2025

China Solar Thermal Power Industry

Blue Book

National Solar Thermal Power Industry Technology Innovation Strategic Alliance
Solar Thermal Power Committee of China Renewable Energy Society

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Citation format: Solar Thermal Power Industry Technology Innovation Strategic Alliance, et al. China Solar Thermal Power Industry Blue Book (2025) [J]. Advanced Technology of Electrical Engineering and Energy, 2026, DOI: 10.12067/ATEEE2601019.

National Solar Thermal Power Industry Technology Innovation Strategic Alliance
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January 2026

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1. Overview of Solar Thermal Power Technology

1.1 Principles of Solar Thermal Power Technology

According to the national standard 'Terminology for Concentrating Solar Thermal Power', solar thermal power generation is a system that converts solar radiation into thermal energy and generates electricity through a thermodynamic conversion process. Solar thermal power, also abbreviated as CSP (Concentrating Solar Power) or STE (Solar Thermal Electricity), generally consists of three main components: a heat collection system, a thermal storage and heat exchange system, and a thermal-mechanical-electrical conversion system.
Solar thermal power concentration forms mainly include eight types: tower concentration, trough concentration, linear Fresnel concentration, dish concentration, wheel concentration, rotating tower concentration, secondary and multiple reflection concentration, and transmission concentration.

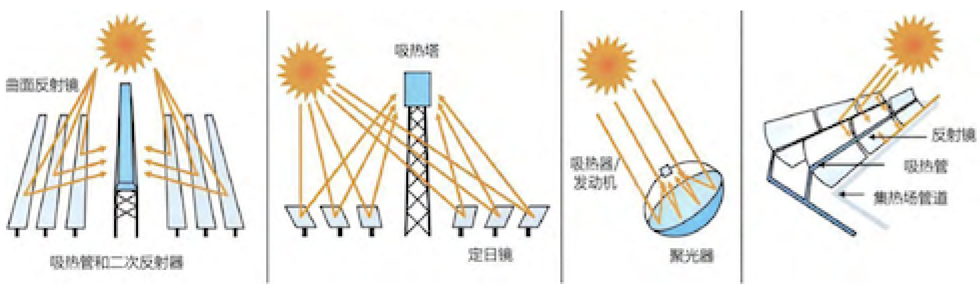


Figure 1: Four Solar Thermal Power Concentration Forms

Linear Fresnel (line focus), Tower (point focus), Dish (point focus) and Trough (line focus), and

Source: IEA, 2014

1.1.1 Molten Salt Tower Solar Thermal Power System

A molten salt tower solar thermal power system mainly consists of heliostats, a receiver tower, a receiver, high and low temperature molten salt storage tanks, a steam generator, and a steam turbine generator set.

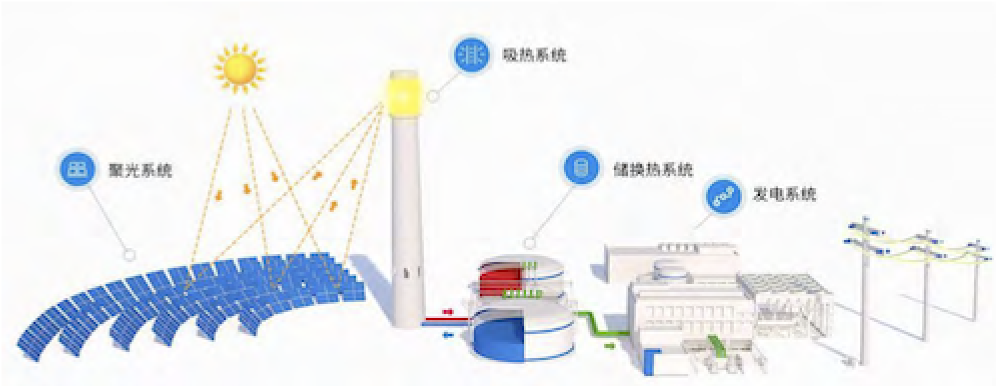


Figure 2: Molten Salt Tower Solar Thermal Power System Schematic Diagram

Source: Kesun Technology

聚光系统 = Heliostat Field / Concentration System

吸热系统 = Heat Absorption System / Receiver System

储换热系统 = Thermal Storage and Heat Exchange System

发电系统 = Power Generation System

1.1.2 Thermal Oil/Molten Salt Trough Solar Thermal Power System

A thermal oil trough solar thermal power system mainly consists of parabolic trough collectors (including concentrators and receiver tubes), a molten salt heat exchange and storage system, a thermal oil/steam generation system, and a steam turbine generator set.

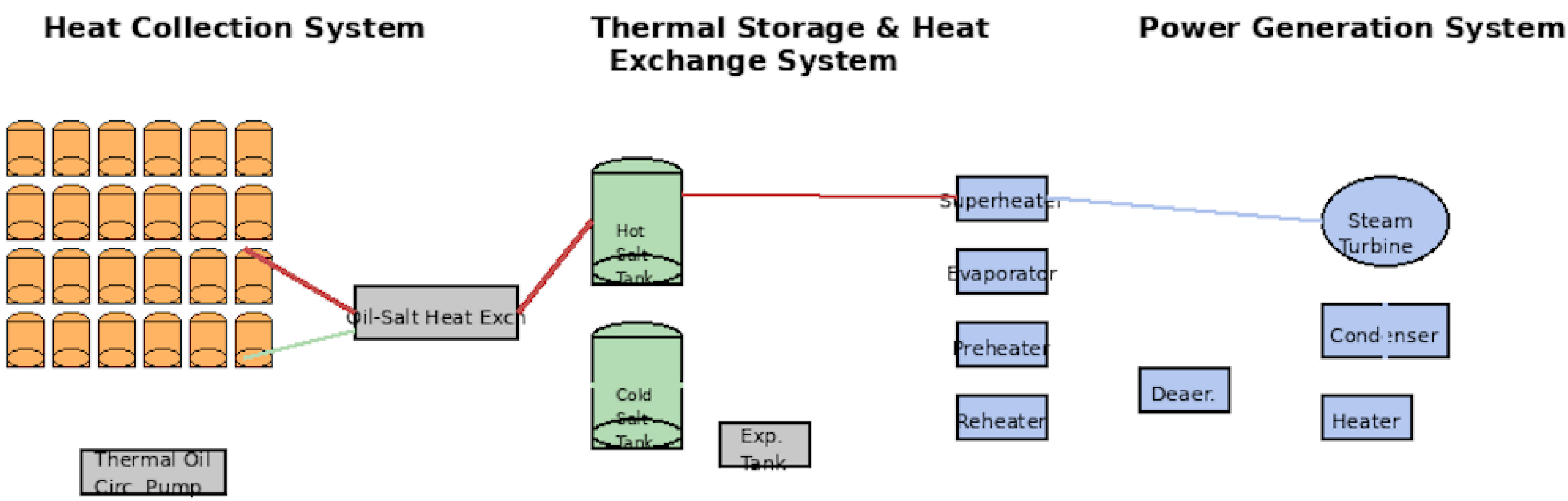


Figure 3: Thermal Oil Trough Solar Thermal Power System (Conventional Flow)

Source: Longteng Solar

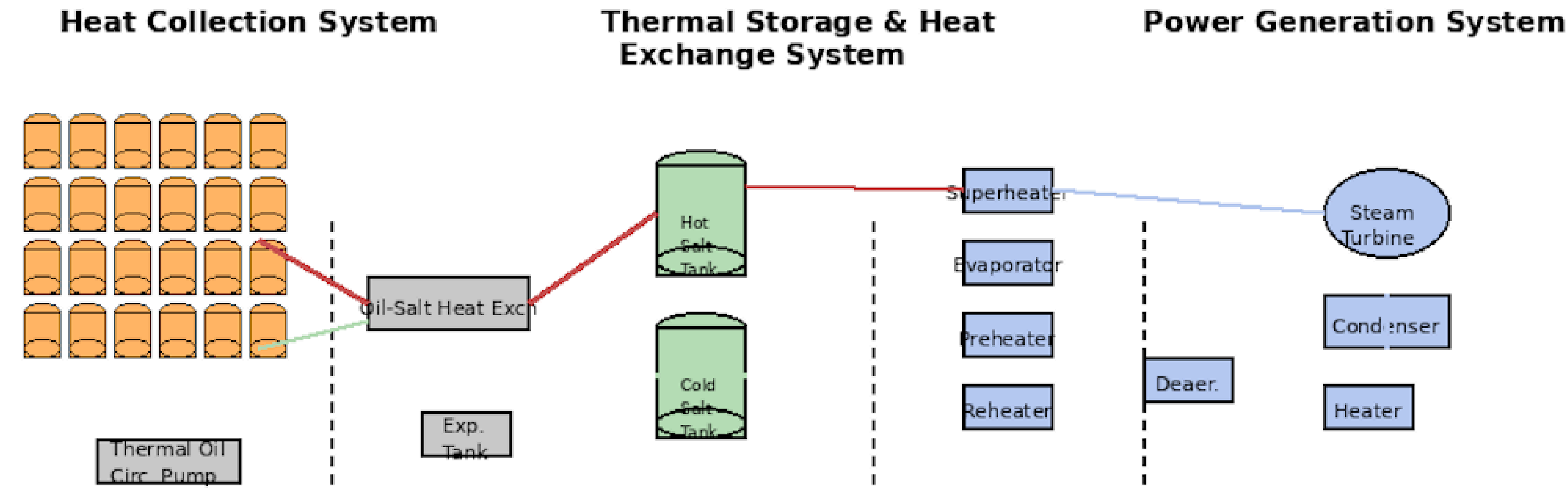


Figure 4: Thermal Oil Trough Solar Thermal Power System (Decoupled Flow)

Source: Longteng Solar

1.1.3 Molten Salt Linear Fresnel Solar Thermal Power System

A molten salt linear Fresnel solar thermal power system consists of Fresnel collectors, high and low temperature molten salt storage tanks, a steam generator, and a steam turbine generator set.

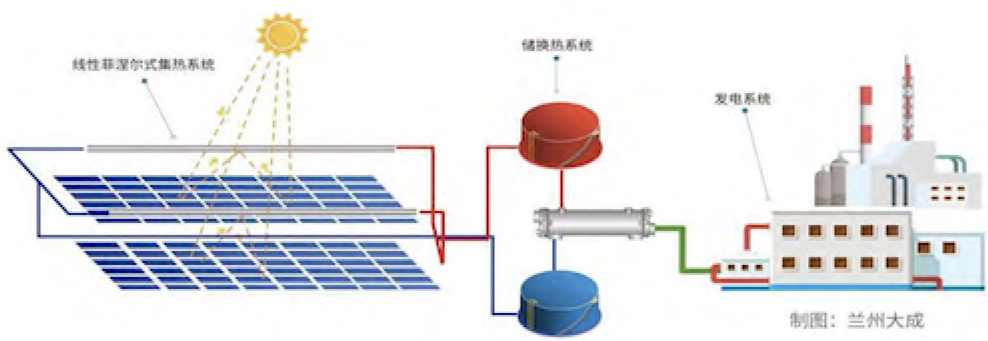


Figure 5: Molten Salt Linear Fresnel Solar Thermal Power System

Source: Lanzhou Dacheng

线性菲涅尔式集热系统 = Linear Fresnel Concentration and Heat Collection System

储换热系统 = Thermal Storage and Heat Exchange System

发电系统 = Power Generation System

1.1.4 Secondary Reflection Tower Solar Thermal Power System

A secondary reflection tower solar thermal power system mainly consists of heliostats, a secondary reflection tower, a receiver, high and low temperature molten salt tanks, a steam generation system, and a steam turbine generator set.

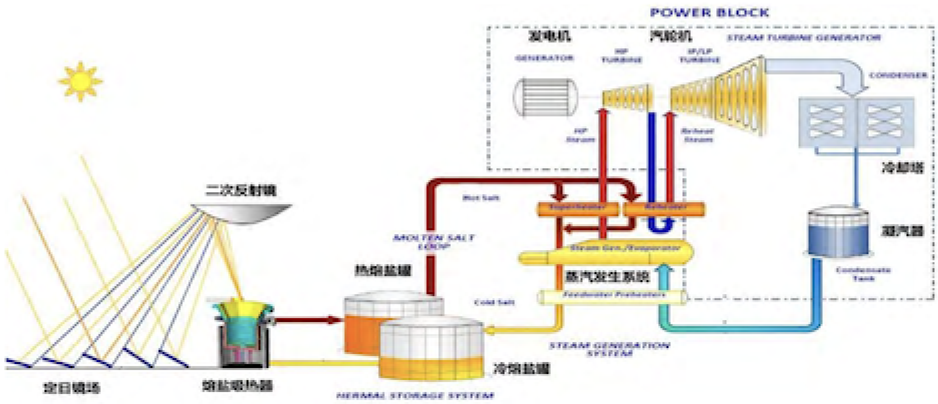


Figure 6: Secondary Reflection Tower Solar Thermal Power System

Source: Zhongqing Solar

定日镜场 = Heliostat Field

二次反射镜 = Secondary Reflector

熔盐吸热器 = Molten Salt Receiver

热熔盐罐 = Hot Molten Salt Tank

冷熔盐罐 = Cold Molten Salt Tank

蒸汽发生系统 = Steam Generation System

发电机 = Generator

汽轮机 = Steam Turbine

冷却塔 = Cooling Tower

凝汽器 = Condenser

Figure 7: Secondary Reflection Tower System On-site Operating Photo

Source: Zhongqing Solar

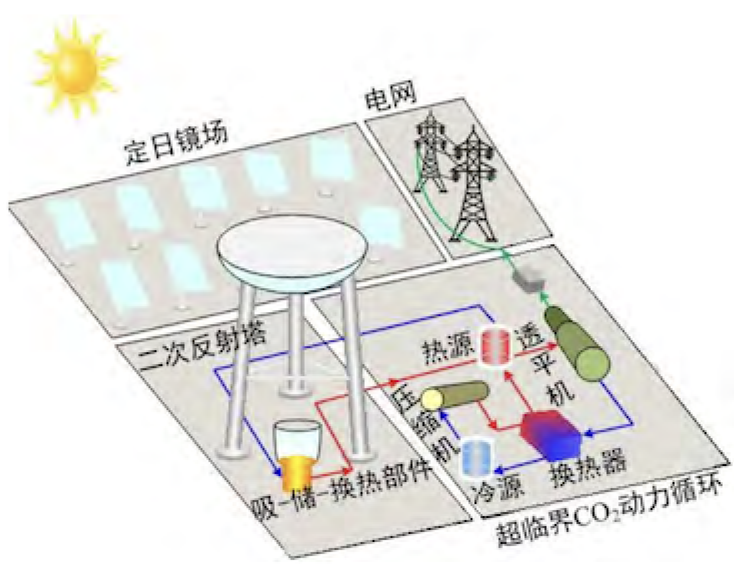


Figure 8: Secondary Reflection Tower with Supercritical CO2 System

Source: Zhongqing Solar

定日镜场 = Heliostat Field

电网 = Power Grid

二次反射塔 = Secondary Reflection Tower

吸储换热部件 = Heat Absorption, Storage and Exchange Component

热源 = Heat Source

压缩机 = Compressor

透平机 = Turbine

换热器 = Heat Exchanger

冷源 = Cold Source

超临界CO_2动力循环 = Supercritical CO_2 Power Cycle

Figure 9: Cable-Stayed Secondary Reflection Tower High Concentration System

Source: Zhongqing Solar

1.1.5 Novel Concentrators

In addition to the traditional concentration forms mentioned above, various novel concentrator technologies are being developed and tested to improve efficiency and reduce costs.

1.2 Solar Thermal Power Technology Development Roadmap

Solar thermal power generation converts solar energy into thermal energy and generates electricity through thermodynamic cycles. The solar heat collection temperature is related to both photothermal conversion efficiency and thermodynamic conversion efficiency, and is the most important factor determining the energy efficiency and cost of solar thermal power generation.

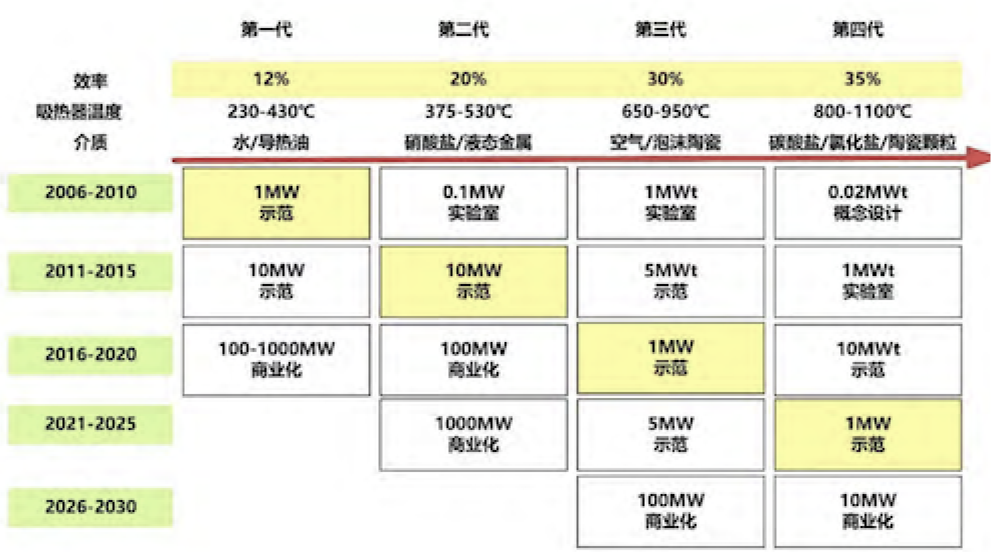


Figure 10: Solar Thermal Power Technology Development Roadmap

Showing four generations from 400°C (1st gen) to 1000°C+ (4th gen)

Headers:

第一代 = 1st Generation

第二代 = 2nd Generation

第三代 = 3rd Generation

第四代 = 4th Generation

效率 = Efficiency

吸热器温度 = Receiver Temperature

介质 = Medium / Heat Transfer Fluid

Media Types:

水/导热油 = Water/Thermal Oil

硝酸盐/液态金属 = Nitrate Salt/Liquid Metal

空气/熔盐陶瓷 = Air/Molten Salt Ceramic

碳酸盐/氧化盐/陶瓷颗粒 = Carbonate Salt/Oxide Salt/Ceramic Particles

Development Status:

示范 = Demonstration

实验室 = Laboratory

概念设计 = Concept Design

商业化 = Commercialization

Currently, China has achieved commercial demonstration of second-generation power plants using molten salt as the heat transfer medium and first-generation solar thermal power technology using thermal oil as the medium.

On May 28, 2024, at 19:01, a 200kW supercritical carbon dioxide solar system successfully generated electricity for the first time in the the world, with receiver temperature and power of 700°C/1MWth, and turbine generator set parameters of 550°C/14MPa/0.2MW.

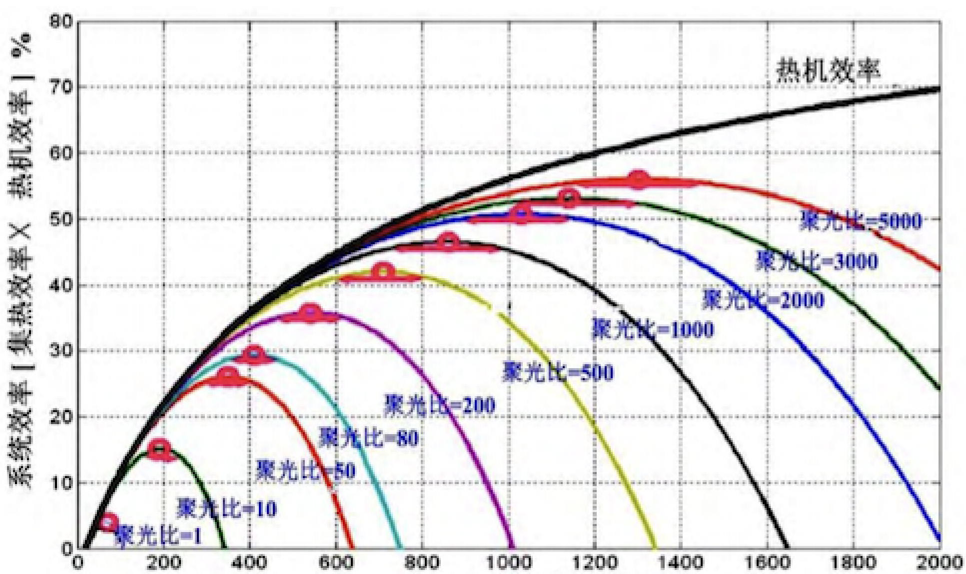


Figure 11: Relationship Between Solar Heat Collection Temperature, Concentration Ratio, and System Power Generation Efficiency

Y-axis:

System Efficiency / Heat Transfer Efficiency / Photoelectric Efficiency (when consistent)

X-axis:

Heat Collection Temperature (℃)

(The Chinese text in blue represents Concentration Ratios - shown as from 1 to 5000)

1.3 Differences Between Solar Thermal and Photovoltaic Power

Both solar thermal power and photovoltaic power generation belong to forms of solar energy utilization, but there are significant differences between them. The most critical difference is: solar thermal power generation has large-scale, low-cost, and high-safety long-term energy storage function at the plant level; the back end uses steam turbine generator sets for power generation, which can exert support and regulation effects on the grid similar to coal-fired units.

Figure 12: Solar Thermal Power and Photovoltaic Power Integrated Project Real Scene

Source: CHN Energy Qinghai Company

Table 1: Comparison of Characteristics Between Solar Thermal Power and Photovoltaic Power

Aspect	Photovoltaic Power	Solar Thermal Power
Power Generation Principle	Light-to-electricity conversion	Heat-to-electricity conversion
Grid Integration	Difficult, prone to curtailment	Stable, 24-hour capable, grid-friendly
Output Characteristics	Intermittent, fluctuating	Stable, flexible, continuous 24h
Peaking Capability	Requires external storage	Built-in peaking capability
Frequency Regulation	Weak support	Full primary/secondary regulation
Carbon Footprint Factor	0.0520 kgCO2e/kWh	0.0312 kgCO2e/kWh

1.4 Position of Solar Thermal Power in the Energy System

China has clearly stated that by 2035, the total installed capacity of wind and solar power generation nationwide will strive to reach more than 3.6 billion kilowatts. In the next 10 years, China needs to add about 200 million kilowatts of wind and solar installed capacity annually.

Table 2: National Government Policies on Solar Thermal Power

Date	Document/Policy	Key Content
Oct 2021	Action Plan for Carbon Peak by 2030	Actively develop solar thermal power
Jun 2022	14th Five-Year Plan for Renewable Energy	Promote long-duration thermal storage
Jan 2025	Energy Law of PRC	Article 25: Actively develop

Date	Document/Policy	Key Content
		CSP
Dec 2025	Opinions on Large-Scale Development	2030 target: 15GW installed capacity

2. Solar Thermal Power Market Development

2.1 China's Solar Thermal Power Installed Capacity

According to statistics from the Solar Thermal Power Industry Technology Innovation Strategic Alliance, as of the end of 2025, China's cumulative installed capacity of solar thermal power units reached 1,738.2MW, an increase of 107% compared to 2024. In 2025, China added 9 grid-connected solar thermal power plants with a total installed capacity of 900MW.

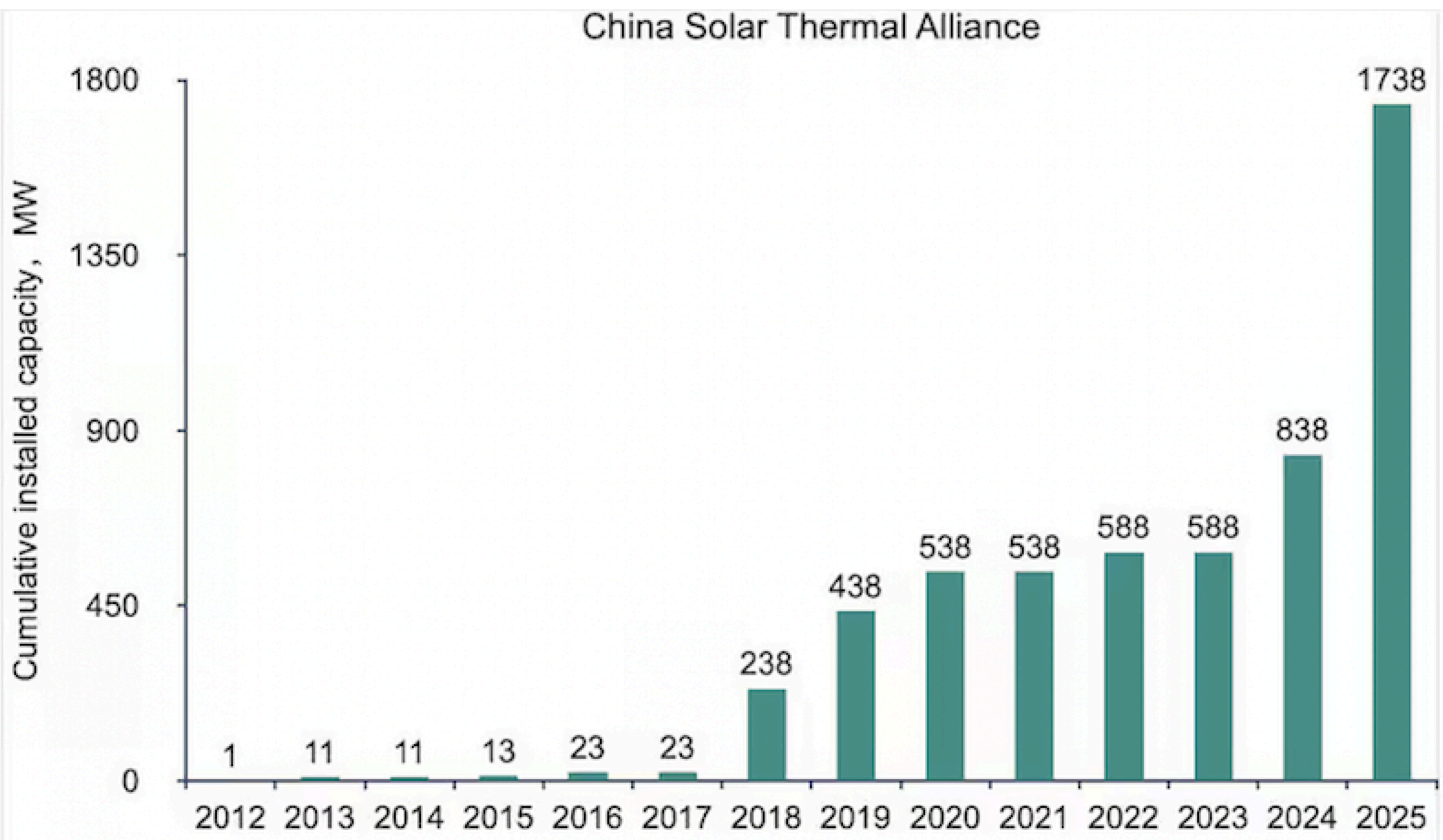


Figure 13: China's Solar Thermal Power Cumulative Installed Capacity Development as of 2025

Table 3: China's New Solar Thermal Power Plants in 2025

9 CSP plants that connected to the grid in 2025

No.	Project Name	Solar Concentration	Capacity, MW
1	Three Gorges Energy Qingyu DC Phase II (Lot 3) 100MW CSP Plant	tower	100
2	Three Gorges Energy Golmud 100MW CSP Plant	tower	100
3	Energy China Zhejiang Thermal Power Turpan Qiketai 100MW CSP Plant	tower	100
4	CGD Jinta 1000MW CSP Plant	tower	100
5	SPIC Henan Company Xinjiang CSP + PV Integrated Project	tower	100
6	Xinjiang Turpan Tangshan Haitai 100MW Tower CSP Plant	tower	100
7	Three Gorges Corporation Hami 1GW CSP + PV Project	LFR	100
8	Three Gorges Hengji Nengmai Guazhou 700MW CSP Energy Storage+ Project	tower	100
9	CHN Energy Qingyu DC Phase II (Lot 1) 100MW CSP Project	tower	100

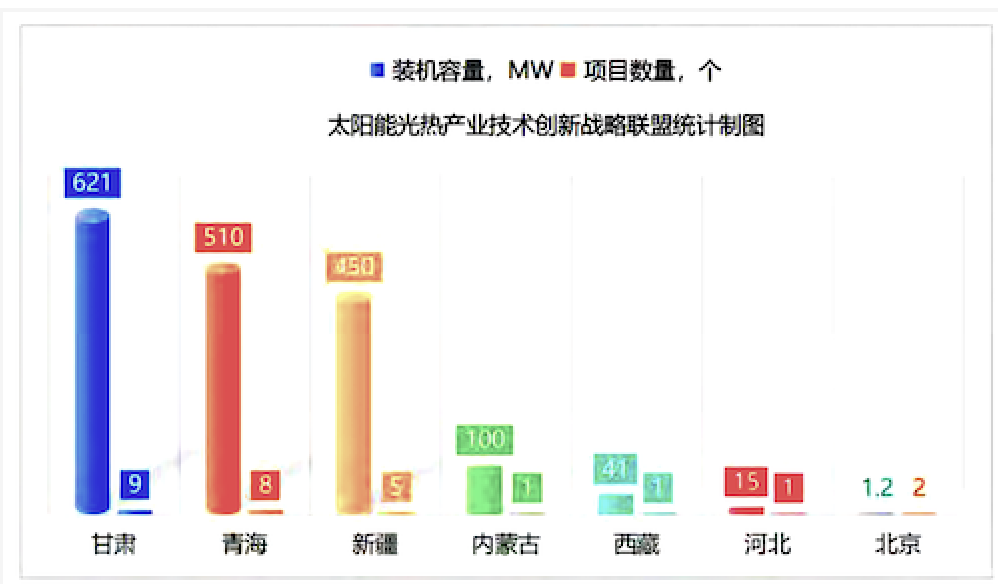


Figure 14: China's Solar Thermal Power Cumulative Installed Capacity by Province/Region as of 2025

甘肃 = Gansu

青海 = Qinghai

新疆 = Xinjiang

内蒙古 = Inner Mongolia

西藏 = Tibet

河北 = Hebei

北京 = Beijing

2.2 Global Solar Thermal Power Installed Capacity

By the end of 2025, the cumulative installed capacity of solar thermal power generation in major countries and regions worldwide reached 8,800.2MW, a year-on-year increase of 11.4%.

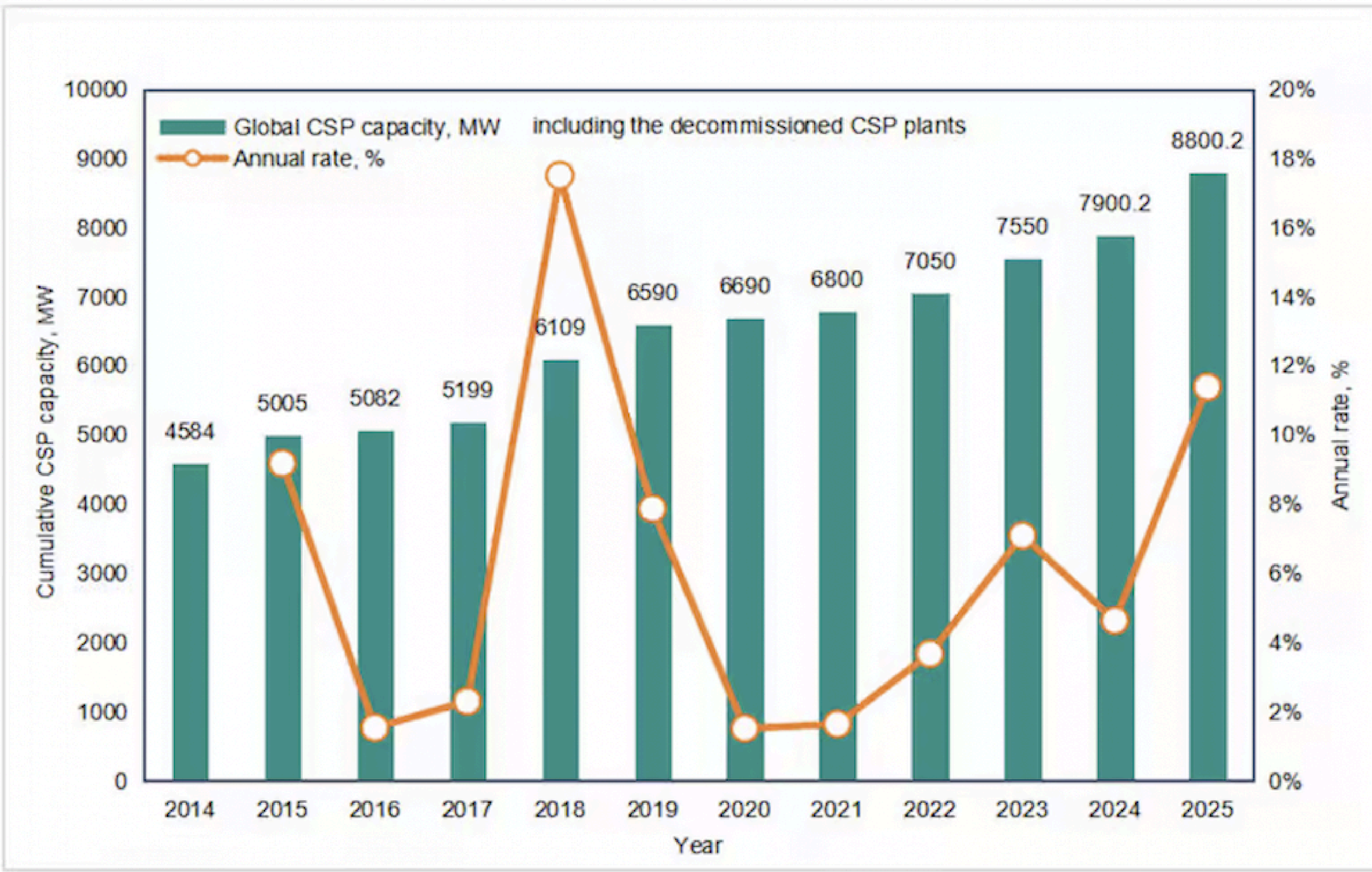


Figure 15: Global Cumulative Installed Capacity by Country/Region

2.3 Distribution by Solar Thermal Power Concentration Technology

In China's cumulative installed capacity: tower technology accounts for approximately 70.82%, trough technology 10.93%, linear Fresnel technology 14.50%, secondary reflection technology 2.88%.

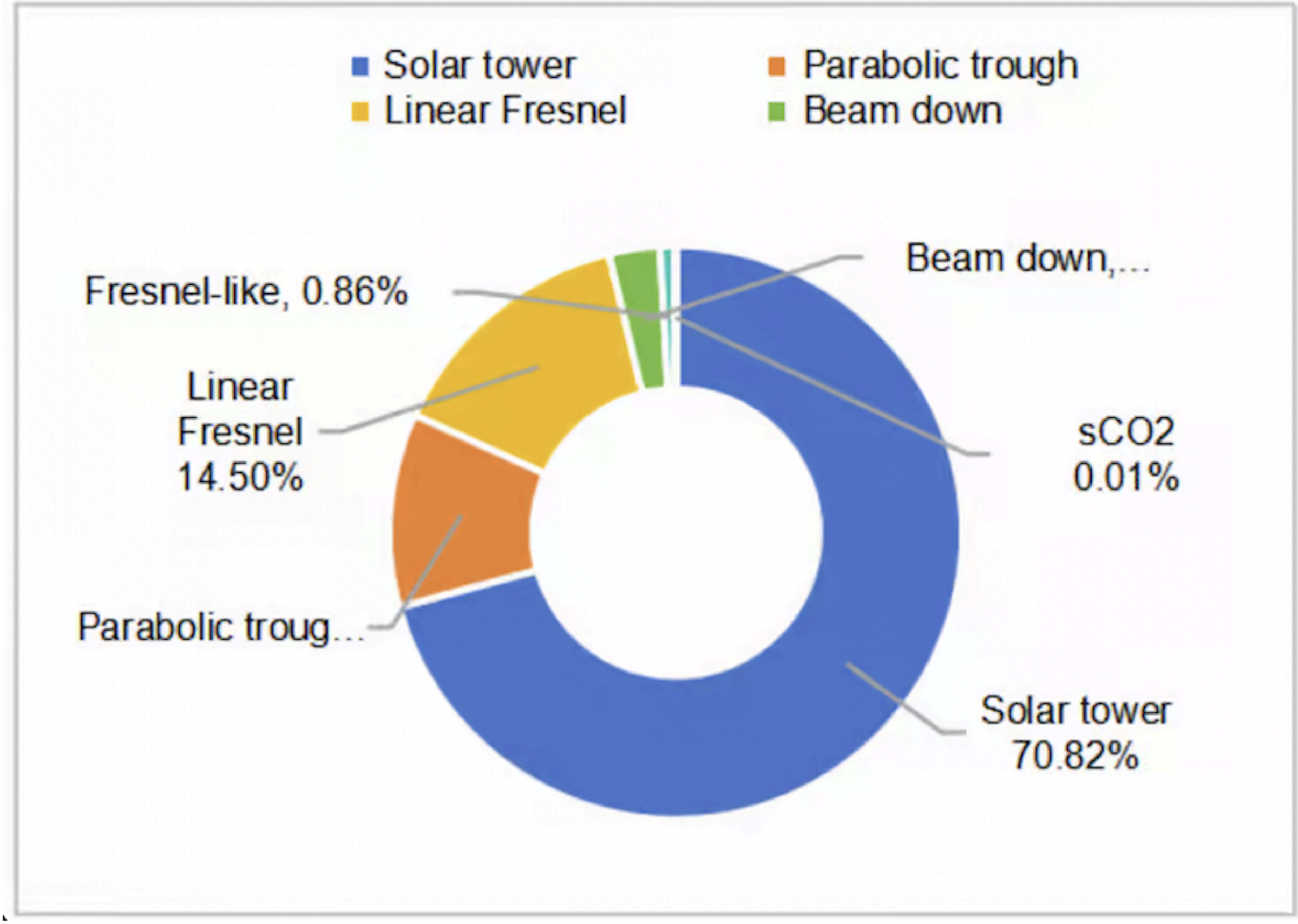


Figure 16: Distribution of Concentration Technologies in Cumulative Installed Capacity in China 2025

2.4 Projects Under Construction in China

Currently, there are approximately 22 solar thermal power projects in the substantive construction stage with a total installed capacity of 2,750MW.

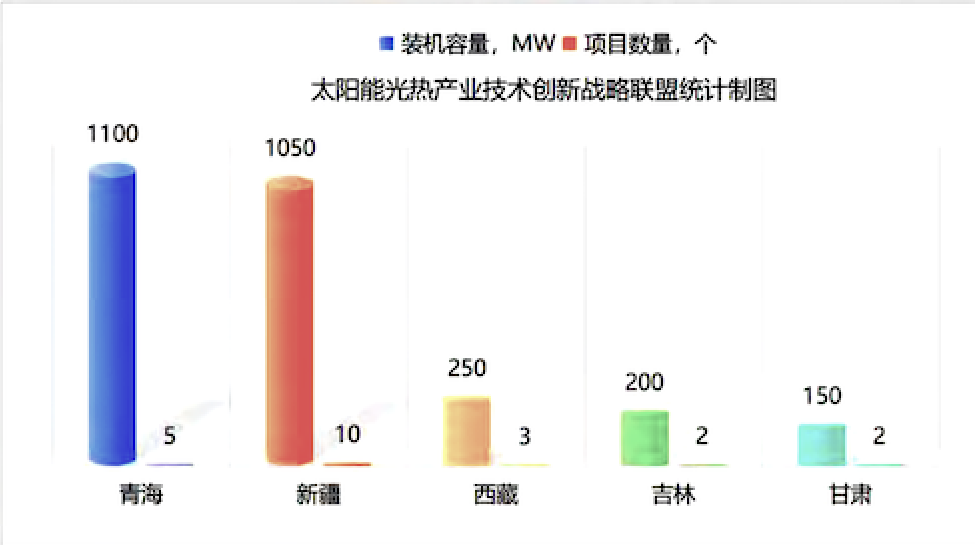


Figure 17: Distribution of Solar Thermal Power Projects Under Construction in China

青海 = Qinghai

新疆 = Xinjiang

西藏 = Tibet

吉林 = Jilin

甘肃 = Gansu

2.5 Planned and Proposed Solar Thermal Power Projects in China

Approximately 33 projects are planned and proposed, with a total installed capacity of approximately 4,200MW. By 2030, China's target is to reach around 15,000MW total installed capacity.

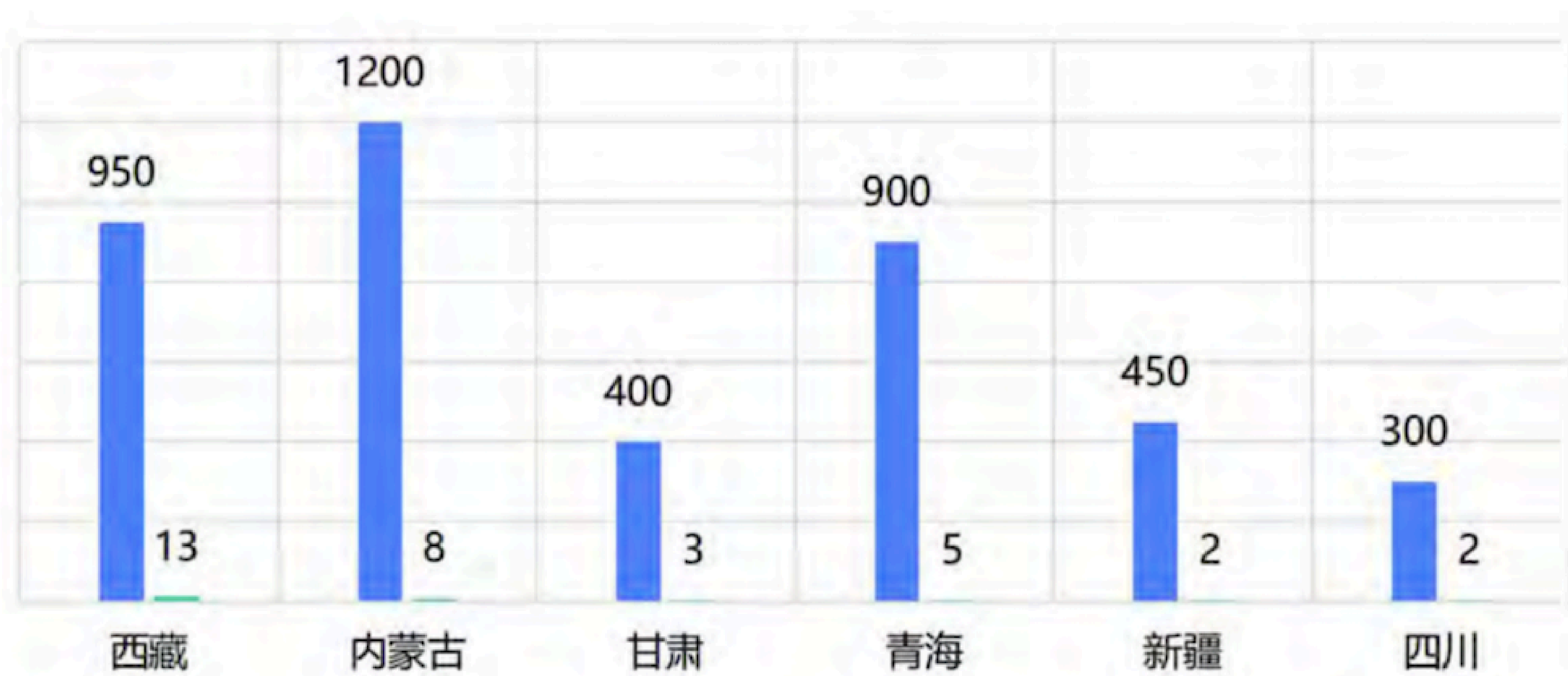


Figure 18: Distribution of Planned and Proposed Solar Thermal Power Projects in China

西藏 Tibet

内蒙古 Inner Mongolia

甘肃 Gansu

青海 Qinghai

新疆 Xinjiang

四川 Sichuan

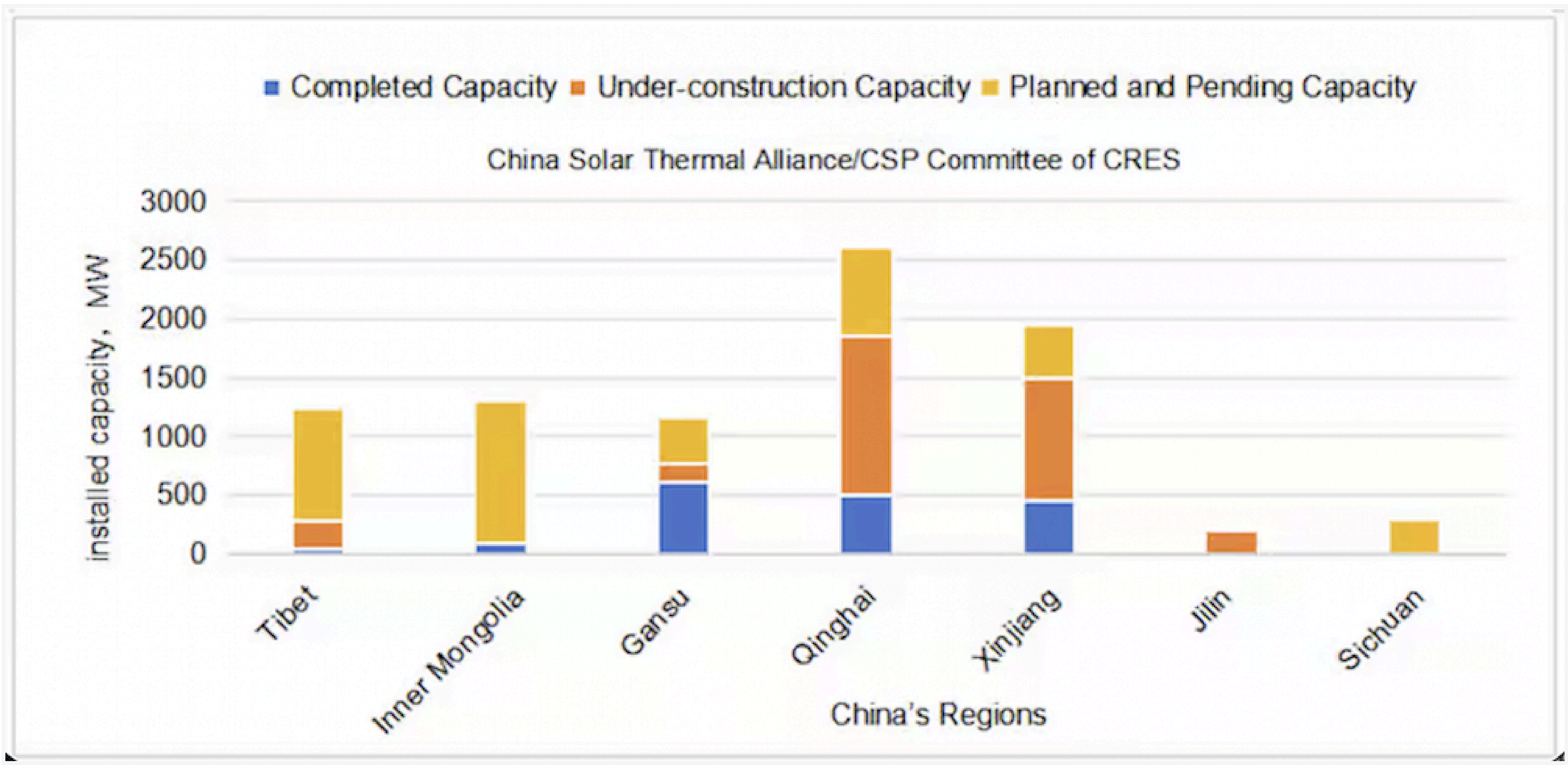


Figure 19: Total Solar Thermal Power Installed Capacity by Province in Northwest China

Built, Under Construction, and Planned

3. Operation of Solar Thermal Power Demonstration Projects

Key Demonstration Projects Performance Summary (2025):

Project	Capacity	2025 Generation	Key Achievements
CGN Delingha Trough	50MW	146.38 million kWh	3.67% YoY increase
Shouhang Dunhuang Tower	100MW	244.82 million kWh	3.7% YoY increase
Luneng Golmud Tower	50MW	148.23 million kWh	55.92% YoY increase

3.9 200kW Supercritical CO2 Solar Thermal Power System

On May 28, 2024, at 19:01, the world's first supercritical carbon dioxide solar thermal power system successfully generated electricity. Receiver temperature and power: 700°C/1MWth. Turbine generator set: 550°C/14MPa/0.2MW.

Figure 20: Supercritical Carbon Dioxide Solar Thermal Power System Located in Yanqing, Beijing


12-21-2025 星期日 12:20:38

Figure 21: Solar Particle Heat Collection System Working on Winter Solstice Day 2025 in Yanqing, Beijing

3.10 Longteng Solar Molten Salt Large Trough Collector System

Figure 22: Longteng Solar Molten Salt Trough Concentration and Collection System Verification Platform

Source: Longteng Solar

Table 5: Technical Parameters of Longteng Solar Platform

Parameter	Value
Heat Collection Area	2,376 m²
Collector Aperture Width	8.6 m
Design Maximum Outlet Temperature	565°C

Parameter	Value
Heat Transfer/Storage Medium	Binary Nitrate Salt

4. Solar Thermal Power Industry Chain

China has established a relatively complete solar thermal power industry chain. Domestic production rate of core equipment exceeds 90%. Major achievements include development of large-aperture heliostats and 8.6m trough collectors, breakthrough in high-temperature molten salt receivers, and mass production of vacuum receiver tubes.

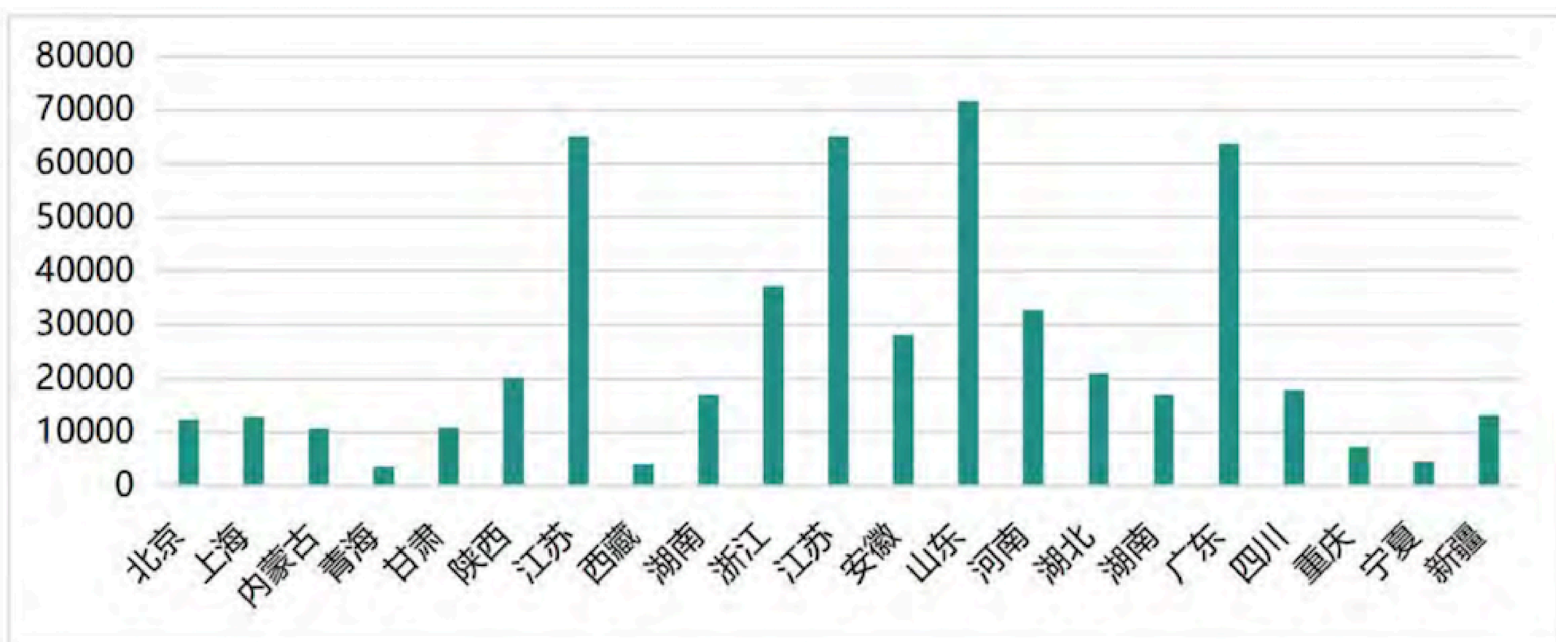


Figure 23: Locations of the industrial supply chain for China's CSP by province as of 2025

X-axis shows the provinces (left to right) - four leading provinces in **bold**:

北京 Beijing

上海 Shanghai

内蒙古 Inner Mongolia

青海 Qinghai

甘肃 Gansu

陕西 Shaanxi

江苏 **Jiangsu**

西藏 Tibet

湖南 Hunan

浙江 Zhejiang

辽宁 **Liaoning**

安徽 Anhui

山东 **Shandong**

河南 Henan

湖北 Hubei

广东 **Guangdong**

四川 Sichuan

重庆 Chongqing

宁夏 Ningxia

新疆 Xinjiang

5. Solar Thermal Power Technology R&D Status

China has invested significantly in solar thermal power R&D through the National Key R&D Program. Research areas include ultra-high temperature heat collection, advanced thermal storage materials, high-efficiency receivers, supercritical CO_2 power cycles, and multi-energy complementary systems.

6. Techno-Economic Analysis of Solar Thermal Power

6.3 Core Positioning and Application Scenarios

Solar thermal power is positioned as:

- Green low-carbon base guaranteed power source
- Peak regulation and frequency regulation power source
- Long-duration energy storage at power plant scale

- Grid support service provider (voltage, frequency, inertia)

7. Carbon Emission Reduction from Solar Thermal Power

7.1 Carbon Footprint Factor of Solar Thermal Power

The carbon footprint factor for solar thermal power generation is 0.0312 kgCO_2e/kWh, significantly lower than photovoltaic power (0.0520 kgCO_2e/kWh).

Table 6: Carbon Footprint Factors for Different Power Generation Types

Power Generation Type	Carbon Footprint Factor (kgCO_2e/kWh)
Wind Power	0.0110
Nuclear Power	0.0115
Hydropower	0.0118
Solar Thermal Power	0.0312
Photovoltaic Power	0.0520
Natural Gas Power	~0.4-0.5
Coal Power	~0.8-1.0

8. Development Recommendations for Solar

Thermal Power

8.1 Existing Problems and Challenges

1. Solar thermal power costs remain relatively high compared to mature technologies
2. High technical complexity requires specialized expertise
3. Need to enhance system peak regulation support capacity

8.2 Development Recommendations

- Promptly study and issue compensation mechanisms
- Strengthen top-level design and planning guidance
- Evaluate solar thermal-PV integrated projects
- Promote classified large-scale diversified development
- Accelerate technology and industrial innovation

Conclusion

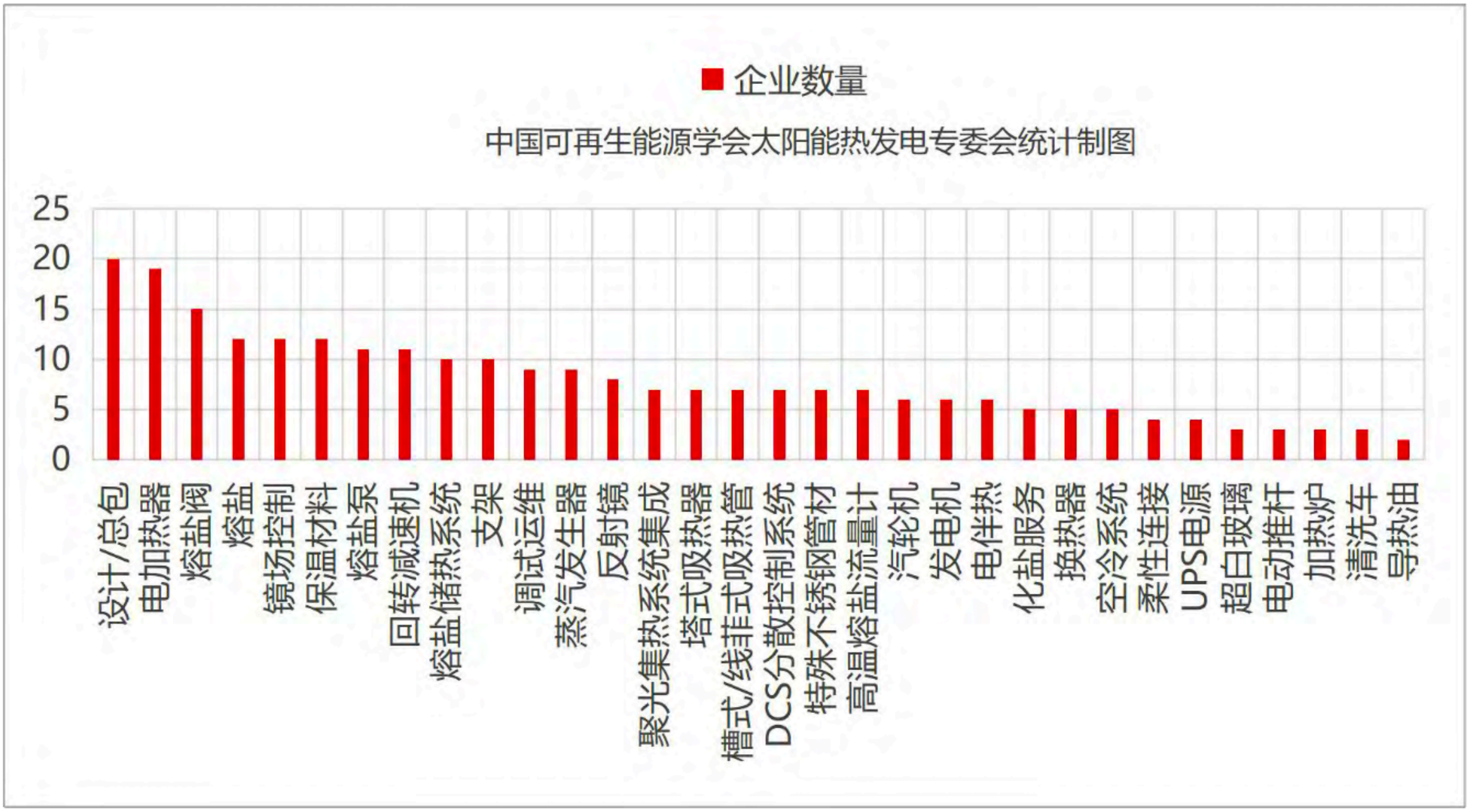
The year 2025 marks a significant milestone in China's solar thermal power industry development. With cumulative installed capacity reaching 1,738.2MW and the release of supportive national policies setting a 2030 target of 15GW, the industry has entered a new phase of large-scale development.
China has established a complete industrial chain, achieved technological breakthroughs including the world's first supercritical CO_2 solar thermal power system, and accumulated valuable operational experience. Demonstration projects have shown consistent performance improvements, with several achieving record-high annual generation in 2025.

The integration of solar thermal power with wind and photovoltaic power in large-scale renewable energy bases, combined with its unique dispatchability and long-duration storage capabilities, positions it as a crucial technology for China's energy transition. Looking ahead, continued focus on cost reduction through technological innovation, economies of scale, and optimized operations will be essential for realizing its full potential in China's journey toward carbon neutrality.

9. Appendix

9.1 Solar Thermal Power Industry Statistics

Figure 24: Number of Companies in China's Solar Thermal Power Industry by Type



Translation of Chart Elements:

- **Title:** 企业数量　Number of Companies
- **Subtitle:** 中国可再生能源学会太阳能热发电专委会统计制图　Statistics Chart by China Renewable Energy Society Solar Thermal Power Committee
- **Y-axis:** Company count (0-25)
- **X-axis:** Various company names in the solar thermal power industry

Description: This bar chart displays the distribution of companies across different categories in China's solar thermal power industry. The chart shows approximately 40 different companies or organizations, with the number of companies per category ranging from 20 at the highest to 2 at the lowest. The top three categories each have approximately 15-20 companies, indicating strong industry participation in these key sectors.

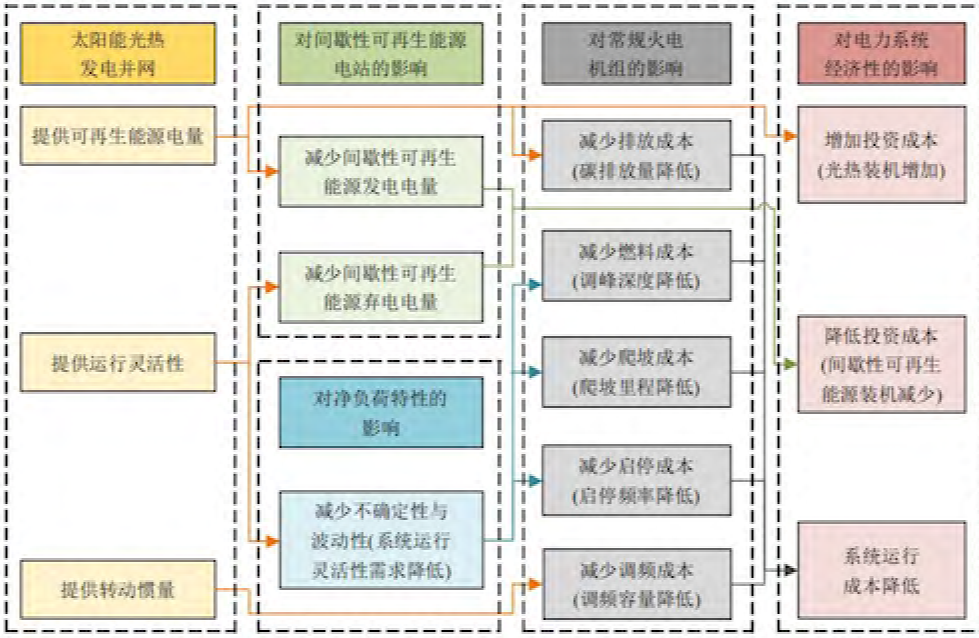


Figure 25: Solar Thermal Power Grid Integration - System Impact Analysis

Reading from top to bottom:

Column 1 - Solar Thermal Power Capabilities (Yellow boxes):

Solar Thermal Power Grid Connection

Provide Renewable Energy Electricity

Provide Operational Flexibility

Provide Rotational Inertia

Column 2 - Impact on Renewable Energy and Grid Characteristics (Green/Blue boxes):

Impact on Intermittent Renewable Energy Power Plants

Reduce Intermittent Renewable Energy Generation

Reduce Intermittent Renewable Energy Curtailment

Impact on Net Load Characteristics

Reduce Uncertainty and Volatility (System Operation Flexibility Demand Decreases)

Column 3 - Impact on Conventional Thermal Power Units (Gray boxes):

Impact on Conventional Thermal Power Units Economics

Reduce Emission Costs (Carbon Emissions Decrease)

Reduce Fuel Costs (Peak Regulation Depth Decreases)

Reduce Ramping Costs (Ramping Distance Decreases)

Reduce Start-Stop Costs (Start-Stop Frequency Decreases)

Reduce Frequency Regulation Costs (Frequency Regulation Capacity Decreases)

Column 4 - Impact on Power System Economics (Pink boxes):

Impact on Power System Economics

Increase Investment Costs (CSP Capacity Addition)

Reduce Investment Costs (Intermittent Renewable Energy Capacity Reduction)

System Operation Costs Decrease

Analysis: This flowchart illustrates the comprehensive value proposition of solar thermal power integration into the grid. It demonstrates how solar thermal power provides multiple benefits: reducing curtailment of intermittent renewables, lowering operational costs of conventional power plants across five different cost categories, and ultimately reducing overall system operating costs despite the initial capital investment in CSP capacity.

9.2 National Voluntary Greenhouse Gas Emission Reduction (CCER) Trading

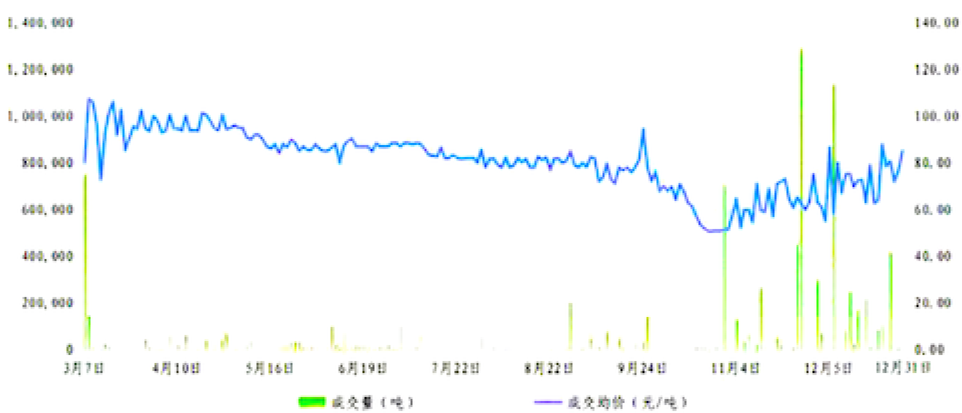


Figure 26: CCER Trading Volume and Average Price Throughout 2025

Green bars: Trading Volume (tons)

Blue line: Average Trading Price (yuan/ton)

- **X-axis:** Dates from March 7 to December 31 2025

- **Left Y-axis:** Trading volume (0 to 1,400,000 tons)
- **Right Y-axis:** Price (0.00 to 140.00 yuan/ton)

Key Observations:

- Trading volume remained relatively low throughout most of 2025, with occasional spikes
- Major volume peaks occurred in mid-November and early December, with the highest spike exceeding 1.2 million tons
- Average trading price started around 80-100 yuan/ton in March
- Prices remained relatively stable at 85-95 yuan/ton through mid-year
- A significant price surge occurred in November-December, with peaks reaching approximately 125 yuan/ton
- Year-end prices stabilized around 80-90 yuan/ton

Market Significance: This chart demonstrates the growing maturity of China's voluntary carbon market for solar thermal power projects. The increased trading activity in Q4 2025, particularly the volume spikes in November-December coinciding with price increases, suggests heightened market interest and liquidity as the year-end approached, likely driven by corporate carbon neutrality commitments and policy deadlines.

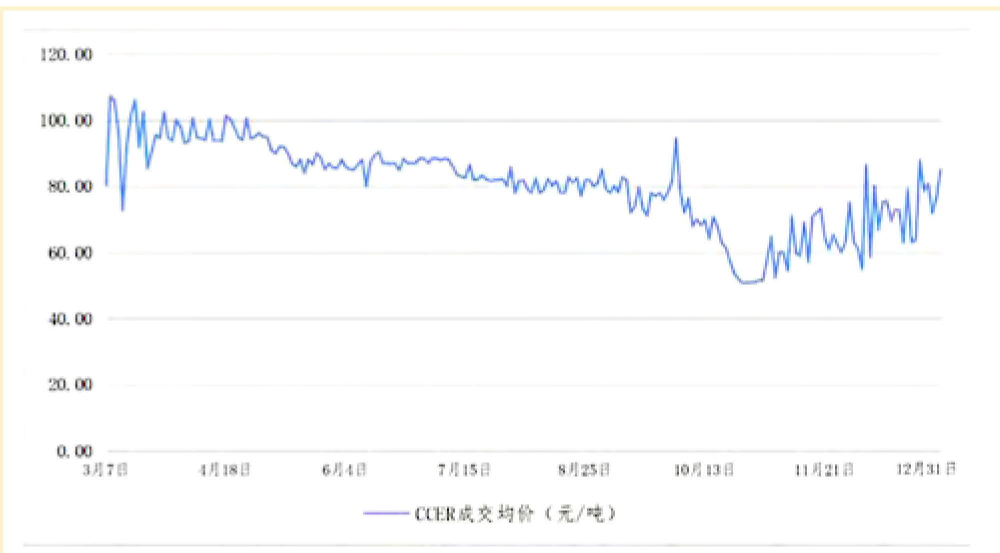


Figure 27: CCER Average Trading Price Trend (2025)

- **X-axis:** Dates from March 7 to December 31, 2025
- **Y-axis:** Price range (0.00 to 120.00 yuan/ton)

Price Trend Analysis:

- **Q1 2025 (March):** Starting price approximately 80-110 yuan/ton with high volatility
- **Q2 2025 (April-June):** Price stabilization around 85-100 yuan/ton
- **Q3 2025 (July-September):** Gradual decline from 85 to 75 yuan/ton
- **Early Q4 2025 (October):** Sharp drop to year's lowest point of approximately 50 yuan/ton

- **Late Q4 2025 (November-December):** Strong recovery with a spike to approximately 95 yuan/ton in late November, followed by stabilization at 70-85 yuan/ton by year-end

Market Interpretation: The October price trough likely reflects a combination of increased CCER supply from newly registered projects and reduced demand during the mid-year period. The subsequent Q4 recovery demonstrates renewed market confidence and increased corporate purchasing ahead of annual compliance and reporting deadlines. The year ended with prices approximately 10-15% lower than the March opening, suggesting market maturation and improved price discovery mechanisms.

9.3 Solar Thermal Power Projects Registered for CCER Trading

Several solar thermal power demonstration projects have successfully registered for China's voluntary greenhouse gas emission reduction trading system (CCER), contributing to carbon neutrality goals. Key registered projects include:

- CPECC Hami 50MW Molten Salt Tower CSP Independent Power Generation Project
- Qinghai Luneng Golmud Multi-Energy Complementary 50MW Tower CSP Project
- Dunhuang Shouhang Energy 10MW Molten Salt Tower CSP Project
- Dunhuang Shouhang Energy 100MW Molten Salt Tower CSP Project
- CGN Solar Energy Delingha Phase I 50MW Trough CSP Independent Power Generation Project

These projects demonstrate the dual value proposition of solar thermal power: providing clean, dispatchable electricity while generating tradable carbon credits that enhance project economics and support China's carbon neutrality objectives.

Summary of Appendix Findings

The appendix data provides crucial supplementary evidence supporting the main report's conclusions:

Industry Structure (Figure 24): The diversity and quantity of companies across different sectors demonstrates a mature and comprehensive industrial ecosystem capable of supporting large-scale solar thermal power deployment.

System Value (Figure 25): The multi-dimensional impact analysis reveals that solar thermal power delivers value far beyond simple electricity generation, providing essential grid services that reduce costs across multiple categories of conventional power plant operations while enabling higher penetrations of intermittent renewables.

Carbon Market Development (Figures 26-27): The CCER trading data from 2025 shows an emerging but increasingly active voluntary carbon market for solar thermal power projects. Despite some volatility, the market demonstrated resilience and recovered from mid-year lows, closing the year with healthy trading activity. This provides an important additional revenue stream that improves project economics and demonstrates market recognition of solar thermal power's environmental benefits.

Together, these appendix materials reinforce the central narrative of the Blue Book: China's solar thermal power industry has achieved critical mass in terms of industrial capacity, demonstrated clear system value beyond energy generation, and is beginning to monetize its environmental benefits through carbon markets—all essential foundations for the industry's transition from demonstration to large-scale commercial deployment toward the 2030 target of 15GW installed capacity.