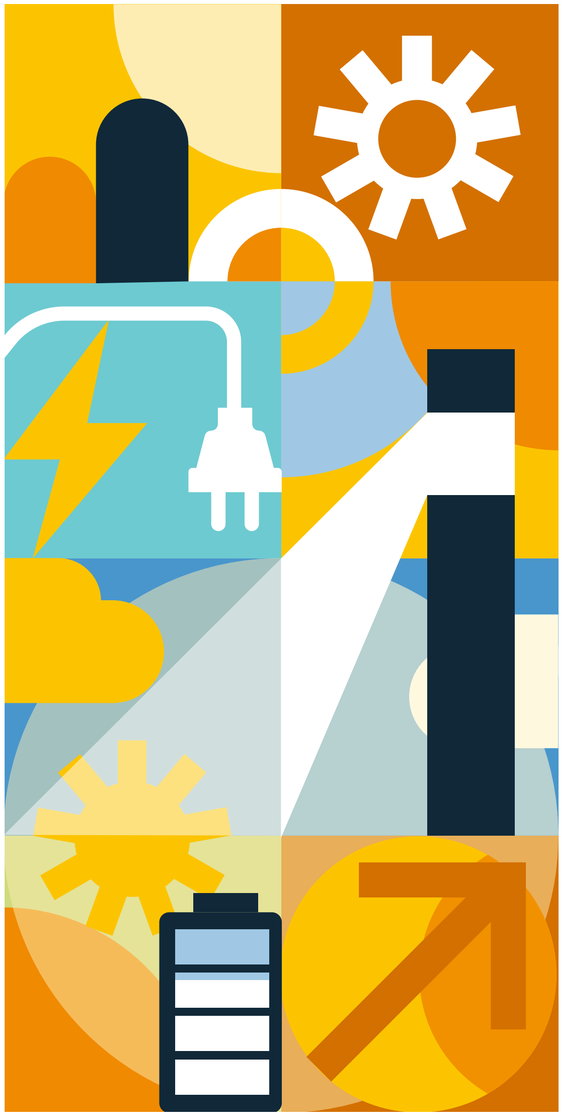


CONCENTRATED SOLAR THERMAL POWER (CSP)

KEY FACTS FOR 2024

- 350 MW of CSP generation capacity was connected to the grid in 2024, 250 MW of which in China.
- China's CSP market is growing rapidly, with some 8.1 GW of projects in various stages of development, construction and commissioning at the end of 2024 – more than the total installed capacity globally in 2024 (7.2 GW).
- In South Africa, the long-delayed 100 MW Redstone project came online in 2024.
- In 2024, there was little commercial CSP activity outside of China.

7.2 GW
total global installed CSP capacity in 2024.

350 MW
of CSP generation capacity was connected to the grid in 2024.

China
is set to become the lead market for CSP, with 8.1 GW of projects in various stages of development.

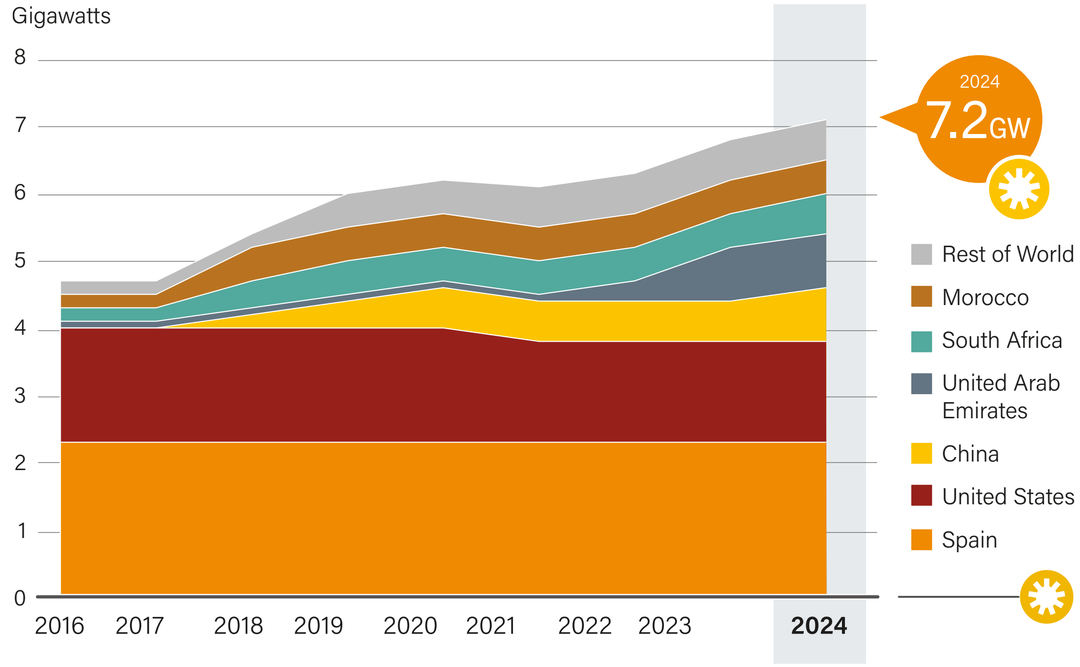
CSP MARKETS

In 2024, the trend of CSP capacity growth continued, as China's pipeline grew further and the first projects under the current 14th Five-Year Plan (FYP) were connected to the grid.[1] Total global installed capacity grew by 350 Megawatt (MW) and reached 7.2 Gigawatt (GW); (→ *See Figure CSP-1*).[2]

Global growth in CSP capacity is now driven by the expansion of the **Chinese CSP market**, which is supported by favourable policies.[4] In 2024, several key policies relevant to CSP[5] were adopted at national and provincial levels, including a provincial feed-in tariff for standalone CSP projects of CYN 0.55 per kWh (approx. 7.6 US cents/kWh) in Qinghai province[6] and China's new Energy Law, which includes a national goal to develop CSP.[7] Building on the successful technical demonstration of Chinses CSP designs during the 13th FYP (2016-2020), during the 14th FYP (2021-2025), construction has commenced on some 34 CSP plants co-located with other renewables projects (so called "CSP+" projects).[8] The majority of these CSP+ projects co-locate 100 MW CSP towers with several hundred MW of solar PV or wind generation capacity.[9] A minority deploy parabolic trough or Fresnel plants instead of towers.[10] These hybrid projects are meant to evaluate the potential of CSP as a storage and peak-shaving resource to stabilise the Chinese grid as it becomes increasingly reliant on intermittent renewable generation.[11] In 2024, three projects started to produce power, so that total installed capacity grew by 250 MW.[12] The pipeline of plants under construction grew to some 3.3 GW, a large fraction of which is expected to be completed in 2025.[13] Additional projects totalling a further 4.8 GW are in the planning stage for the 15th FYP (2026-2030).[14] For the 15th FYP, developers are asked to increase the share of CSP capacity in CSP+ projects, initially to 200 MW CSP per project, with the intention of reaching GW-scale CSP projects by 2030.[15]

Two CSP+ projects completed in China in 2024 are located in the Gobi desert renewable generation bases[16] in Gansu province and employ two different technical approaches.[17] The first project, constructed by China's National Nuclear Corporation (CNNC) in Yumen, has been in operation since September 2024. This 700 MW hybrid project includes, as of 2024, the largest operational Fresnel CSP plant (100 MW) with molten salt as heat transfer medium. The plant is hybridised with 400 MW PV and 200 MW wind generation capacity and features eight hours of storage capacity.[18] Similarly, the Huidong New Energy Akesai facility, commissioned in November 2024, combines a 110 MW molten salt tower CSP plant with 640 MW of PV, forming a 750 MW CSP-PV hybrid.[19] The third project completed in 2024 was a 40 MW parabolic trough installation in the city of Zabuye in the Tibet Autonomous Region. This project pioneers the use of CSP for combined heat and power (CHP) at very high altitude - over 4,500 meters above sea level. The project will supply continuous electricity and solar industrial process heat (SIPH) in the form of steam to an off-grid lithium processing facility.[20] Notably, the plant

FIGURE CSP-1
Global installed Concentrated Solar Thermal Power Capacity by Country, 2015-2024



Source: See endnote 2 for this section.

2.3 GW

Spain has the largest installed CSP capacity in the world, but saw no new commercial activity in 2024.

employs the well proven **Eurotrough**[21] (like the two previous Chinese parabolic trough plants[22]) and includes a 16-hour thermal energy storage system, supplemented by a 20 MW/40 MWh battery and 35 MW of solar PV. The rapid construction in just under two years, under harsh conditions and in a region with no previous CSP references, highlights the increasing project delivery capabilities of the Chinese supply chain.[23] Collectively, these 2024 projects attest to China's commitment to CSP deployment using different configurations (Fresnel, tower, trough) and applications (hybridisation with other renewable energy sources, industrial CHP).[24]

In **Europe**, there was very little commercial CSP activity in 2024; no additional CSP plants started construction or were completed. In **Italy**, the CSP 3 Bilancia project, a 4 MW Fresnel plant with 16 hours of storage, was slated for completion in 2024 but appears to be still unfinished in early 2025. It would contribute to Italy's National Energy and Climate Plan (NECP) target of 873 MW of CSP capacity by 2030 (currently just below 10 MW).[25] In **Spain**, which had the largest installed CSP capacity of any country in the world, at 2.3 GW, due to an ambitious deployment programme between 2008 and 2013.[26] 2024 once again saw no commercial activity that would lead to new plants. There remains an implementation gap to deliver on the ambitious goal of 4.8 GW of CSP by 2030 in Spain's updated NECP.[27] After a failed 220 MW CSP auction in 2022, which did not result in the awarding of any projects,[28] Spain held no additional auctions in 2023 or 2024. If any new CSP capacity is to be completed by 2030, given the typical project lead time of three to five years, a European project pipeline will need to emerge soon.[29]

In **Australia**, Vast Solar continued its efforts in 2024 to financially close the VS1 project at Port Augusta, which will deliver power and heat to a green methanol plant.[30] The 30 MW/288 MWh VS1 plant employs third-generation CSP technology that uses sodium as heat transfer fluid. A 150 MW expansion of the plant is planned.[31] In 2024, the company conducted successful tests of the receiver.[32] Another project in the advanced planning stages is the 150 MW hybrid concentrated PV and 90 MW/720 MWh solar-thermal storage Yadnarie project by Raygen, which is planned to begin operations by 2027.[33]

In the **rest of the world**, no new CSP plants broke ground in 2024 and none are expected to be completed in 2025.[34] In **South Africa**, the Redstone project was connected to the grid in 2024.[35] It was developed jointly by the experienced Israeli-Chinese solar field developer BrightSource, the Chinese EPC SEPCO III, which was also involved with a Moroccan tower project, and experienced European suppliers including John Cockeril for the receiver and Siemens Energy for the turbine.[36] However, no new projects are expected, as CSP was excluded from planned capacity expansions in the Integrated Resource Plan updates of 2019 and 2023.[37] In **Morocco**, construction on the Noor Midelt 1 project has still not started, despite a power purchase agreement (PPA) awarded in 2019.[38] Two projects that were initially planned as PV-CSP hybrid plants, Noor Midelt 2 and 3, were awarded as PV plus battery projects in 2024.[39] The molten-salt tower Noor 3 was out of operation for most of 2024 due to a leak in the molten salt tank, but has resumed operations in early 2025.[40] In the **United States**, which is home to the second-largest installed CSP capacity at 1.5 GW, the Crescent Dunes project is once again operational after facing similar problems,[41] but there is no indication that any new projects are planned; while the 386 MW landmark Ivanpah plant, which does not include energy storage capabilities, is slated to close in 2026 as the electricity it produces is considered too expensive by the off-taker.[42]

POLICY AND MARKET DEVELOPMENTS TO WATCH

Several countries, including Botswana, Egypt, India, Italy, Kuwait and Spain, have previously announced their intentions to issue tenders for new CSP plants,[43] but no new tenders were launched or projects awarded in 2024. **India** was preparing a CSP tender for 2024 but has not announced the details.[44] Meanwhile, the deadline for awards under **Botswana**'s CSP tender passed in the spring of 2024, but results have not been announced.[45] Similarly, the tender for a 200 MW CSP plant as part of the Shagaya project in **Kuwait** has not yet yielded any results.[46]

INDUSTRY AND INNOVATION

The Chinese CSP industry continues to successfully innovate and is accumulating experience and building project delivery capabilities[47]. One path is through collaboration with experienced CSP companies from the early lead markets in Spain and the United States.[48] For example, the solar fields of two out of three Chinese projects commissioned in 2024 rely on the intellectual property (IP) and expertise of the experienced German company SBP Sonne for their solar fields, and were constructed by Chinese partners Dongfang and China Ship Building New Power.[49] Another pathway for learning has been through involvement as engineering, procurement and construction (EPC) companies in international projects; for example, the delivery of the Redstone project by SEPCO III, which is part of PowerChina.[50] Chinese companies are now moving beyond first-of-a-kind plants and delivering portfolios consisting of multiple plants, improving their processes through repetition and learning-by-doing. For example, Cosin Solar, had a pipeline of 11 tower plants under construction in 2024.[51] Improved automation allowed for a 30% faster installation of Stellio heliostats in the third solar field of the 100 MW Gonghe project, which is slated for completion in 2025, compared to the first solar field using the same heliostat.[52] Given the dearth of new projects outside China, Chinese companies are expected to strengthen their position and competitiveness in the global CSP supply chain.

As no additional projects were awarded or broke ground outside of China in 2024, no recent global cost data is available. In China, **CSP costs** decreased significantly under the 14th FYP.[53] The investment cost for a 100 MW tower with approximately 10 hours of storage was CNY 32,000/kW (approx. USD 4,444/kW) in the demonstration batch in the 13th FYP (2016-2020),[54] but was reduced to CNY 16,000-16,200/kW (approx. USD 2,222-2,251/kW) for the most recent plants.[55] As a result, the installation costs of the 750 MW Huidong New Energy Akesai hybrid plant are quoted at CNY 7200/kW (approx. USD 930/kW),[56] contrasting sharply with much higher costs for international projects like South Africa's Redstone (approx. USD 7,360/kW).[57] The Chinese CSP industry aims to reduce CSP installation costs further to below CNY 11,000/kW (approx. USD 1,530/kW) for larger plants (≥600 MW) by the late 2020s, through optimised operation and maintenance, and supply chain efficiency.[58] In China, the revenue of hybrid projects is still often aligned with local coal benchmarks; the two completed CSP+ projects in Gansu receive CNY 0.31/kWh (approx. 4.3 US cents/kWh).[59] This is far below the CSP-specific tariffs seen internationally, such as the 7.3 US cents/kWh enshrined in the 2017 PPA for Noor Energy 1 (~9.4 cents in 2024 dollars).[60] The low tariff in Gansu can be attributed to the high share of PV in the project, which has a much lower installation cost than CSP. In contrast, standalone CSP projects in Qinghai receive CNY 0.55/kWh (approx. 7.6 US cents/kWh) under the province's new feed-in tariff.[61] China is targeting a levelised cost of electricity (LCOE) for CSP in the range of 5-7 US cents/kWh for the near future.[62] The Chinese project that the LCOE could go below 5 US cents/kWh once higher-temperature CSP plants become commercially available[63] – which is in the range of the US Department of Energy's SunShot goal for 2030.[64]

Indeed, progress towards **advanced third generation CSP** is picking up speed in China. The Chinese Academy of Sciences completed a 0.2 MW demonstration plant showcasing particle receiver technology that reached 800°C to deliver power via an sCO_2 cycle in May 2024.[65] In the **United States**, Sandia National Laboratories tested the receiver of G3P3, a 1 MW demonstration plant under construction since 2023, that will demonstrate falling particle receiver technology.[66] The California startup Heliogen terminated its 5 MW demonstration facility after the design phase to focus its efforts on second generation CSP.[67] In Europe, **Swiss** startup Synhelion completed its demonstration plant for solar-chemical hydrocarbon production, DAWN, which is located in Jülich, **Germany**.[68]

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800 °C

Peak temperature reached by China's new particle receiver CSP technology in 2024, advancing third-generation CSP and sCO_2 cycle applications.

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PRODUCTION AND COMMUNICATION

REN21 Secretariat, Paris, France

The endnotes for this fact sheet are available to download on

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