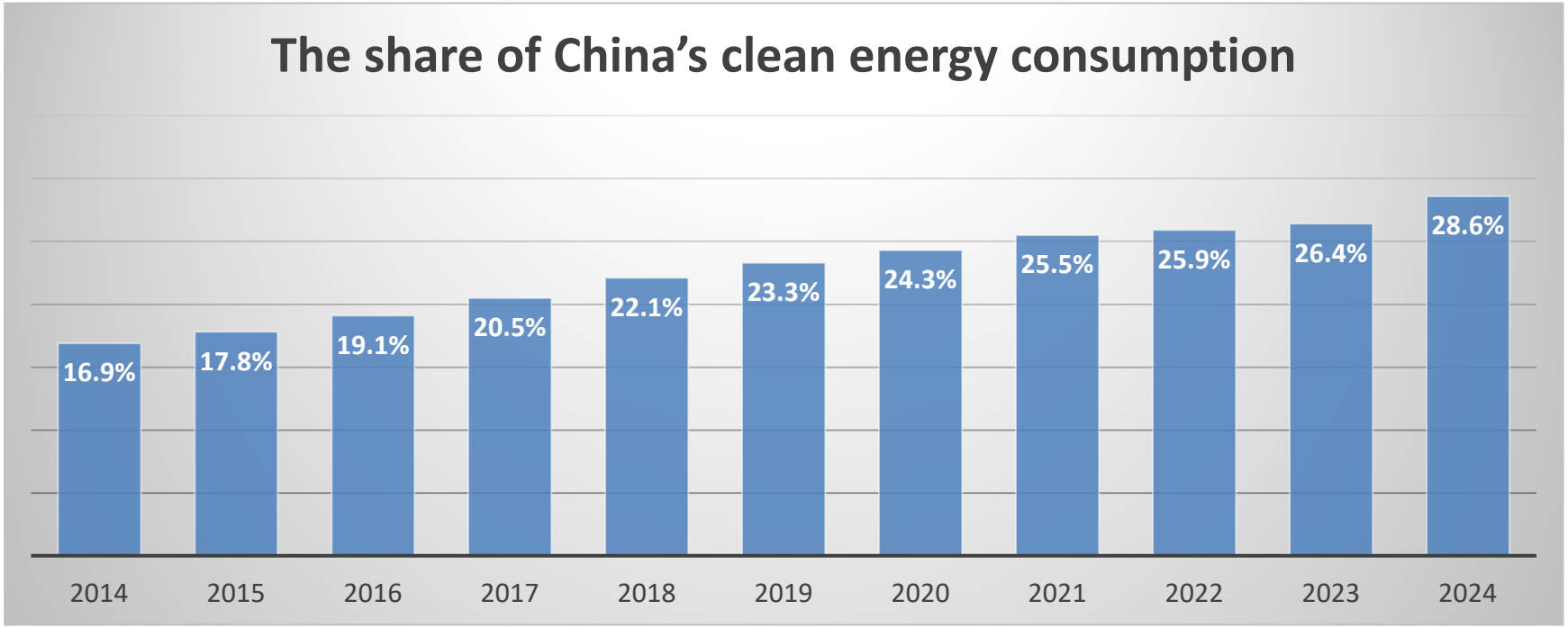
China is promoting the construction of a **new power system**: clean, low-carbon, safe, abundant, economical, efficient, supply and demand coordinated, flexible, intelligent.

- **能源法**：国家支持**优先开发利用可再生能源**，合理开发和清洁高效利用化石能源，推进非化石能源安全可靠有序替代化石能源，提高非化石能源消费比重。

Energy Law: China supports **the priority development of renewable energy**, clean and efficient utilization of fossil energy, promotes the safe, reliable and orderly replacement of fossil energy with non fossil energy, and increases the proportion of non fossil energy consumption.

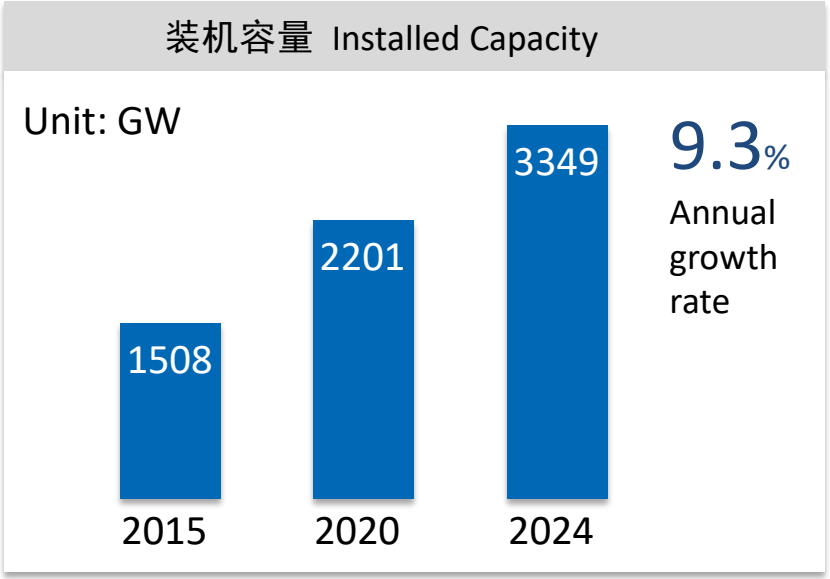
- 2024年，中国**清洁能源消费比重**达到**28.6%**，较2014年提高**11.7个百分点**，煤炭消费比重累计下降**12.6个百分点**。

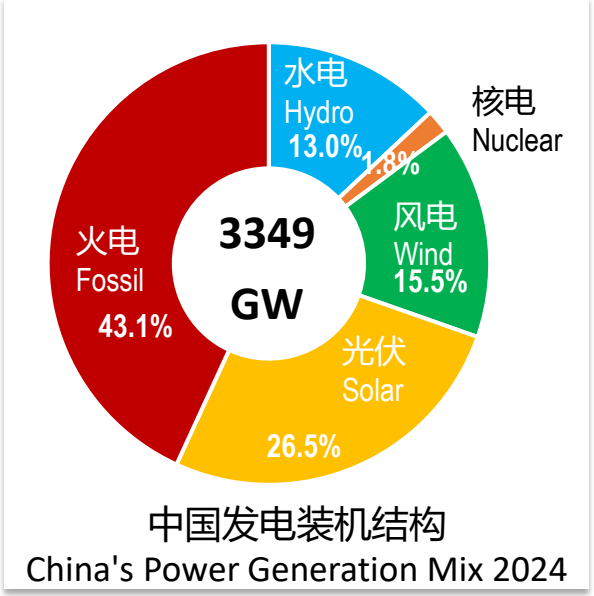
In 2024, the share of clean energy consumption reached 28.6%, up 11.7 percentage points from 2014. In the same period, the share of coal consumption dropped by 12.6 percentage points.



- 2024年，中国发电总装机容量达到33.5亿千瓦，其中**非化石能源发电**装机容量超过**19.5亿千瓦**，占发电装机总量的**58.2%**。新能源发电新增装机3.6亿千瓦，占新增发电装机比重超过82%。

In 2024, the total installed capacity of power generation reached 3,350 GW, of which non fossil energy accounted for **1,950 GW**, or **58.2%**. Newly installed capacity of wind and solar generation reached 360GW, 82% of total newly installed capacity.





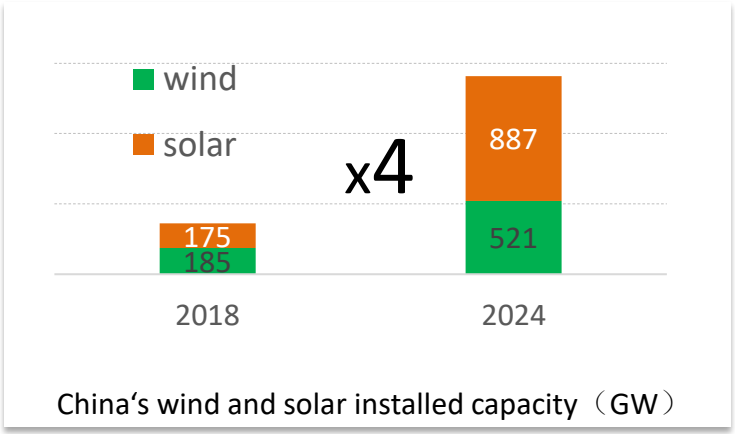
中国发电装机结构
China's Power Generation Mix 2024

- **风光装机总量超过14亿千瓦，**是2018年的4倍以上，**提前6年实现气候雄心峰会上宣布的2030年12亿千瓦装机目标。**

Wind and solar generation capacity has surpassed 1,400GW, quintupled over the past 6 years. **The commitment at Climate Ambition Summit has been fulfilled six years in advance.**

- 2024年，非化石能源发电量约**4.2万亿千瓦时**，占总发电量比重约**42%**。

In 2024, electricity generated from non fossil energy was about **4,200 TWh**, accounting for **42%** of the country's total electricity generation.



China's wind and solar installed capacity（GW）

- 中国构建了全国统一的大电网，形成“西电东送”跨省跨区输电格局，**输电能力超过3亿千瓦**。建成20条特高压直流输电通道，年输送**可再生能源电量占比超过50%**。

China has built a unified national interconnected power grid and the West-East Transmission corridor with transmission capacity of over 300GW. 20 UHVDC transmission lines are in operation, renewable power accounts for over 50% of the total transmission power.

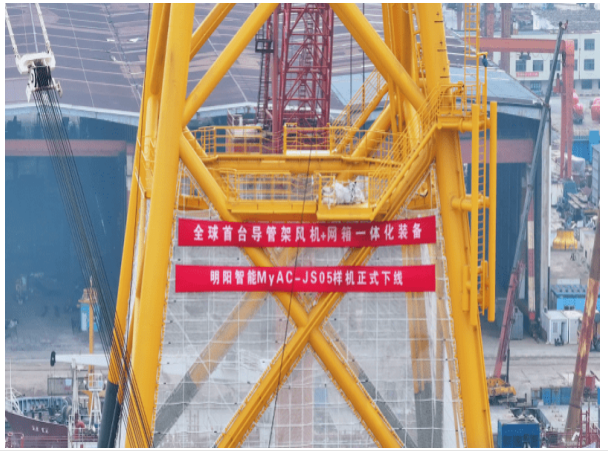
Transmission Lines Distance Over 220kV **960,000 km**	**Transformation Capacity Over 220kV** **5.8 million MVA**	**Electricity transmitted by UHVDC/UHVAC Technology** **2400 TWh**
Average Power Supply Availability (ASAI) **99.911%**	**Average Customer Hours Interrupted (SAIDI)** **2.14/8.74/7.83h**	**Average Customer Interruptions (SAIFI)** **0.68/2.56/2.30**

- **中国大容量风机制造技术成熟，海上风电技术不断取得突破。**一是18MW海上风机已研制成功，多台深远海漂浮式风机已并网。二是正在开展海上风电耦合制氢、海洋牧场等示范项目。

China's large-capacity wind turbine manufacturing technology is mature, and the offshore wind power technology keeps making breakthroughs. 18MW offshore wind turbine was successfully developed, deep-sea floating wind turbines have been connected to the grid. Furthermore, demonstration projects such as offshore wind power + hydrogen production and offshore wind power + marine ranching are launched.

18MW海上风电机组
18MW offshore wind turbine

7.25MW漂浮式风电机组
7.25MW floating wind turbine



风渔一体化风电导管架
Wind-fishery integrated wind power jacket

- **中国晶硅光伏技术快速发展，钙钛矿光伏产业化进程加速**，光伏技术在多元化场景中广泛应用。一是TOPCon电池和异质结电池等N型电池已实现规模化生产，BC电池正在实现产业化。二是钙钛矿电池效率达到世界最高的26.1%，已建成百兆瓦级钙钛矿组件中试线。三是光伏电站在荒漠、水面、建筑等场景广泛建设。

China's crystalline silicon photovoltaic technology is rapidly developing. The industrialization process of perovskite photovoltaic is advancing. The photovoltaic technology is widely used in diversified scenarios. N-type cells such as TOPCon cells and heterojunction cells have achieved large-scale production, and BC cells are being industrialized. The efficiency of perovskite cells has reached 26.1%, and an 100MW-level pilot line for perovskite modules has been built. Solar power plants are widely constructed in deserts, water surfaces, buildings and other scenarios.

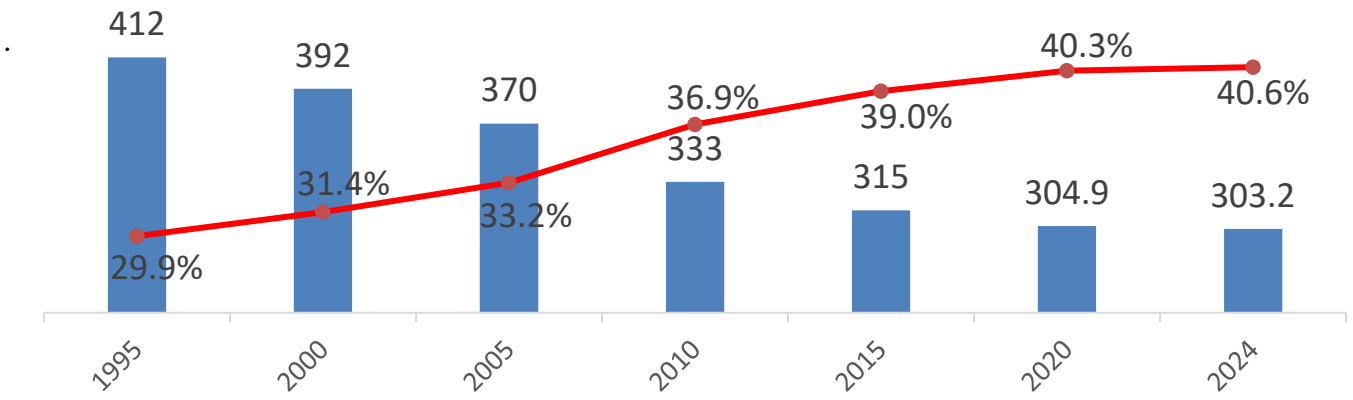
异质结电池生产
Heterojunction Cell Production

钙钛矿光伏组件
Perovskite Photovoltaic Module

水面漂浮式光伏电站
Floating Solar Power Plant

- **中国已建成全球最大清洁煤电供应体系。**6000千瓦及以上火电厂平均供电煤耗从1995年的412克标煤/千瓦时下降到2024年的**303.2克标煤/千瓦时，净发电效率40.6%**。中国先进高参数燃煤发电技术快速发展，世界首台630℃高效超超临界机组在建。

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 412 gce/kWh in 1995 to **303.2 gce/kWh** in 2024, with a net efficiency up to **40.6%**, which has reached world-class levels. China's high-parameter coal-fired power generation technology is advancing, 630°C Ultra-Supercritical Coal-fired Power Unit is under construction.

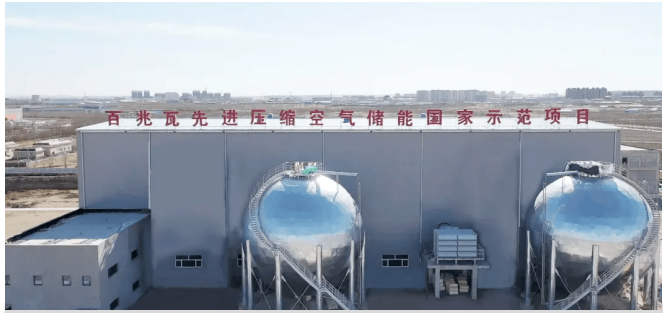


1995-2024年火电平均供电煤耗&净效率
Average Coal Consumption Rate for Power Supply & Net efficiency (1995-2024)

630℃ 1000MW超超临界二次再热煤电机组在建
630°C 1000MW Double Reheat Ultra-Supercritical Coal-fired Power Unit under construction

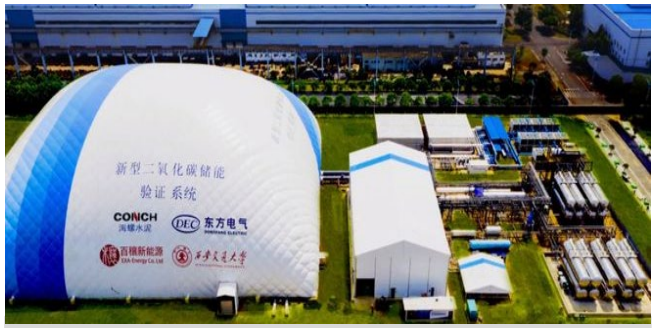
- **中国以锂离子电池、液流电池和压缩空气储能为代表的新型储能技术实现多元化发展。**一是容量300Ah以上的储能电芯已实现规模化生产和应用。二是世界首个百兆瓦级压缩空气储能电站、百兆瓦级全钒液流电池储能调峰电站已投运。三是压缩二氧化碳储能、重力储能等先进储能技术正在开展示范。

China's new energy storage technologies, represented by lithium-ion batteries, flow batteries and compressed air energy storage, have achieved diversified development. The energy storage batteries with a cell capacity of more than 300Ah have achieved large-scale production and application. The world's first 100MW compressed air energy storage power station and 100MW vanadium flow battery energy storage power station have been put into operation. Advanced energy storage technologies such as compressed CO2 energy storage and gravity energy storage are being demonstrated.



100MW压缩空气储能电站
100MW Compressed Air Energy Storage Power Station

100MW/400MWh全钒液流电池储能电站
100MW/400MWh Vanadium Redox Flow Battery Energy Storage Power Station



10MW/20MWh压缩二氧化碳储能系统
10MW/20MWh Compressed CO_2 Energy Storage System

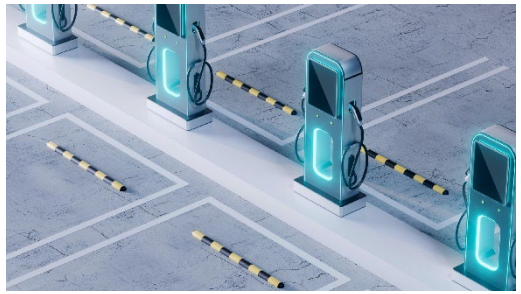
第2部分 中国电力系统转型面临的挑战

Part II
Challenges to China's Power System Transformation

中国电力系统转型面临的挑战
Challenges to China's Power System Transformation

- **电力需求刚性增长。**“十四五”以来，中国全社会用电量超预期增长，年均增速7%以上。光伏组件、电池、电动汽车等新型产业快速发展，数据中心、充电、居民空调负荷增加，预计未来5年全社会用电量年均增量5000-6000亿千瓦时。

Challenge I: Robust growth of electricity demand. Since the 14th Five-Year Plan（2021-2025）, electricity demand has grown faster than anticipation, on average by above 7%. Considering the increase production of PV modules, batteries and EVs, the growing stock of air conditioners, expansion of data centers, and increasing charging demand, the annual growth of electricity demand during the 15th Five-Year（2026-2030） will stay at a high level.




中国电力系统转型面临的挑战
Challenges to China's Power System Transformation

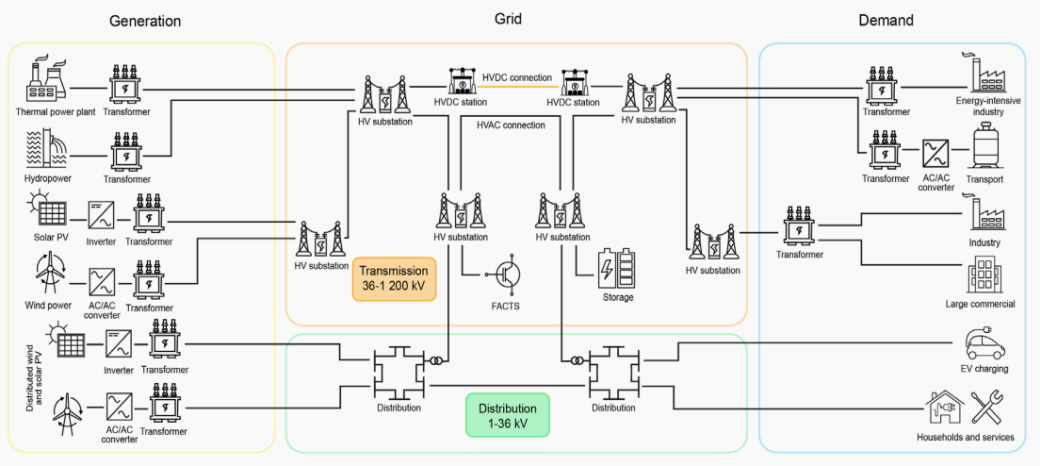
- **极端天气下电力供应保障难度加剧。**电力系统新能源发电占比不断提升，受气候影响增加。台风、雨雪冰冻、极热无风等极端天气发生频率增加，电力保供难度增加。

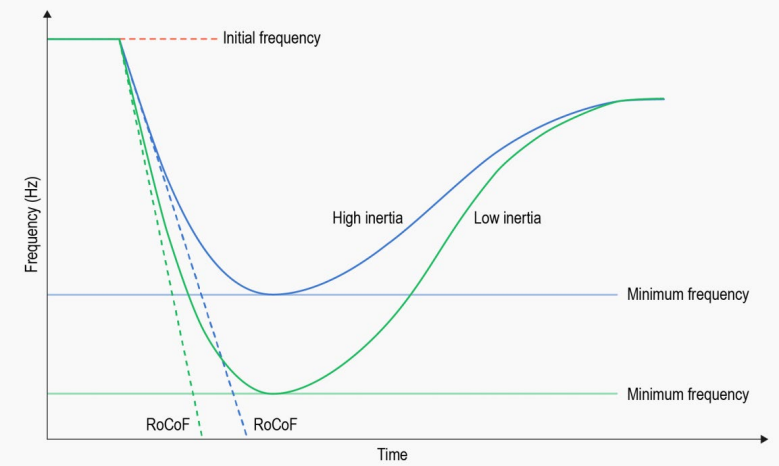
Challenge II: Frequency of extreme weather. As the share of renewables in the electricity generation mix rises, both electricity supply and demand become more weather-dependent. The frequency of extreme weather, like storm, heatwave etc, puts reliable power supply under strain.

中国电力系统转型面临的挑战
Challenges to China's Power System Transformation

- **电网稳定运行风险加大。**高比例新能源、高比例电力电子“双高”特征进一步凸显，电力系统惯性降低，电压支撑能力减弱，电网稳定运行风险加剧。

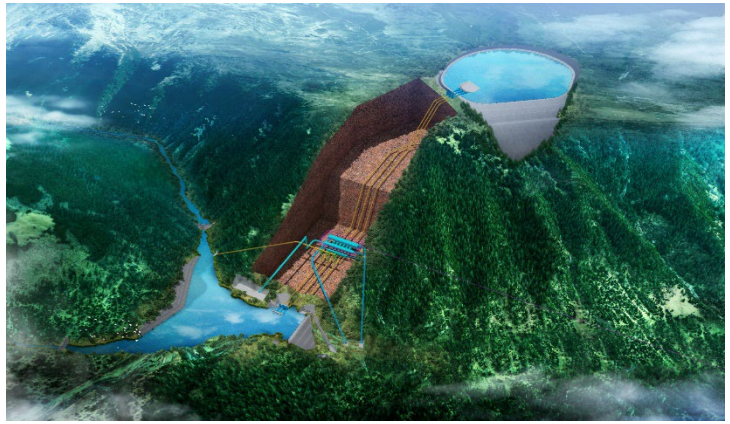
Challenge III: System stability. The replacement of traditional synchronous generators by converter-connected variable renewables results in the weakening of voltage waveform and decrease in physical inertia. The power system is facing stability challenges.





- **系统调节能力不足。**新能源快速发展，但尚未形成可靠替代能力，对系统调节能力（短周期和长周期）提出更高要求。

Challenge IV: Increased flexibility needs. At higher penetrations of renewables, the inherent variability of solar and wind resources contributes to the increased need for flexibility across all timescales (in hours within a day, in weeks and in seasons).



第3部分中国电力系统转型及发电能效提升措施

Part III

China's Measures of Power System Transformation and Energy Efficiency Enhancement in Electricity Generation

1. 加快构建新型电力系统

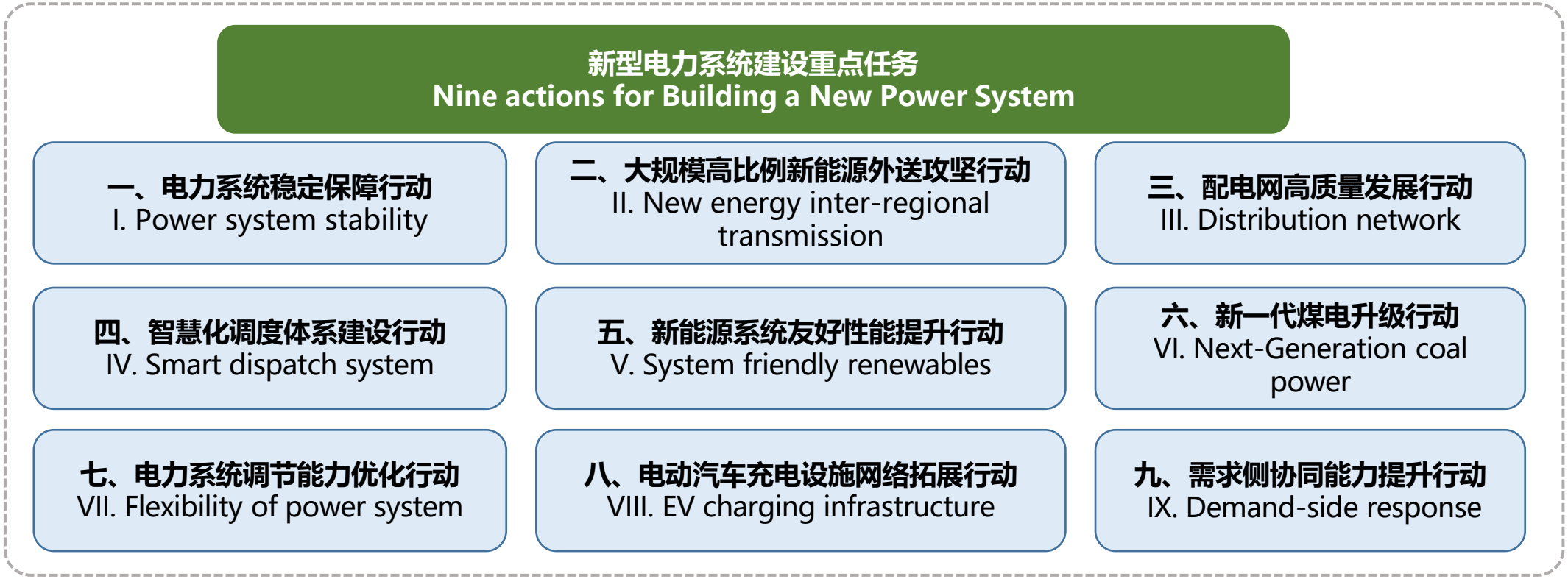
1. Construction of a new power system

- 国家发展改革委、国家能源局等制定印发**《加快构建新型电力系统行动方案》**。

Release **the Action Plan for the Construction of a New Power System**.

- **在2024—2027年重点开展9项专项行动，**推进新型电力系统建设取得实效。

To establish a New Power System, **nine key actions** will be implemented from 2024 to 2027.



- 发布**《新型电力系统发展蓝皮书》**。《蓝皮书》是以支撑“双碳”战略为目标导向的电力系统发展蓝图，对新型电力系统的发展理念、内涵特征、发展阶段、总体架构和重点任务进行全面阐述。

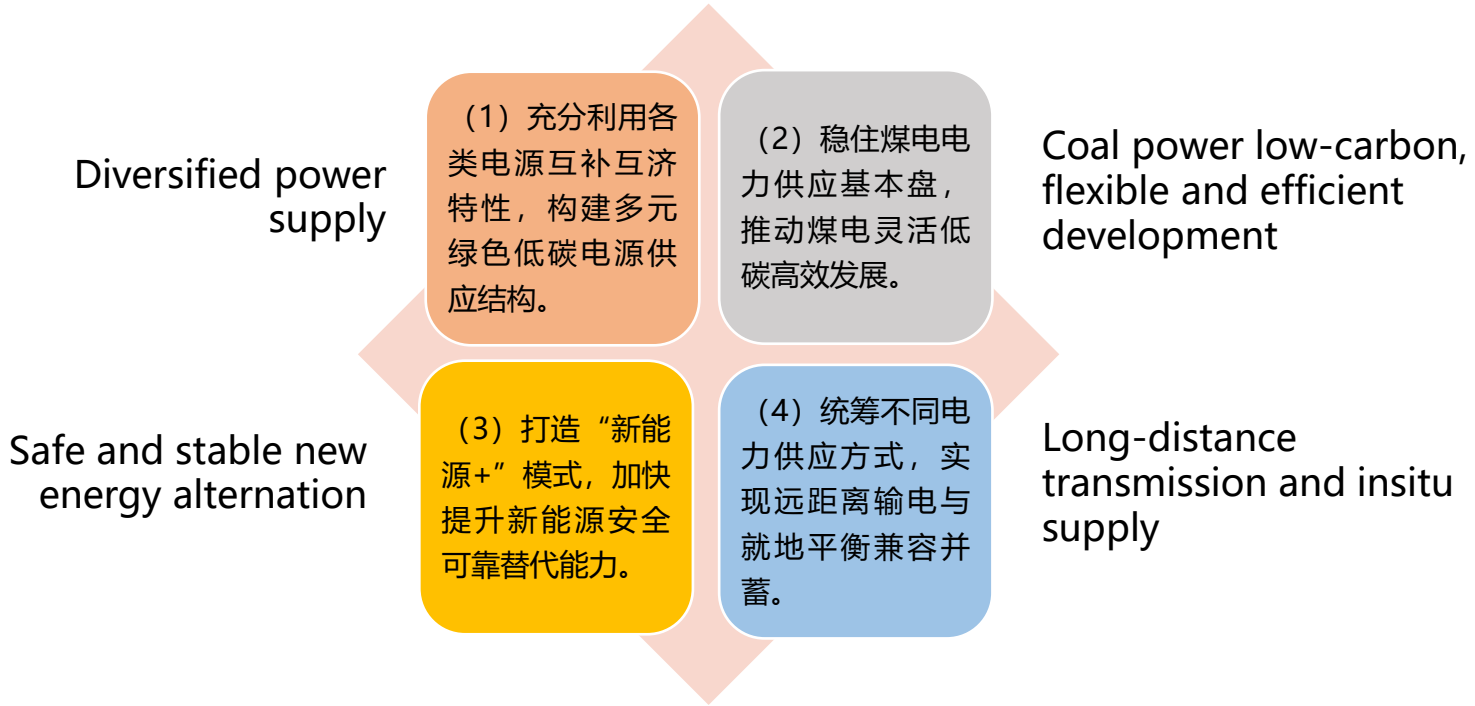
The Blue Book on New Power System Development details the new power system's blueprint, framework, and tasks.

01 结合新型能源体系建设要求和“双碳”发展战略研判电力系统发展趋势，分析现有电力系统面临的主要挑战和问题。Analyzes development trends and challenges in building the new power system.

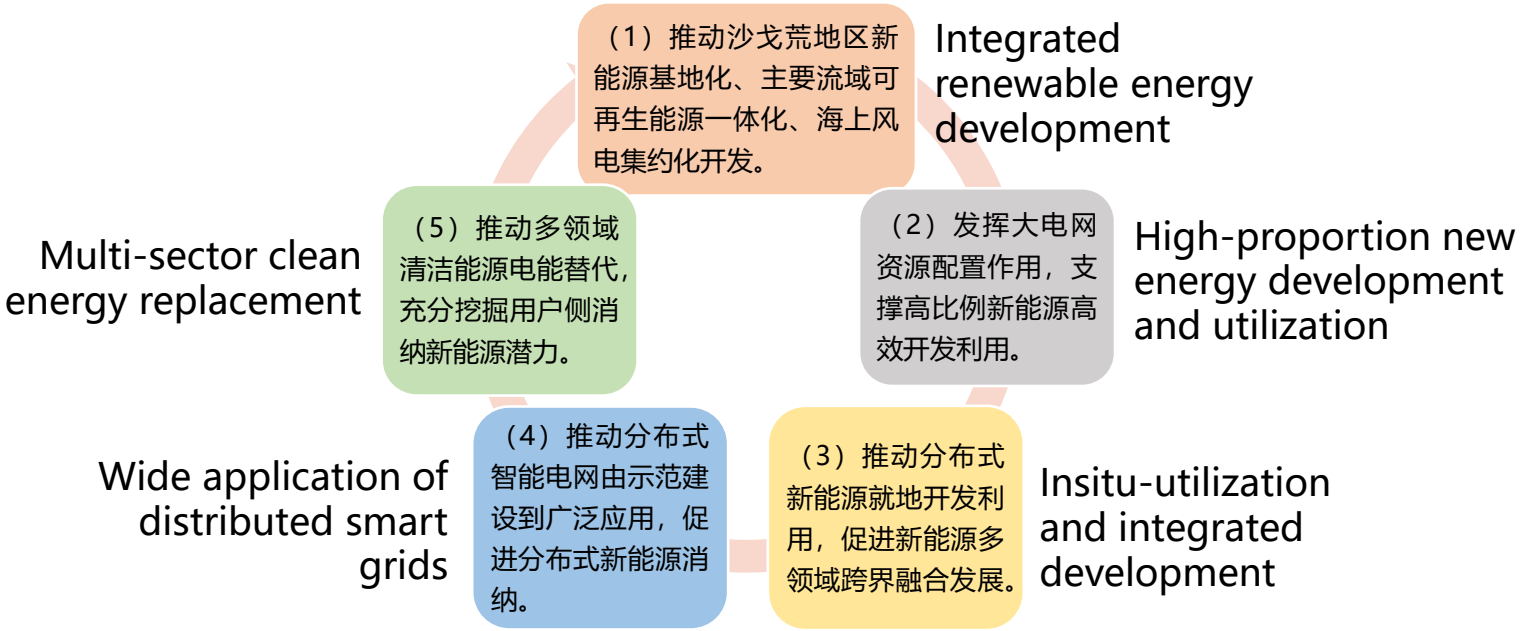
02 全面阐述新型电力系统发展理念、内涵特征，研判新型电力系统的发展阶段及显著特点。Defines the concepts, features, development stages, and characteristics.

03 提出建设新型电力系统的总体架构和重点任务。Sets the framework and tasks for building the new power system.

- **加强电力供应保障性支撑体系建设。**统筹绿色与安全，推动保障性支撑电源建设，积极发展常规水电、核电，在落实气源的前提下因地制宜建设天然气调峰电站，推动煤电清洁低碳发展、优化发展布局，依托技术创新提升新能源可靠替代能力，构建多元化电力供应体系。**Strengthening the power supply support system.** Balance green growth and security by developing supportive power sources, such as conventional hydro, nuclear, gas and clean, low-carbon coal power.

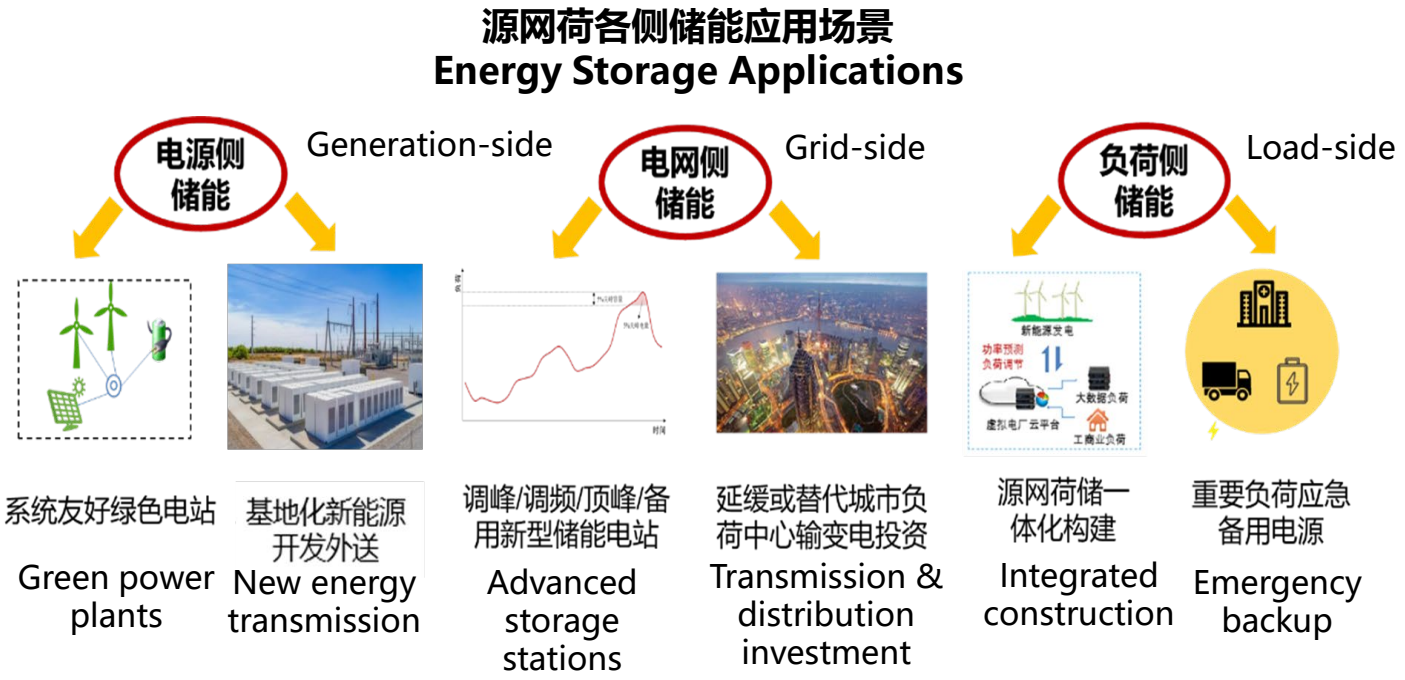


- **加强新能源高效开发利用体系建设。**加大力度规划建设以大型风电光伏基地为基础、以其周边清洁高效先进节能的煤电为支撑、以稳定安全可靠的特高压输变电线路为载体的新能源供给消纳体系。推动新能源集中与分布并举、陆上与海上并举、就地利用与远距离外送并举，构建新能源多元化开发利用新格局。**Developing an efficient system for new energy development and utilization** that is supported by large-scale wind and solar farms, nearby clean, advanced coal plants, and stable ultra-high voltage transmission lines.



- **加强储能规模化布局应用体系建设。**新型储能可发挥支撑电力保供、提升系统调节能力、提升电网运行稳定性等多种重要作用，在新型电力系统中需求巨大。新型储能发展布局需充分结合系统需求及技术经济性，积极拓展应用场景，在源网荷各侧规模化、科学化发展布局。

Strengthening the construction and scientific layout of energy storage. The layout of energy storage, in the generation side, grid side and load side, needs to be optimized scientifically according to the system demand and application scenarios.



中国电力系统转型及发电能效提升措施

China's Measures of Power System Transformation and Energy Efficiency Enhancement in Electricity Generation

加强电力系统智慧化运行体系建设

Establishing a smart power system

- 建设适应新能源发展的新型调度运行体系
- New dispatch systems
- 推动电网智能升级
- Smart grids update
- 打造新型数字基础设施
- New digital infrastructure

强化新型电力系统标准与规范创新

Innovation of standards and regulations for the new power system

- 完善源网荷储各环节相关标准
- Standards of generation, grid, storage and demand side
- 加强电力安全领域标准研究
- Power safety standards
- 推动电力市场相关标准出台
- Market standards
- 提前谋划新技术新业态领域标准
- Standards of emerging technologies and business models

强化核心技术与重大装备应用创新

Innovation in core technology and major equipment applications

- 清洁安全高效发电技术装备
- Power generation
- 先进灵活高效输配电技术装备
- Transmission and distribution
- 规模化高安全性储能技术装备
- Energy storage
- 电力系统安全稳定运行技术
- Power system safety and stability operation

- **强化相关配套政策与体制机制建设。**配套政策与体制机制是构建新型电力系统的制度保障，是充分发挥市场在资源配置中的决定性作用、推动有效市场和有为政府相结合的关键支撑。
- **Strengthening supporting policies and mechanisms** as an institutional safeguard for the market's decisive role in resource allocation.

01 建立适应新型电力系统的**电力市场体系**
A market system suited to the new power system

02 发挥**价格政策**的关键引导作用
Pricing policies as a guiding tool

03 完善新型电力系统建设的**投融资和财税政策体系**
Enhanced investment, financing, and fiscal policies

04 打造自主创新的**技术研发体系**
An independent, innovative R&D system

05 构筑绿色低碳、竞争有活力的电力工业体系
A green, competitive, dynamic, low-carbon power industry

06 完善先进高效的**电力行业治理体系**
Advanced, efficient governance

2. 煤电节能提效和低碳化改造

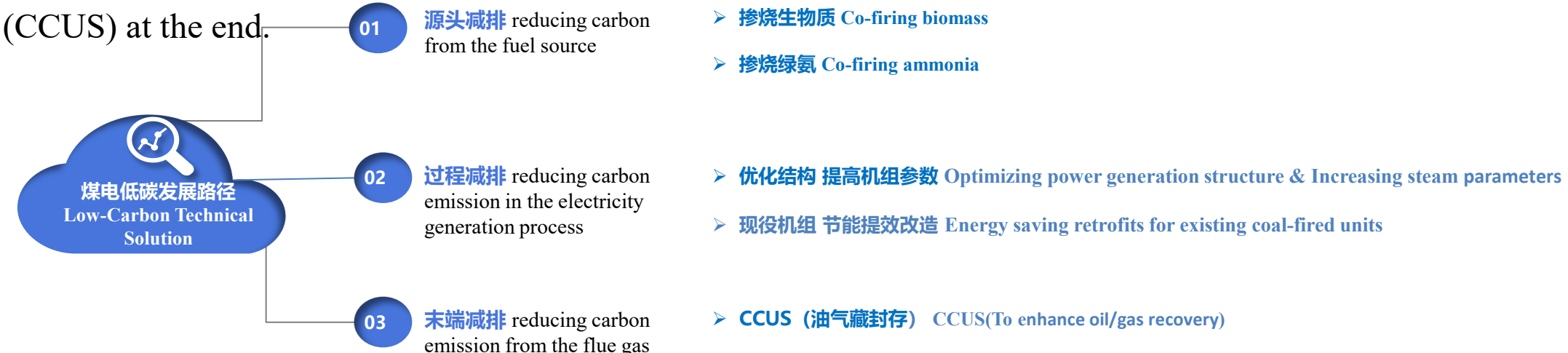
2. Energy efficiency enhancement and Low-Carbon Transformation of Coal-Fired Power Plants

- 中国正**立足自身能源资源禀赋**，坚持先立后破，有计划分步骤实施碳达峰行动。为了保障能源电力供应安全，煤电仍将是中国电力系统的重要组成部分，但煤电装机占比和发电量占比都将保持下降趋势，煤电将逐步作为**支撑性和调节性电源**。

Based on its own **energy resource endowment**, China is using the idea of "establishing the new before abolishing the old" in energy transition, and is taking well-ordered steps to peak carbon emissions. To ensure energy security, coal-fired power plants will still be a necessary part of China's power system. But the share of their installed capacity and power generation in the whole system will maintain a **downward** trend. Coal-fired power plants will gradually play the role to **provide firm capacity and flexibility**.

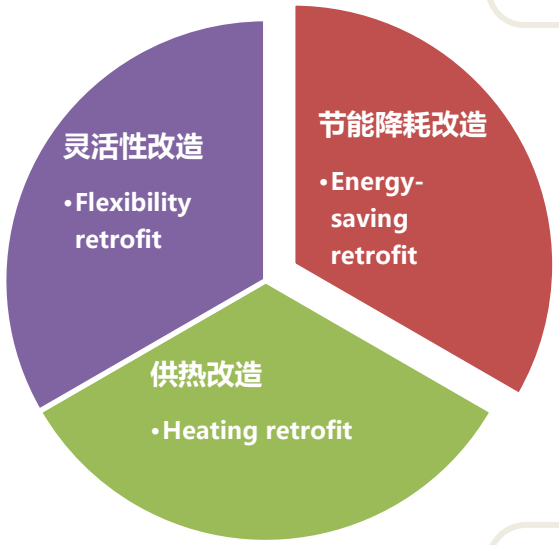
- **煤电低碳化转型路径：**从**源头碳减排、过程碳减排、末端碳减排**等方面推动煤电节能降碳，具体路径包括：一是掺烧绿氢、绿氨、生物质等零碳燃料替代部分燃煤；二是进一步节能提效；三是在末端实施碳捕集利用与封存（CCUS）。

Low-Carbon technical solutions of coal-fired power plants: By **reducing carbon from the fuel source, reducing carbon emission in the electricity generation process, reducing carbon emission from the flue gas**, etc. The specific paths include: first, by mixing green hydrogen, green ammonia, biomass and other zero-carbon fuels instead of coal; second, through further energy saving and efficiency improvement; third, by implementing Carbon Capture and Utilization and Storage (CCUS) at the end.



- 为推动能源行业结构优化升级，进一步提升煤电机组清洁高效灵活性水平，2021年中国国家发展改革委员会、国家能源局制定了**《全国煤电机组改造升级实施方案》，推动煤电行业实施节能降耗改造、供热改造和灵活性改造“三改联动”**。

China's National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) released **the Implementation Plan for the National Renovation and Upgrading of Coal Power Generating Units**, which promotes the implementation of the energy saving retrofit, heating retrofit and flexibility retrofit of the coal power.



提高机组蒸汽参数 Rise of steam parameters

优化回热系统 Optimization of the heat regenerative system

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

优化管道设计 Optimization of key piping's design

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

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

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

- 为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，助力实现碳达峰碳中和目标，中国国家发展改革委员会、国家能源局制定了**《煤电低碳化改造建设行动方案》**。

China's National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) released **the Action Plan for the Low-Carbon Transformation of Coal-fired Power Plant**, which promotes the low-carbon retrofitting of existing coal-fired power plants and the low-carbon construction of new coal-fired power plants.

三种改造和建设方式：

- **生物质掺烧**：实施煤电机组耦合生物质发电，具备掺烧10%以上生物质燃料能力。
- **绿氨掺烧**：利用风电、太阳能发电等可再生能源富余电力，通过电解水制绿氢并合成绿氨，实施燃煤机组掺烧绿氨发电，具备掺烧10%以上绿氨能力。
- **碳捕集利用与封存**：分离捕集燃煤锅炉烟气中的二氧化碳，通过压力、温度调节等方式实现二氧化碳再生并提纯压缩。推广应用二氧化碳高效驱油等地质利用技术、二氧化碳加氢制甲醇等化工利用技术。因地制宜实施二氧化碳地质封存。

Three applicable technologies:

- **Biomass co-firing**: to achieve more than 10% of biomass fuel combustion.
- **Green ammonia co-firing**: using wind and solar power to produce green hydrogen and then synthesize green ammonia, and then to blend green ammonia in fuel combustion (more than 10%).
- **CCUS**: separate and capture CO2 in the flue gas of coal-fired power plants. CO2 geological utilization includes oil production. CO2 chemical utilization includes CO2 hydrogenation to produce methanol.

- **典型生物质掺烧项目** 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 of co-firing biomass** with gasified biomass--Xiangyang power plant unit 6 in Hubei; with direct combustion of biomass—Rizhao power plant unit 4 in Shandong.
- .

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

- 掺烧方式：生物质气化耦合 Co-firing: gasified biomass
- 生物质发电功率：10.8MW Biomass Electrical Power: 10.8 MW
- 掺烧比例：1.68% Co-firing ratio: 1.68%
- CO_2 减排量：约5万吨/年 CO_2 emission reduction: ~ 50,000 t/a
- 投产时间：2018年9月 Start Operation: Sep. 2018

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

- 掺烧方式：生物质直燃耦合 Co-firing: direct combustion of biomass
- 生物质发电功率：34MW Biomass Electrical Power: 34 MW
- 掺烧比例：5% Co-firing ratio: 5%
- CO_2 减排量：约14万吨/年 CO_2 emission reduction: ~ 140,000 t/a
- 投产时间：2022年11月 Start Operation: Nov. 2022

- **典型掺氨燃烧项目** 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 of co-firing ammonia** Tongling power plant 300MW unit in Anhui; Taishan power plant 600MW unit 4 in Guangdong.

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

- 最大掺氨比例：10万千瓦负荷下30%
Maximum ratio of co-firing ammonia: 35% with a load below 100 MW
- 氨燃尽率：99.99%
Burn-up of ammonia: 99.99%
- 燃烧形式：纯氨燃烧器
Combustion Type: pure ammonia

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

- 最大掺氨比例：多种负荷下20%
Maximum ratio of co-firing ammonia: 20% under various loads
- 氨燃尽率：99.99%
Burn-up of ammonia: 99.99%
- 燃烧形式：煤粉混氨燃烧器
Combustion Type: ammonia-coal co-firing

- **典型CCUS项目** 国家能源泰州电厂CCUS项目、华能正宁电厂CCUS项目、国华锦界电厂捕集与封存全流程项目。
- **Typical projects of CCUS** Taizhou power plant in Jiangsu; Zhengning power plant in Gansu; Jinji power plant in Shanxi.

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

- 碳捕集规模: 50万吨/年
Carbon Capture Capacity: 500,000 t/a
- CO_2利用：驱油40万吨，其他10万吨
CO_2 Utilization: EOR (20,000t/month), other industrial uses
- 投产时间：2023年
Start Operation: Jun. 2023

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

- 碳捕集规模: 150万吨/年
Carbon Capture Capacity: 1,500,000 t/a
- CO_2利用: 陇东地区油田驱油、地质封存
CO_2 Utilization: EOR and storage
- 预计投产时间:2025年
Start Operation: expected in 2025

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

- 碳捕集规模: 15万吨/年
Carbon Capture Capacity: 150,000 t/a
- CO_2利用：驱油及工业利用
CO_2 Utilization: EOR and other industrial use
- 投产时间:2021年
Start Operation: Jan. 2021

3. 加快推进可再生能源发展

3. Accelerate the development of renewable energy

- 印发**《关于大力实施可再生能源替代行动的指导意见》**，着力提升可再生能源安全可靠替代能力，加快推进重点领域可再生能源替代应用。

Release **the Guiding Opinions on Vigorously Implementing Renewable Energy Substitution Action** to enhance the reliable substitution ability of renewables and accelerate the renewable energy substitution in various sectors.

- **总体要求：**“十四五”重点领域可再生能源替代取得积极进展，2025全国可再生能源消费量达到11亿吨标煤以上；“十五五”各领域优先利用可再生能源的生产生活方式基本形成，2030年全国可再生能源消费量达到15亿吨标煤以上，有力支撑实现2030年碳达峰目标。

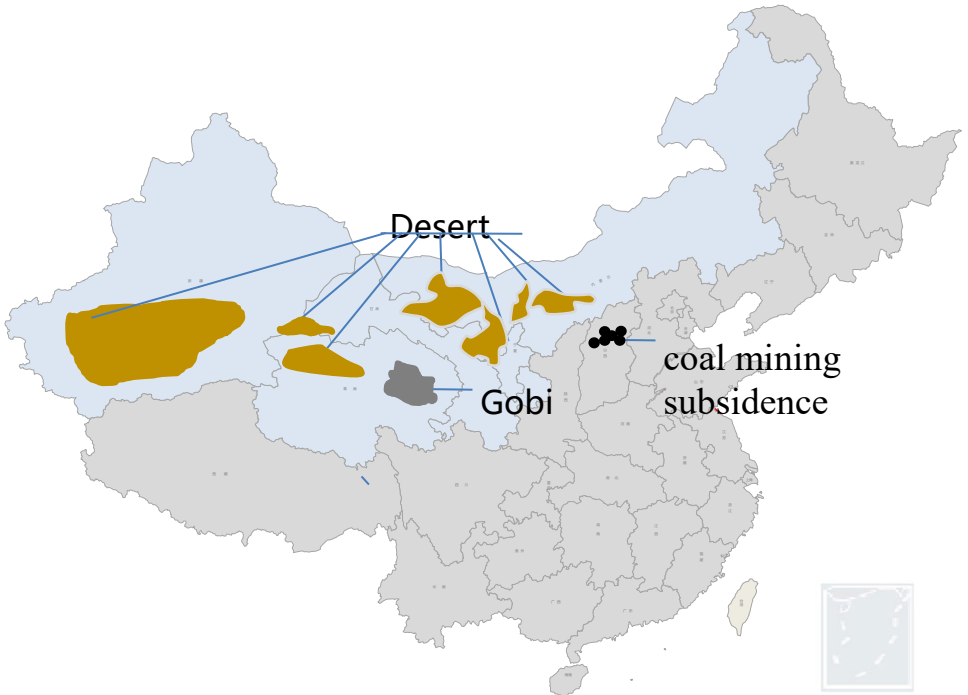
General Requirement: Positive progress of the substitution of renewable energy in key areas in the 14th Five-Year Plan. The national consumption of renewable energy will reach **more than 1.1 billion tons of standard coal in 2025**, and **more than 1.5 billion tons of standard coal in 2030**.

• 大力发展风电、太阳能发电

Vigorously develop wind power and solar power

- 按照风光电基地、支撑性调节性电源、跨省区输电通道“三位一体”统筹推动以沙漠、戈壁、荒漠、采煤沉陷区为重点的大型风电光伏基地和配套跨省跨区输电通道建设。

Develop the large-scale wind and solar bases, especially in the desert, Gobi, and coal mining subsidence areas.



- **大力发展风电、太阳能发电**

Vigorously develop wind power and solar power

- 推进海上风电大规模、集中式开发，积极推进深远海海上风电项目开发与成本下降。

Develop large-scale offshore wind power, and promote the development and cost reduction of deep-sea offshore wind power projects.

- **大力发展风电、太阳能发电**

Vigorously develop wind power and solar power

- 发展分布式风电、光伏，推进工业园区、公共建筑等屋顶光伏开发。

Develop distributed wind power and PV, especial rooftop PV in industrial parks, public buildings, etc.

- 推动光伏发电与大数据中心等信息产业融合发展，推动光伏在铁路沿线、高速公路等交通领域开发与应用。

Promote the integrated development of PV with information industries (such as big data centers), and transportation fields (such as railway lines and highways).

光伏建筑一体化
Photovoltaic Building Integration (PVBI)

交能融合
Transportation and energy integration

新能源+数据中心
VRE+big data center

• 大力发展风电、太阳能发电

Vigorously develop wind power and solar power

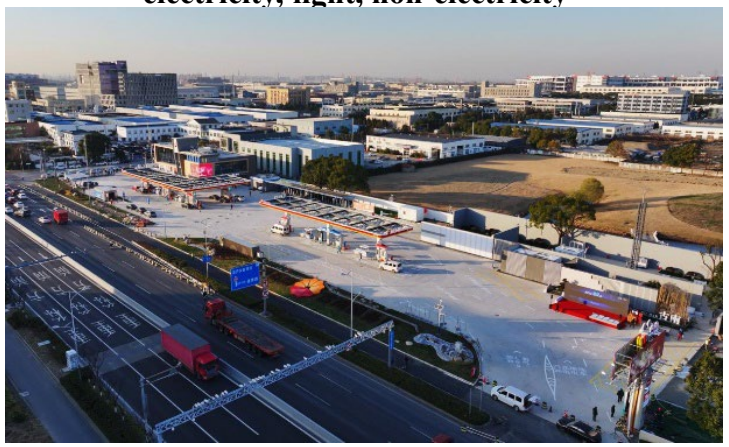
- 推进光伏与农牧业、渔业相结合开发，一批农光互补、渔光互补等光伏复合项目建设模式得到推广；光伏治沙项目开发有序推进，在内蒙古、新疆、青海等地区，建设了一批光伏治沙新能源发电基地。

Develop agricultural-solar and fishery-solar complementation projects and desert-control solar projects.

天门市50万千瓦 “渔光一体”光伏发电项目
fishery-solar complementation project

蒙西基地库布其200万千瓦光伏治沙项目
desert-control solar projects

中石油“油气氢电光非”全业态综合能源站
Comprehensive energy station for oil, gas, hydrogen, electricity, light, non-electricity



- **大力发展风电、太阳能发电**

Vigorously develop wind power and solar power

- 推动光热发电规模化发展，提高能源转换效率、增加储热时长、降低造价成本。

Develop solar-thermal generation, improve energy conversion efficiency, increase heat storage hours, and reduce construction costs.

中广核德令哈50MW槽式光热电站
Delingha 50MW parabolic trough power plant

中控德令哈50MW塔式光热电站
Delingha 50MW solar tower power plant

首航节能敦煌100MW塔式光热电站
Dunhuang 100MW solar tower power plant

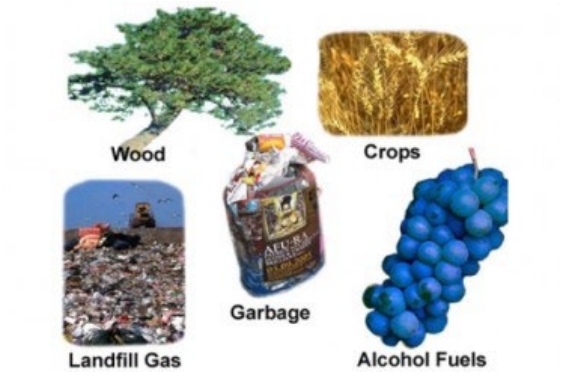
- **因地制宜发展水电、地热等其他可再生能源**
- **Develop hydropower, geothermal energy and other renewables**

科学有序推进大型水电基地建设，统筹推进水风光综合开发。

Develop large-scale hydropower orderly, and develop hydro, wind, and solar power comprehensively.

稳步发展生物质发电。促进地热能资源合理高效利用，推动波浪能、潮流能等规模化利用。

Develop biomass power steadily . Promote the efficient utilization of geothermal energy resources, and the utilization of wave energy, tidal energy, etc.

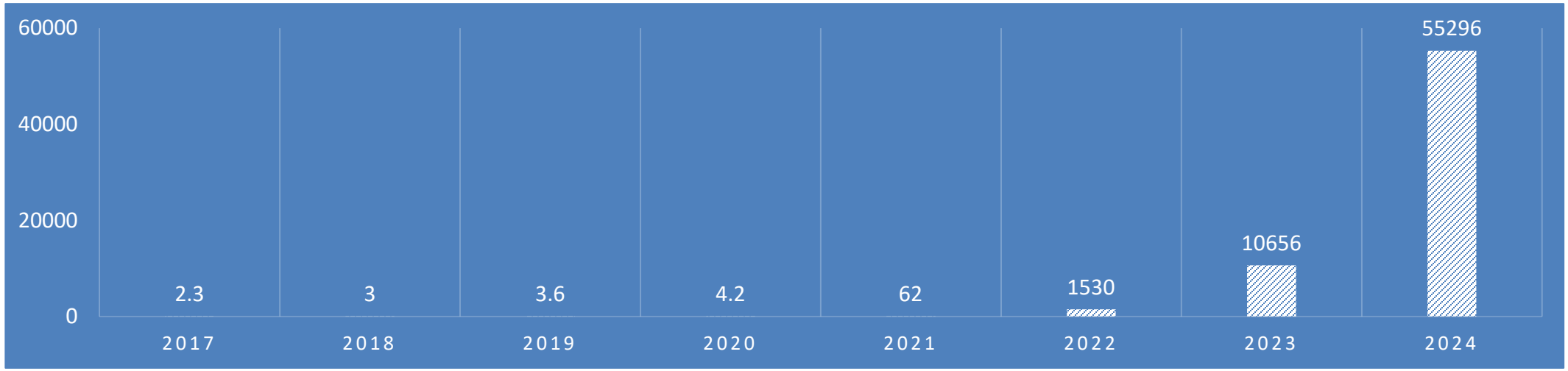


• 大力发展风电、太阳能发电

Vigorously develop wind power and solar power

- 推进**可再生能源绿色电力证书**全覆盖，促进可再生能源电力消费。截至2024年12月底，全国累计核发绿证约49.55亿个，同比增长21倍，绿证市场供给充足。全国累计交易绿证约5.53亿个，同比增长4倍，绿电消费水平显著提升。

Release **the Green Electricity Certificate** to promote renewable power consumption. At of the end of 2024, the total number of green certificates issued nationwide is about 4.955 billion, a year-on-year increase of **21 times**; the total number of green certificates traded nationwide is about 553 million, a year-on-year increase of 4 times.



2017年以来绿证累计交易量变化情况（单位：万个）Green certificate trading volume since 2017 (unit: 10 thousand)

4、促进可再生能源并网消纳

4. Promote the Grid Integration and Consumption of Renewables

- **加强电网基础设施建设与互联互通**
- **Grid infrastructure reinforcement and upgrade**

推进跨省跨区输电通道规划建设，优化加强电网主网架，推进省间灵活互济工程建设，提升大电网资源配置能力。

Reinforce the West-East Transmission corridor, cross-region interconnection and transmission network to allocate electric power nationwide and leverage geographic complementarity.

印发**《关于新形势下配电网高质量发展的指导意见》**，全面提升城乡配电网供电保障能力和综合承载能力。发展智能微电网和综合能源系统，提升新能源就地就近平衡消纳能力。

Release **the Guiding Opinions on High Quality Development of Distribution Network under the New Situation** to enhance the power supply and integration ability of distribution network. Develop microgrid and multi-energy system to improve the self-balancing capability of local areas and reduce the system costs of accommodating renewables.

- **加强电网基础设施建设与互联互通**
- **Grid infrastructure reinforcement and upgrade**

加快推进电网智能化发展，采用先进的电网设备设施、运行控制技术，以及数字化、智能化等技术，推动建设适应可再生能源发展的智慧化电网调度运行体系。

Develop smart grid, adopt advanced grid equipment and facilities, operation control technology, as well as digital and intelligent technologies, to promote the construction of an intelligent grid scheduling and operation system that adapts to the development of renewable energy.

- **加强电力系统调节能力建设**
- **Enhancing the flexibility of power system**

印发**《关于加强电网调峰储能和智能化调度能力建设的指导意见》《电力系统调节能力优化专项行动实施方案》**，提升电力系统调节能力，促进新能源消纳。

Release **the Guiding Opinions on Improving the Flexibility and Intelligent Dispatching Ability of the Power Grid, the Action Plan for Enhancing the Flexibility of Power System**.

做好抽水蓄能电站规划建设，推进电源侧、用户侧新型储能建设，优化电网侧储能布局，推动电化学储能、物理储能、抽水蓄能等各类型储能的技术发展

Promote the development and technology innovation of energy storage of multiple types and timescales.

深入挖掘负荷侧资源调节潜力，积极培育负荷聚合服务、虚拟电厂等，完善电价和电力市场机制

Explore demand response potential, develop load aggregation and virtual power plants, improve pricing and electricity market mechanism.

Thank you!

谢 谢!