



Task 1 Strategic PV Analysis and Outreach

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# National Survey Report of PV Power Applications in CHINA 2023





## What is IEA PVPS TCP?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The Technology Collaboration Programme (TCP) was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of 6.000 experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the TCP's within the IEA and was established in 1993. The mission of the programme is to “enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems.” In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct ‘Tasks,’ that may be research projects or activity areas.

The 25 IEA PVPS participating countries are Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkiye, and the United States of America. The European Commission, Solar Power Europe and the Solar Energy Research Institute of Singapore are also members.

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## What is IEA PVPS Task 1?

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. An important deliverable of Task 1 is the annual “Trends in photovoltaic applications” report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the country National Survey Report for the year 2023. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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### COVER PICTURE

Photo provided by Dr.Bingnan Wang, National Center of Supervision & Inspection on Solar Photovoltaic Products Quality (CPVT)



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# 1 INSTALLATION DATA

The PV power systems market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, PV installations are included in the 2023 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2023, although commissioning may have taken place at a later date.

## 1.1 Applications for Photovoltaics

By the end of 2023, China's cumulative installed capacity of renewable energy had exceeded 1,517GW, which was an increase of 24.9% from 2022, accounting for 51.9% of the country's total installed capacity of power generation. It's historically exceeding the total installed capacity of thermal power, and the share of coal power installed capacity had dropped to below 40% for the first time. Among the cumulative installed capacity, wind power is 441GW(AC) and solar power is 609GW(AC) .

In 2023 , China's new PV installation was 216.3GW(AC), up 147.5% year-on-year. Among them, utility PV installed 120.01GW, up 230.7% year-on-year while distributed PV installed 96.29GW, up 88.4% year-on-year.

Benefiting from the large-scale grid connection of the first batch of utility-scale, centralized PV new installations in 2023 reversed the distributed. In terms of distributed PV types, the new installation of commercial and industrial was 52.81GW, accounting for 24.4% of the PV new installation while the residential PV was 43.48GW, accounting for 20.1%.

In April 2023, the Guiding Opinions on Energy Work in 2023 issued by the National Energy Administration emphasized the need to start the construction of offshore PV. All coastal provinces have accelerated the layout of offshore PV construction, and have successively issued specific rules to support the development of offshore PV. Offshore PV is mainly divided into pile-fixed and floating two major types. At present, China's offshore floating PV is mainly focused on experiments, harbor testing, and demonstration projects.

## 1.2 Total photovoltaic power installed

Table 1: Annual PV power installed during calendar year 2023

		Installed PV capacity in 2023 [MW]	AC or DC
	Decentralized	96290	AC
	Centralized	120010	AC
	Off-grid	-	-
	<b>Total</b>	<b>216300</b>	<b>AC</b>

**Table 2: Data collection process**

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	Decentralized : AC $\approx$ DC Centralized : DC=AC* 1.2
Is the collection process done by an official body or a private company/Association?	Data on annual and accumulated PV grid-connected installation capacity in 2023 were published by National Energy Administration. Off-grid installation accounts for a very small scale in China so the data was estimated by PV experts.
Link to official statistics (if this exists)	<a href="http://www.nea.gov.cn/">http://www.nea.gov.cn/</a>

**Table 3: The cumulative installed PV power in 4 sub-markets (In AC)**

Year	Off-grid [MW]	Grid-connected distributed [MW]	Grid-connected centralized [MW]	Total [MW]
2010	0	190	283	800
2011	0	680	2000	3500
2012	0	890	2630	7060
2013	0	3100	16,320	19,420
2014	0	4670	23,380	28,050
2015	0	6060	37,120	43,180
2016	0	10,320	67,100	77,420
2017	0	29,660	100,540	130,200
2018	0	50,620	123,840	174,460
2019	0	62,630	141,670	204,300
2020	0	78,310	174,790	253,100
2021	0	107,510	198,480	305,990
2022	0	157,620	234,420	392,040
2023	0	254,440	354,480	608,920

**Table 4: Other PV market information (In AC)**

	2023
Number of PV systems in operation in your country	Total installed 216.3GW Distributed PV 96.29GW ; utility PV 120.01GW.
Decommissioned PV systems during the year [MW]	N/A
Repowered PV systems during the year [MW]	N/A

**Table 5: PV power and the broader national energy market**

	Data(2022)	Data(2023)
Total power generation capacities [GW]	2564GW	2920GW
Total renewable power generation capacities (including hydropower) [GW]	1213GW	1517GW
Total electricity demand [TWh]	8640 TWh	9220TWh
New power generation capacities installed [GW]	<b>199.74GW</b>	369GW
New renewable power generation capacities (including hydropower) [GW]	152.25GW (hyd. 23.87 GW, wind 37.63 GW, PV 87.41 GW, Bio 3.34 GW)	303GW (hyd. 7.58 GW, wind 75.66 GW, PV 216 GW, Bio 2.82 GW)
Estimated total PV electricity production (including self-consumed PV electricity) in [GWh] (or [TWh])	432 TWh	583 TWh
Total PV electricity production as a % of total electricity consumption	5%	6%
Average yield of PV installations (in kWh/kWp)	1500 kWh/kWp	1400kWh/kWp





## 2 COMPETITIVENESS OF PV ELECTRICITY

### 2.1 Module prices

Table 6: Typical module prices

Year	Lowest price of a standard module crystalline silicon	Highest price of a standard module crystalline silicon	Typical price of a standard module crystalline silicon
2023	0.9 Yuan/W	1.8 Yuan/W	1 Yuan/W

### 2.2 System prices

Table 7: Turnkey PV system prices of different typical PV systems

Category/Size	Typical applications and brief details	Current prices [Yuan/W]
Residential BAPV 5-10 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected households. Typically roof-mounted systems on villas and single-family homes.	3.8
Small commercial BAPV 10-100 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	3.6
Large commercial BAPV 100-250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected large commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	3.4
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected industrial buildings, warehouses, etc.	3.2
Small centralized PV 1-20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	3.3
Large centralized PV >20 MW	Grid-connected, ground-mounted, centralized PV systems that work as central power station. The electricity generated in this type of facility is not tied to a specific customer and the purpose is to produce electricity for sale.	3.0

**Table 8: National trends in system prices for different applications**

Year	Residential BAPV  Grid-connected, roof-mounted, distributed PV system 5-10 kW [Yuan/W]	Small commercial BAPV  Grid-connected, roof-mounted, distributed PV systems 10-100 kW [Yuan/W]	Large commercial BAPV  Grid-connected, roof-mounted, distributed PV systems 100-250 kW [Yuan/W]	Centralized PV  Grid-connected, ground-mounted, centralized PV systems 10-50 MW [Yuan/W]
2023	3.8	3.6	3.4	3.0

## 2.3 Financial Parameters and specific financing programs

**Table 9: PV financing information in 2023**

Different market segments	Loan rate [%]
Average rate of loans – residential installations	4.3%
Average rate of loans – commercial installations	4.0%
Average cost of capital – industrial and ground-mounted installations	4.0%

## 2.4 Specific investments programs

### Financial Leasing

In 2023, centralized PV projects were dominated by utility-scale base projects while private enterprises acquired an increasingly smaller share of quotas in these projects, and financial leasing institutions played a greater role in distributed PV. The newly installed capacity of distributed PV reached 96.29GW in 2023, accounting for 44.5% of the total installation.

Unlike the investment entities for centralized PV projects, the development of distributed PV projects remains predominantly in the hands of private enterprises. Distributed PV is more suitable to adopt financial leasing as the main financing method due to the characteristics of small single scale, scattered project distribution, and difficult management, etc. Huaneng Tiancheng Financial Leasing, Yuexiu Leasing, Huaxia Financial Leasing, as representatives of leasing organizations, had financed distributed PV projects particularly in the residential PV for more than 100 billion yuan in 2023.

### Power Plant Transaction

In 2023, the scale of domestic PV power plant acquisitions was about 5.4GW, with transaction values exceeding 20 billion yuan. The major sellers of PV power plants were GCL New Energy, Chint Anneng, Trina Solar, etc., while the buyers were primarily State Power Investment Corporation (SPIC), China National Nuclear Corporation (CNNC), Huaneng Renewables, and Yuexiu Capital. Among them, SPIC's acquisition scale reached nearly 900MW, accounting for 17% of the total. Yuexiu Capital, which had the largest acquisition scale, has acquired and held more than 4GW of residential PV.



## 2.5 Additional Country information

Table 10: Country information

Retail electricity prices for a household [Yuan/kWh]	0.56-0.62
Retail electricity prices for a commercial company [Yuan/kWh]	0.5-1.25



### 3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

**Table 11: Summary of PV support measures**

Category	Residential			Commercial + Industrial			Centralized		
	Legacy	On-going	New	Legacy	On-going	New	Legacy	On-going	New
Feed-in tariffs	-	Yes	-	-	Yes	-	-	Yes	-
Feed-in premium (above market price)	-	-	-	-	-	-	-	-	-
Capital subsidies	-	-	-	-	-	-	-	-	-
Green certificates	-	Yes	-	-	Yes	-	-	Yes	-
Renewable portfolio standards with/without PV requirements	-	Yes	-	-	Yes	-	-	Yes	-
Income tax credits	-	-	-	-	-	-	-	-	-
Self-consumption	-	Yes	-	-	Yes	-	-	-	-
Net-metering	-	-	-	-	-	-	-	-	-
Net-billing	-	-	-	-	-	-	-	-	-
Collective self-consumption and delocalized net-metering	-	-	-	-	-	-	-	-	-
Sustainable building requirements	-	Yes	-	-	Yes	-	-	-	-
BIPV incentives	-	-	-	-	Yes	-	-	-	-
Merchant PV facilitating measures	-	-	-	-	-	-	-	-	-
Other (specify)	-	-	-	-	-	-	-	-	-



## 3.1 National targets for PV

China's goal of achieving a total installed capacity of over 1200GW for wind power and solar power by 2030 has been achieved six years ahead of schedule. By the end of July 2024, the combined installed capacity of wind power and PV power in China reached 1206GW<sup>1</sup>.

## 3.2 Direct support policies for PV installations

### 3.2.1 Mandatory solar

In April 2022, the General Specification for Building Energy Efficiency and Renewable Energy Utilization issued by the Ministry of Housing and Urban-Rural Development (MOHURD) came into effect, requiring that building energy efficiency design should be carried out for new buildings, expanded and renovated buildings, as well as energy-saving renovations of existing buildings. Among them, PV must be installed in new buildings.

In March 2022, the Ministry of Housing and Urban-Rural Development (MOHURD) issued the “14th Five-Year Plan” for the development of building energy efficiency and green buildings, clearly stating that by 2025, China aims to complete the energy-saving renovation of existing buildings with an area of more than 350 million square meters, and the new installed PV capacity in new buildings should reach more than 50GW.

In the project approval, land grant, construction plan review, Shanghai has implemented the relevant requirements, such as the proportion of PV installation on the roofs of new industrial plants, transportation facilities, public institutions is not less than 50%, while the PV proportion on the roofs of new public buildings and residential buildings is not less than 30%, according to the principle of “build as much as feasible”.

### 3.2.2 Development measures of accommodation

Same as in 2022, the incentive policy 2023 of the renewable energy power accommodation continued the RPS responsibility, strictly implementing the requirements for the proportion of renewable energy power in the West-East power transmission and cross-provincial & cross-region power transmission. The share in 2023 was in principle not less than the actual performance in 2022. As for the 2024 non-hydro power accommodation increased by 1.7 percentage points from 2023, which reflected a shared responsibility orientation for the accommodation of renewable energy.

To solve the problem of accommodation by upgrading the level of green power application. On the one hand, policy guidance has been used to increase the proportion of green power applications and promote the accommodation of new energy power. National Development and Reform Commission and other three ministries and commissions issued the Notice on Strengthening the Connection between Green Electricity Certificates and Energy Conservation and Carbon Reduction Policies to Vigorously Promote the accommodation of Non-fossil Energy, clearly requiring that non-fossil energy is not included in the total amount of energy accommodation and intensity of the regulation. Some regions have also issued documents to guide high energy-consuming enterprises to increase green power accommodation through the method of linking green power and green certificates with energy efficiency assessment.

On the other hand, the industry has made positive attempts to link PV with related scenarios. For example, PV hydrogen production is a large-scale controllable application scenario for

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<sup>1</sup> Source from National Energy Administration



green power, which can be used to enhance the accommodation of PV green power, and the green ammonia and green methanol industries derived from it also have high added value, which can become a new revenue growth point.

### **3.2.3 Development measures of the construction and management PV installation**

To pay equal attention to the construction of the utility-scale wind/PV power projects in desert, Gobi, and arid land areas, and PV/Wind/Hydro hybrid power in Southwest, and the development of distributed PV power. In terms of utility PV base development, the focus in 2023 was on promoting the layout and construction of the utility-scale wind/PV power projects in desert, Gobi, and arid land areas, with the first batch of utility-scale bases basically completed and connected to the grid during the year, and the second batch partially connected to the grid.

To regulate land use for PV power generation and implement categorized management. On March 28, China issued a notice on supporting the development of the PV power generation industry and regulating land management. It requires that the development plan of PV power generation industry should be well connected with the spatial planning of land. It encourages the development of PV power generation industry by utilizing unused land and inventory construction land. With the premise of strict ecological protection, it encourages the siting and construction of large PV bases in the Gobi desert regions. It centers on the implementation of categorized management of PV power generation land, making it clear that the power land shall not occupy arable land.

To standardize project development and reduce non-technical costs. In September 2023, the National Energy Administration issued the "Plan for Conducting Special Rectification Work on Improper Market Intervention Behaviors in the Fields of Renewable Energy and Hydro-pumped Storage Development," aiming to specifically rectify improper market intervention behaviors in the renewable energy and hydro-pumped storage industries.

The effectiveness of the "County-Scale PV Promotion" distributed PV roof pilot is obvious, coupled with the guiding materials developed by the National Energy Administration, triggered a hot trend of residential rooftop PV development. In 2023, the year-on-year growth of new distributed PV installation was about 80%, and the year-on-year growth of new residential PV installation was 72.8%.

The distributed PV is a multi-pronged approach of "County-Scale PV Promotion", industrial and commercial distributed, and residential PV. With the advancement of the power market and the adjustment of time-of-use tariff policy, more "PV+" fusion industry and business models appeared. For most of the central and eastern provinces, renewable energy is not included in the energy consumption control policies, RPS responsibility and the backdrop of declining PV product prices all contribute to the advancement of distributed projects.

In order to ensure that distributed PV "should be connected to the grid as much as possible," the National Energy Administration launched a pilot program to assess the carrying capacity of the power grid for distributed PV connections and to evaluate measures for enhancement.

### **3.2.4 Development measures of Feed-in tariffs**

In 2021-2022, newly approved wind power and newly filed PV power generation in the current year was connected to the grid with local coal benchmark prices. The continuation of the policy was halted in 2023, primarily because the scope and scale of renewable energy sources, such as PV, participating in the electricity market was expanding. Notably, a unified grid-parity policy



for new renewable energy generation had not been established. Since 2023, provinces have put forward corresponding requirements for market participation and formed feed-in tariffs based on current policies according to the percentage of new energy penetration of PV and other new energy sources, as well as the process of advancing the electricity market.

As the share of PV power generation continued to rise, many provinces adjusted their time-of-use tariff, and the range of midday, when PV power output is at its maximum, as a deep valley tariff of time-of-use expanded, and the peak-to-valley ratio increased.

In 2023, Hebei, Shanxi, Mengxi, Liaoning, Shandong, Zhejiang, Ningxia, Gansu, Qinghai, Xinjiang and other provinces and regions implemented the valley tariff in the midday, when PV power output is at its maximum, setting the season, time period, and proportion of fluctuation differently in the midday valley tariff. The range of valley is between 1~ 8 hours, and the valley tariff is between 46 ~ 70% below the flat load tariff.

The range of valley tariff continues to expand in 2024, for example, in Hubei Province, where 2 hours at noon is used as a valley segment. The impact of time-of-use tariff is not only on the demand side, but also on the grid-connection side, for example, the grid-connection side in Gansu in 2024 continues to implement time-of-use tariff. The transaction benchmark price of the peak, valley, flat load segments, is calculated by multiplying the coal benchmark price by a peak-to-valley time-of-use coefficient<sup>2</sup> for new energy enterprises participating in medium- and long-term trading. The transaction price should not exceed the transaction benchmark price.

Time-of-use tariff significantly reduced the levelized benefits of PV power generation. The low feed-in tariff made it difficult for some plants to make a profit, and even for self-consumption industrial and commercial distributed projects, problems were arisen with the implementation of fixed-agreement tariffs. But on the other hand, it also provided application space for PV and energy storage.

### **3.2.5 Development measures of PV energy storage**

Among the new energy storage related policies in various regions in 2023, China introduced a number of PV storage policies, involving centralized PV power plants as well as distributed. Among them, Tibet and Gansu had the longest time requirement for energy storage, reaching 4 hours, and Henan had the highest percentage requirement for energy storage, at 35-55%. Distributed storage policy was concentrated in Guangdong, Henan, Zhejiang, Hebei and other regions, and some distributed PV energy storage application cases may appear in these regions in 2024. In addition, Inner Mongolia also had a strong demand for PV energy storage, but these storage projects were mainly industrial parks green power supply projects, power generation, transmission, loading, and storage integration projects, Integrated wind and solar-powered hydrogen production projects, mostly wind and PV common consideration of the demand for energy storage.

In 2023, energy storage subsidies were more refined across the region, with the most subsidies especially for demand-side energy storage applications. In terms of demand-side energy storage subsidies, the main subsidies were energy storage plant discharge subsidies, one-time investment subsidies calculated on the basis of installed capacity. Anhui, Jiangsu, Zhejiang for PV and energy storage applications, also developed the corresponding subsidies, showing the purpose of promoting the application of PV energy storage.

<sup>2</sup> peak segment coefficient = 1.5, flat segment coefficient = 1, valley segment coefficient = 0.5



### 3.2.6 Development measures of Green Certification

On August 3, China issued the Notice on Advancing the Full Coverage of Renewable Energy Green Power Certificates to Promote Renewable Energy Electricity Consumption, which systematically provided for the issuance and trading of green certificates, realizing full coverage of green certificates for renewable energy sources such as centralized and distributed PV power generation.

According to the current policy, the green certificate, as the only proof of the environmental attributes, as well as the production and consumption of China's renewable energy electricity, has been given a variety of uses, including the green certificate is used to measure the fulfillment of the responsibility weight of renewable energy power, and the power corresponding to green certificate transactions is included in the "14th Five-Year" provincial governments' energy-saving target assessment indexes, and green certificates are credentials for enterprises to consume green electricity.

Since the enactment of the Green Certificate Policy in July 2023, there had been exponential growth in the volume of green certificates trading, with cumulative volume increasing from 34.55 million at the end of June 2023 to 136 million at the end of March 2024. In 2023, the average price of centralized PV green certificates was 31 yuan per certificate, and the average price of distributed PV was 8-9 yuan per certificate. After the main body completed the green certificate transaction, the seller of the certificate can obtain the proceeds, which was equivalent to an increase of 0.008-0.031 yuan in levelized benefit of energy after the sale of the certificate for the PV project.

### 3.2.7 BIPV development measures

#### National Aspects:

In 2023, the Ministry of Housing and Urban-Rural Development and other departments issued relevant policies, emphasizing that the rapid decline in PV costs has laid the foundation for the large-scale development of PV building integration, and encouraging local governments to introduce subsidy policies.

The Ministry of Industry and Information Technology, the Ministry of Housing and Urban-Rural Development and other five departments jointly issued the Notice on the Fourth Batch of Intelligent PV Pilot Demonstration Activities, which prioritizes directions such as architectural PV, prioritizing the direction of BIPV and promoting the deep integration of PV technology and buildings.

#### Local Government Aspect:

In February 2023, the "Management Measures for the Use of Special Funds for Pilot Cities for PV Building Application in Bengbu", stating that for ultra-low-energy and near-zero-energy demonstration projects, incentives and subsidies shall be given on a per-floor-area basis, reflecting specific support for BIPV projects.

In May 2023, the "Implementing Rules of Several Policies for Promoting Economic Development in Hefei City" gave different standards of incentives to new residential buildings that met the standards of ultra-low-energy buildings, near-zero-energy buildings, and three-star green buildings, indirectly supported the development of BIPV.





### **3.2.8 Merchant PV development measures**

In December 2023, the China Securities Regulatory Commission and the State-owned Assets Supervision and Administration Commission jointly issued the “Notice on Supporting the Issuance of Green Bonds by State-owned Enterprises”, further enhancing the ability of the capital market to serve the green and low-carbon development, supporting SOEs to issue green bonds for financing, and synergistically pushing forward the reduction of carbon, pollution, expansion of greenery and growth, and driving the private economy to develop in a green and low-carbon manner, facilitating a comprehensive green economic transformation.

It consists mainly of the following.

Firstly, To improve the green bond financing support mechanism and develop various industries such as energy conservation and carbon reduction, environmental protection, resource recycling and clean energy.

Secondly, to help state-owned enterprises carry out green low-carbon transformation and high-quality development, rationalizing bond financing to accelerate the formation of green and low-carbon production methods, strengthening green scientific and technological innovation, and playing a demonstrative role in the green and low-carbon development of state-owned enterprises.

Thirdly, to play a leading role in green investment by state-owned enterprises, leading the supply of funds in key areas of green development, and supporting state-owned enterprises to carry out infrastructure REITs pilot projects.

Fourthly, to strengthen the organization and implementation of the guarantee. The Securities and Futures Commission and the State-owned Assets Supervision and Administration Commission shall promote the state-owned enterprises to better use of green bonds to finance, optimizing the capital market, serving in the green field of financing.

In 2023, a total of 480 green bonds were issued in China, amounting to 840.37 billion yuan. Clean energy was the one that attracted the largest amount of fund-raising investment, accounting for about 44.64%, and green transportation was the next largest area, accounting for about 27.99%.



### 3.3 Self-consumption measures

**Table 12: Summary of self-consumption regulations for small private PV systems in 2023**

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Savings on the electricity bill + bonus (some provincial level)
	3	Charges to finance Transmission, Distribution grids & Renewable Levies	Yes
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	Yes
	5	Maximum timeframe for compensation of fluxes	Real-time
	6	Geographical compensation (virtual self-consumption or metering)	None
Other characteristics	7	Regulatory scheme duration	20 years
	8	Third party ownership accepted	None
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	None
	10	Regulations on enablers of self-consumption (storage, DSM...)	Yes
	11	PV system size limitations	6 MW
	12	Electricity system limitations	None
	13	Additional features	None

#### 3.3.1 Development measures of green Electricity demands

In order to focus on controlling fossil energy consumption, China has gradually improved its policies for regulating the total amount and intensity of energy consumption over the past two years. National Development and Reform Commission and other three ministries and commissions issued the Notice on Strengthening the Connection between Green Electricity Certificates and Energy Conservation and Carbon Reduction Policies to Vigorously Promote the accommodation of Non-fossil Energy, clearly requiring that non-fossil energy is not included in the total amount of energy accommodation and intensity of the regulation.

This is an incentive mechanism for renewable energy sources such as PV and for all non-fossil energy. It is oriented that all regions should support the high-quality development of industry and economy with green and low-carbon non-fossil energy consumption, specifically by deducting the consumption of renewable energy, nuclear energy and other non-fossil energy from the total energy consumption of each region, and and accordingly accounting for the reducing target of the energy consumption intensity in each region.



## 3.4 Collective self-consumption, community solar and similar measures

### 3.4.1 Development measures of power generation, transmission, loading, and storage integration

In 2023, China's PV power accommodation rate reached 98%, basically the same as last year. China continuously strengthened the construction of renewable energy grid connection and transmission projects to enhance the cross-provincial and cross-regional resource allocation capabilities of the power grid, and persistently reinforced the balancing and regulation capabilities of the electricity system, such as comprehensively promoting flexibility retrofits of thermal power, facilitating the development of hydro-pumped storage plants and other measures to significantly elevate energy storage dispatching, to further leverage the flexible regulation capabilities of new energy storage.

In 2023, China continued to strengthen the construction of supporting projects for renewable energy grid integration, completing two UHV (Ultra-High Voltage) AC transmission projects, which further enhanced the capability of optimizing resource allocation on a large scale. Significant efforts were made to construct new energy grid integration and transmission projects at and below the 750 kV throughout the year, resulting in the completion of a number of key cross-regional power transmission and distribution project. These projects were designed to meet the grid connection needs of both centralized and distributed renewable energy power generation. China actively supported the construction of utility-scale wind and PV power projects in desert, Gobi, and arid land areas, completing over 70 utility-scale wind and PV power transmission projects on schedule, and starting the construction of the first UHV transmission project of utility-scale wind and PV power transmission.

In 2023, innovative research and practice were advanced in engaging various load-side resources in the market. The National Development and Reform Commission, the National Energy Administration, and other relevant departments jointly issued the "Measures for Demand Side Management in 2023" and introduced the "Measures for Power Load Management in 2023." Tianjin, Hebei, and Shandong actively engaged in valley shaft demand response, achieving a maximum response scale of 2.667GW and cumulatively facilitating the consumption of 97.96GWh of renewable energy.

## 3.5 Tenders, auctions & similar schemes

To pay equal attention to the construction of the utility-scale wind/PV power projects in desert, Gobi, and arid land areas, and PV/Wind/Hydro hybrid power in Southwest, and the development of distributed PV power. In terms of utility PV base development, the focus in 2023 was on promoting the layout and construction of the utility-scale wind/PV power projects in desert, Gobi, and arid land areas, with the first batch of utility-scale bases basically completed and connected to the grid during the year, and the second batch partially connected to the grid.

The distributed PV is a multi-pronged approach of "County-Scale PV Promotion", industrial and commercial distributed, and residential PV. With the advancement of the power market and the adjustment of time-of-use tariff policy, more "PV+" fusion industry and business models appeared. For most of the central and eastern provinces, renewable energy is not included in the energy consumption control policies, RPS responsibility and the backdrop of declining PV product prices all contribute to the advancement of distributed projects.



In order to ensure that distributed PV “should be connected to the grid as much as possible,” the National Energy Administration launched a pilot program to assess the carrying capacity of the power grid for distributed PV connections and to evaluate measures for enhancement. In the six pilot provinces of Shandong, Heilongjiang, Henan, Zhejiang, Guangdong and Fujian, each province selected 10 pilot counties (cities) to carry out pilot work. The pilot provinces published their carrying capacity assessment results in the fourth quarter of 2023, and although there was a wide disparity in each province, the distributed carrying capacities were all limited and in urgent need of upgrading. Therefore, on the basis of the results of the assessment in the pilot districts, we can establish a sound mechanism for regular assessment and publication.

In February 2024, the National Development and Reform Commission and the National Energy Administration issued the Guiding Opinions on the High-Quality Development of Distribution Grids under the New Circumstances, which put forward that the development goal of distribution grids in 2025 is to have a stronger and clearer distribution grid structure, a reasonably abundant power supply and distribution capacity, a significant increase in the carrying capacity and flexibility of distribution grids, and the ability to have access to about 500GW of distributed new energy and about 12 million charging piles capacity.

## **3.6 Other utility-scale measures including, floating and agricultural PV**

### **3.6.1 Development measures of offshore PV**

In the past two years, China attached great importance to the development of marine energy, and the relevant ministries and commissions also indicated that marine energy would play a more important role in the construction of a new energy system, and that the establishment of a marine industrial system around marine energy can promote the organic integration of the new energy system into the transformation of the whole industrial chain, cultivate new driving forces for economic development, and serve the sustainable development of the economy and society.

In April 2023, the National Energy Administration issued the “2023 Energy Work Guidance”, emphasizing the need to steadily build the utility offshore wind power bases and planning to start the construction of offshore PV. At the same time, since 2022, Shandong, Zhejiang, Jiangsu and other coastal provinces after the full development of non-cultivated land, gradually transferred the application of PV scene from land to sea. Coastal provinces accelerated the layout of offshore PV construction, and introduced specific rules to support the development of offshore PV.

Several companies have already launched offshore modules for offshore PV projects. In May 2023, LONGi became the first batch of enterprises to obtain the “National Preferred Product” - Deep Blue Ocean Environmental Test Certificate for the differentiated weather resistance of PV modules. In the same month, HUASUN launched the V-ocean modules to adapt to offshore PV power stations, bringing more efficient, reliable and lower-carbon products to the offshore PV market.

In May 2023, Jiangsu Province released the “Jiangsu Province Offshore PV Development and Construction Implementation Program (2023-2027)”, which clearly stated that by 2025, the province's cumulative offshore PV grid-connected capacity will reach 5GW, the construction of a new power system along the coast will advance more quickly, and the green and low-carbon transition will be effective. By 2027, the cumulative grid-connected capacity of offshore PV in



the province will reach 10GW, the initial construction of a new coastal power system will be completed, and the level of green and low-carbon development will be significantly improved.

### 3.7 Social Policies

According to data from the National Energy Administration, China's new residential PV installation in 2023 was 43.48GW, up 72% year-on-year. By the end of 2023, the cumulative residential PV installation was 1.158GW. In 2023, the number of new residential PV was about 1.696 million, and the cumulative number of residential PV was about 5.262 million. The average single-family capacity of new residential PV installations nationwide in 2023 was 25.6kW, up 2.8% year-over-year.

According to statistics, China's residential PV cumulative number had exceeded 5 million. Calculating on the basis of an annual rent of 1,500-3,000 yuan per household, the rental income alone can feed the rural areas by 7.5-15 billion yuan. Enterprises and developers in order to develop the market, in the early stage of the installation will give farmers initial installation fee, different across the country, an average of more than 0.5 yuan / watt, each household can get more than 12,000 yuan. According to the residential PV installed capacity of 40GW per year, the annual initial installation fee of residential PV can feed the rural areas about 20 billion yuan. The decline in the cost of PV equipment allowed a large portion of it to be fed back to the farmer, truly increasing income for the farmer.

In addition, many farmers are both owners and operators of residential PV plants at the same time. According to incomplete statistics, China's residential PV industry can directly drive the rural employment of more than 2 million people, coupled with the number of indirect employment, there were nearly 5 million people engaged in the residential PV industry. It can be seen that residential PV not only effectively improve the income of farmers, but also promote the flow of talent back to the countryside to participate in the construction of rural revitalization.

### 3.8 Retroactive measures applied to PV

In the second half of 2023, the Development and Reform Commission of the provinces updated their time-share tariff policies in accordance with the relevant requirements of the NDRC Circular on Further Improving the Time-of-use Tariff Mechanism, and 11 provinces implemented the midday trough tariff at midday. In the second half of 2023, the development and reform commissions of various provinces updated the time-of-use electricity price policies in accordance with the relevant requirements of the "Notice of the National Development and Reform Commission on Further Improving the Time-of-Use Electricity Price Mechanism". During the noon period, 11 provinces implemented low-valley electricity prices at noon.

### 3.9 Indirect policy issues

#### 3.9.1 Rural electrification measures

Promoting the development of rooftop distributed PV systems across entire counties (cities, districts) is a crucial approach for local areas to achieve the "carbon peaking and carbon neutrality goals" and energy transition in rural revitalization. In 2023 in China, the newly registered capacity of rooftop distributed PV pilot projects across entire counties (cities, districts) reached 41.26GW, and the new grid-connected capacity was 29.27GW. Based on survey statistics, by the end of 2023, the cumulative registered capacity of distributed PV pilot projects across entire counties (cities, districts) had reached 146.43GW, accounting for 93.5%



of the planned installed capacity. The cumulative grid-connected capacity had been 58.93GW, accounting for 37.6% of the planned installed capacity. The capacity under construction was 11.28GW.

In April 2023, the National Energy Administration issued the "Guiding Opinions on Energy Work in 2023," emphasizing the implementation of the "Wind Power in Thousands of Townships and Villages Program" and the "PV Power in Thousands of Households Program", steadily advancing the pilot project for the development of distributed PV systems on rooftops across entire counties, and promoting the use of clean energy in rural areas. Carry out pilot projects for the rural energy revolution, to fan out from point to area, advancing the transition of rural energy towards cleanliness and low carbon emissions.

### **3.9.2 Support for electricity storage and demand response measures**

The energy storage market in China continues to grow at a rapid pace in 2023. Data from the National Energy Administration shows that in 2023, the new installed capacity of new energy storage in China is about 22.6GW, the average storage duration is about 2.1 hours, and the new grid-connected new energy storage is about 22.6GW (48.7GWh), which is an increase of 260% compared with that in 2022. The cumulative installed capacity of China's energy storage had reached 66.87 GWh by the end of 2023.

In terms of regional distribution, a total of 29 provinces, cities, and autonomous regions in China achieved grid connection for energy storage projects in 2023, with 11 regions having a scale exceeding 1GWh.

Among the new energy storage related policies in various regions in 2023, China introduced a number of PV storage policies, involving centralized PV power plants as well as distributed. Among them, Tibet and Gansu had the longest time requirement for energy storage, reaching 4 hours, and Henan had the highest percentage requirement for energy storage, at 35-55%. Distributed storage policy was concentrated in Guangdong, Henan, Zhejiang, Hebei and other regions, and some distributed PV energy storage application cases may appear in these regions in 2024. In addition, Inner Mongolia also had a strong demand for PV energy storage, but these storage projects were mainly industrial parks green power supply projects, power generation, transmission, loading, and storage integration projects, Integrated wind and solar-powered hydrogen production projects, mostly wind and PV common consideration of the demand for energy storage.

In 2023, energy storage subsidies were more refined across the region, with the most subsidies especially for demand-side energy storage applications. In terms of demand-side energy storage subsidies, the main subsidies were energy storage plant discharge subsidies, one-time investment subsidies calculated on the basis of installed capacity. Anhui, Jiangsu, Zhejiang for PV and energy storage applications, also developed the corresponding subsidies, showing the purpose of promoting the application of PV energy storage.

In May 2023, the National Development and Reform Commission, the National Energy Administration issued the "Measures for Demand Side Management (Exposure Draft)", which tightened the quantitative targets for demand side response capabilities. It proposed that "by 2025, the demand response capacity of each province should reach 3%-5% of the maximum power load, with provinces where the annual peak and valley difference ratio of maximum power load exceeds 40% achieving 5% or above." The document also emphasized the inclusion of demand-side resources into electricity balance through means such as virtual power plants, and their participation in demand response in the form of



load aggregators or virtual power plants, which will drive the development of the virtual power plant industry.

### **3.9.3 Support for encouraging social acceptance of PV systems**

Xiuzhou PV Technology Museum is the largest PV-themed exhibition hall in China built by the People's Government of Xiuzhou District, Zhejiang Province, with a floor area of 9 000 square meters, and its facade is made of Cadmium Telluride PV thin-film glass, which is an excellent project for the BIPV in China. Since October last year, this PV museum has been operated by ECOPV alliance, Lyu Fang is the curator. And so far there have been about 10 000 visitors. It contains energy and PV science popularization area, the past, present and future of PV display area, showing the public PV science knowledge, latest products, technologies and applications. It is continuously organizing PV-related public welfare activities and science lectures for the public, especially for young people, in order to increase their knowledge of new energy and PV.

### **3.9.4 Other support measures**

In 2022, the European Commission adopted the "Ecodesign and Energy Labelling Schemes (2022-2024)", which proposes the establishment of ecodesign and energy labelling schemes for PV modules, inverters, and systems, including potential carbon footprint requirements. In 2023, the United States introduced two levels of carbon indicators for PV modules and inverters within the latest Electronic Product Environmental Assessment Tool (EPEAT) system. It was specified that all PV module products included in the EPEAT certification system must meet the minimum carbon emission requirements outlined in the document.

The successive release of the above documents draw China's attention to sustainable technologies and green manufacturing in the PV industry. Chinese PV enterprises accelerated their pace of green transformation, making collaborative efforts along the upstream and downstream of the industry chain to enhance their technological level and product quality, reduce energy consumption and carbon emissions during the production process of PV products, and achieve green production and sustainable development, which improved the competitiveness of Chinese PV in the international market.

## **3.10 Financing and cost of support measures**

On January 15, 2024, the Ministry of Finance, the National Development and Reform Commission, and the National Energy Administration jointly issued the "Notice on Strengthening the Routine Management of Feed-in Tariff Additional Subsidies," aiming to standardize and regularly manage the feed-in tariff additional subsidies for renewable energy.

The document requires that power grid enterprises should strictly review and allocate subsidies in accordance with current policies. Based on adjustments to the subsidy list and project verification results, they should promptly adjust and recover the allocated subsidies.

They should strictly implement relevant regulations and manage the subsidies ledger properly, comprehensively and accurately recording the details of subsidy allocations to renewable energy power generation projects.

They should expedite the review and publication of the subsidy project list for renewable energy generation, and maintain effective communication and coordination with provincial authorities, information centers, and project owners. They should also keep monthly statistics on the progress of reviewing the subsidy lists for declared projects. The review status of local



independent power grid enterprises shall be submitted to the State Grid and China Southern Power Grid according to the territorial principle. By the 15th of each month, the State Grid and China Southern Power Grid shall provide written feedback to the Ministry of Finance, the National Development and Reform Commission, and the National Energy Administration on the progress of reviewing the aggregated subsidy list.

## **3.11 Grid integration policies**

### ***3.11.1 Grid connection policies***

In 2023, China's PV power accommodation rate reached 98%, basically the same as last year, remaining a high level. The main reasons are as follows.

The National Development and Reform Commission and the National Energy Administration issued the "Notice on the Responsibility Weights for Renewable Energy Power Integration in 2023", requiring all provinces, autonomous regions, and municipalities to reasonably arrange the scale of guaranteed grid connection for wind power and PV power generation within their respective regions based on the non-hydro power integration responsibility weights.

Adhere to the coordinated development of "quantity" and "quality". The National Energy Administration launched the "Pilot Program to Assess the Carrying Capacity of the Power Grid for Distributed PV Connections and to Evaluate Measures for Enhancement", selecting 6 pilot provinces, such as Shandong, Heilongjiang, Henan, Zhejiang, Guangdong and Fujian to carry out assessments of grid carrying capacity for distributed PV power integration and evaluation of enhancement measures, aiming to guide rational distribution.

China should continuously strengthened the construction of renewable energy grid connection and transmission projects to enhance the cross-provincial and cross-regional resource allocation capabilities of the power grid, and persistently reinforced the balancing and regulation capabilities of the electricity system, such as comprehensively promoting flexibility retrofits of thermal power, facilitating the development of hydro-pumped storage plants and other measures to significantly elevate energy storage dispatching, to further leverage the flexible regulation capabilities of new energy storage.





## 4 INDUSTRY

### 4.1 Production of feedstocks, ingots and wafers

**Table 13: Silicon feedstock, ingot and wafer producer’s production information for 2023**

Manufacturers (or total national production)	Process & technology	Total Production	Product destination	Price
Total	Silicon feedstock [Tonnes]	147.2*10 <sup>4</sup>	N/A	N/A
Total	sc-Si wafers [MW]	668.3*10 <sup>3</sup>	N/A	N/A

Source: CPIA, 2024.5

In 2023, there were 22 polysilicon enterprises in production in China, with an effective capacity of 2.3 million tons/year. The top ten enterprises accounted for 81.7% of the capacity and 95.4% of the output. The polysilicon output reached 1.472 million tons, up 71.8% year-on-year, and the top one in terms of output was Sichuan Tongwei. The wafer production capacity was about 953.6GW, an increase of 46.6% and the wafer output was about 668.3GW, an increase of 80%.

In 2023, China's monocrystalline silicon wafers (p-type and n-type) market share exceeded 99%. The market share of p-type wafers shrunk to 74.5%, and n-type accounted for a growing share of 24.7%. As the downstream demand for n-type monocrystalline products increases, its market share will further increase.

According to the “China Photovoltaic Industry Development Roadmap (2023-2024)”<sup>3</sup>, the average thickness of polysilicon wafers was 170 μm in 2023, and the thickness is forecast to remain unchanged at 170 μm after 2024 due to low market end-use demand. The average thickness of p-type monocrystalline silicon was around 150 μm, a decrease of 5 μm compared to 2022. At the moment, the average thickness of n-type silicon wafers used for TOPCon cells is 125 μm, and for HJT cells is about 120 μm, a decrease of 15 μm and 5 μm respectively compared to 2022. The increased demand for n-type wafers has accelerated the process of wafer thinning technology.

The large size of wafers is conducive to increasing the power of the module, reducing the cost of manufacturing and power generation, and has become an inevitable trend of technological progress. Since 2023, 182mm and 210mm sized wafers have become the mainstream of the market, accounting for a combined share of up to 98%.

At the same time, in 2023, as companies continued to optimize the size of wafers, to achieve the optimal module size, to match the demand for thinning bezels and packaging improvements, to achieve the maximum shipping volume in a single container, thereby

<sup>3</sup> Published by China PV Industry Association(CPIA)



reducing the cost of transporting modules. Especially with ocean freight rates skyrocketing in 2023, this was becoming a necessity.

## 4.2 Production of photovoltaic cells and modules

Module manufacturing is defined as the industry where the process of the production of PV modules (the encapsulation) is done. A company may also be involved in the production of ingots, wafers or the processing of cells, in addition to fabricating the modules with frames, junction boxes etc. The manufacturing of modules may only be counted to a country if the encapsulation takes place in that country.

Total PV cell and module manufacture together with production capacity information is summarised in Table below.

**Table 14: PV cell and module production and production capacity information for 2023**

Cell/Module manufacturer (or total national production)	Technology (sc-Si, mc-Si, a-Si, CdTe, CIGS)	Total Production [MW]		Maximum production capacity [MW/yr]	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
Tongwei	sc-Si	80.8*10 <sup>3</sup>	31.07*10 <sup>3</sup>	95*10 <sup>3</sup>	75*10 <sup>3</sup>
JinkoSolar	sc-Si	55.8*10 <sup>3</sup>	76.43*10 <sup>3</sup>	74.1*10 <sup>3</sup>	93*10 <sup>3</sup>
Longi Green Energy	sc-Si	54*10 <sup>3</sup>	70.17*10 <sup>3</sup>	55*10 <sup>3</sup>	110*10 <sup>3</sup>
JA Solar	sc-Si	39.9*10 <sup>3</sup>	55.05*10 <sup>3</sup>	85*10 <sup>3</sup>	90*10 <sup>3</sup>
Trina Solar	sc-Si	38.8*10 <sup>3</sup>	53.52*10 <sup>3</sup>	68.5*10 <sup>3</sup>	88.5*10 <sup>3</sup>
Thin film manufacturers					
CNBM Optoelectronic Materials	CIGS	-	-	900	-
Advanced Solar Power	CdTe	-	-	140	-
Sun Harmonics	CIGS	-	-	150	-

Source : CPIA, 2024.5

In 2023, the total cell production capacity of mainland China reached 929.9GW, a year-on-year growth of 84%, and the output was about 591.3GW, a year-on-year growth of 78.9%.

TOPCon production capacity has accelerated its growth and become the absolute mainstream of new production capacity. In 2023, the market share of TOPCon cells increased by 14.7%, while that of HJT cells increased by 2%, XBC increased by 0.7% compared to 2022. In addition, cell manufacturers reduced the amount of silver by developing multi-BusBar technology and reducing the width of the fingers. The number of main busbars for P-type cells shifted from 9BB to 11BB and above. Large-sized cells became the mainstream, and the production capacity of rectangular cells was gradually being released. Among large-sized products,



182mm square cells hold roughly 47.7% of the market, followed by 210mm square cells with about 20%. The rest of the market comprised non-square cells. In July 2023, 9 leading enterprises in the PV industry officially reached a consensus to unify the module size to 2382mm\*1134mm.

In 2023, the total production capacity of PV modules in mainland China reached 920GW, and the total output reached 518.1GW, representing year-on-year growth rates of 66.7% and 75.8%, respectively. The average efficiency of PERC monocrystalline cells had reached 23.4%. Due to the continuous increase in silicon wafer sizes and the continuous optimization of module formats, the module power had achieved significant improvements. The mainstream mass production power of 182mm PERC modules had reached 550W. The share of bifacial modules was 40.4% in 2022, and the share increased to 67% in 2023, being the mainstream module encapsulation technology.

As the levelized cost of energy (LCOE) decreases, the PV industry has fostered various application scenarios in different regions. Coastal mudflats and offshore PV plants drive the development of modules with salt spray, corrosion and wind resistance properties. For coastal and humid areas, modules that can withstand heat and humidity have been developed.

The varying degrees of desertification in northwestern China, pushes the development of modules adapted to high day/night temperature differences and strong UV protection. Many enterprises rediscovered the potential of dust-resistant modules and launched such products. In outdoor empirical tests, dust-resistant modules had shown to bring about a power generation increase of more than 2%.

The most prominent feature of China's PV product exports in 2023 is "volume increasing and value decreasing. There was a significant year-on-year increase in export volume, but a slight decrease in export value, due to the continuous decline in supply chain prices. In 2023, China's PV product exports value totaled about \$48.48 billion, a year-on-year decrease of 5.4%.

Benefited from the first batch of large-scale PV base connected to the grid, centralized PV installed capacity in 2023 exceeded the distributed. Centralized PV new installed capacity was 120.01GW, an increase of 230.7% year-on-year, accounting for 55.5% of new PV installations in 2023. Distributed PV installed 96.29GW, an increase of 88.4%, accounting for 44.5% of the new PV installed capacity in 2023. Among them, commercial and industrial PV installed 52.81GW, up 104.1% year-on-year, accounting for 24.4% of the new PV installations; residential PV installed 43.48GW, up 72.2% year-on-year, accounting for 20.1% of the new PV installations.

### 4.3 Manufacturers and suppliers of other components

The brand pattern of China's domestic inverter industry in 2023 had been basically formed, and the more active enterprises currently in production are about 20. The inverter market developed to be dominated by string inverters in 2023, with its share of 80%.

Due to fierce industry competition, improvement of product technology, upgrading of components, and increase in the penetration rate of domestic power devices, the single power of PV inverter is getting bigger and bigger, and the cost of single watt is gradually reduced. The global inverter market in 2023 witnessed "export volume increasing and export value decreasing" due to high stock and increased competition, which prompted suppliers to reduce prices to maintain market share.



- **Storage batteries**

The energy storage market in China continues to grow at a rapid pace in 2023. Data from the National Energy Administration shows that in 2023, the new installed capacity of new energy storage in China is about 22.6GW, the average storage duration is about 2.1 hours, and the new grid-connected new energy storage is about 22.6GW (48.7GWh), which is an increase of 260% compared with that in 2022. The cumulative installed capacity of China's energy storage had reached 66.87 GWh by the end of 2023.

In 2023, the demand for PV project distribution storage occupies a major share in China's renewable energy grid-connected projects. According to statistics from relevant institutions, the installed capacity of energy storage reached 5931MW/14972MWh of the new PV distribution storage installed throughout 2023, accounting for 70% of the application of energy storage in renewable energy grid-connected projects. It is noteworthy that in 2023, the form of energy storage application in Xinjiang, Gansu, Inner Mongolia and other places is changing from new energy distribution storage to independent energy storage. In the future, PV's demand for energy storage allocation will be increasingly met through the form of independent energy storage plant capacity leasing.

In 2023, among the installed new energy storage, lithium-ion battery storage remains absolutely dominant, with the market share further increasing to nearly 99%.

The lithium iron phosphate battery remains the dominant technology type in the domestic energy storage market, and the application forms of non-lithium battery energy storage technology are also continually being enriched. Flywheel and other power-based technologies of the single project towards the 10MW class, 100MW class compressed air and liquid flow battery project is rapidly advancing. The hybrid application of non-lithium energy storage technology and lithium iron phosphate battery is also more and more common, as a way to make up for the lack of cost and technological maturity of non-lithium technologies.

- **Supporting structures**

In 2023, the cost of the support bracket system (including foundation) and installations accounted for about 8% of the investment cost of the power plant. The share of tracking brackets in the power plant system will return to previous levels in 2023 compared to 2022. In the future, the cost share of tracking brackets in PV power plant systems will grow by 3-5%. The cost of tracking brackets and installation accounts for about 6.3% of the total investment in distributed commercial and industrial power plants.

Global shipments of leading tracking brackets companies are clustered in the USA, Europe and China. China accounted for two of the top six, for Arctech, Trina Solar.

- **BIPV products**

With the support of relevant policies of the state and provinces and cities, the combined application of PV power generation system and building has shown a good development trend, and PV modules are also developing in the direction of building materialization and componentization. Many domestic manufacturers have also launched PV products that are integrated with buildings. For example, manufacturers of crystalline silicon-based PV modules for buildings, such as LONGi, Trina Solar, Sunman, Goodwe, JinkoSolar, DAS Solar, have developed rooftop PV components based on crystalline silicon-based technology to realize the integration of PV modules with building roofs and facades. CdTe thin-film PV module manufacturers such as Advanced Solar Power and CNBM (Chengdu) Optoelectronic Materials have also launched PV modules suitable for building facades, which can achieve colorful and patterns according to the needs of the building, and the adjustable light



transmission of the modules can better meet the needs of indoor lighting. In addition, Perovskite thin-film PV companies such as Microquanta, based on the material advantages, developed PV module products with colors and textures that more closely matched architectural aesthetic requirements. These products are being gradually and steadily mass-produced, and the technical challenges of long product life and high stability are being solved.



## 5 PV IN THE ECONOMY

This chapter aims to provide information on the benefits of PV for the economy.

### 5.1 Labour places

**Table 15: Estimated PV-related full-time labour places in 2023**

Market category	Number of full-time labour places
Research and development (not including companies)	0.73 million
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	2.71million
Distributors of PV products and installations	0.12 million
Other	0.44 million
<b>Total</b>	<b>4 million</b>

### 5.2 Business value

**Table 16: Rough estimation of the value of the PV business in 2023 (VAT is excluded)**

Sub-market	Capacity installed [MW]	Average price [Yuan/W]	Value	Sub-market
Off-grid	–	–	–	30 billion Yuan
Grid-connected distributed	96 286	2.917	280.866 billion Yuan	280.866 billion Yuan
Grid-connected centralized	120 014	3.119	374.324 billion Yuan	374.324 billion Yuan
Value of PV business in 2023				685.19 billion Yuan



## 6 INTEREST FROM ELECTRICITY STAKEHOLDERS

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### 6.1 Structure of the electricity system

China is divided into three major power grid companies according to region, namely State Grid, China Southern Power Grid and Inner Mongolia Power Group. The operation area of State Grid Corporation of China covers 26 provinces (autonomous regions, municipalities directly under the Central Government) in China, and the power supply scope accounts for 88% of the land area. China Southern Power Grid covers five provinces and regions, and is connected with the power grids of Hong Kong, Macao and Southeast Asian countries. The power supply area is 1 million square kilometers, and the power supply population is 272 million. Inner Mongolia Power (Group) Co., Ltd. is a wholly state-owned super large power grid enterprise directly under the Inner Mongolia Autonomous Region. It undertakes the task of power supply for industrial, agricultural and animal husbandry production in 8 cities (leagues) and for the daily life of 14 million urban and rural residents. Meanwhile, it provides power to North China, Yulin in Shaanxi, and Mongolia across provinces, regions and borders.

In 2023, in terms of the power structure in China, thermal power accounted for the largest share of 66.3%, followed by hydropower, accounting for 13.6%; wind power accounted for 9.4%; PV power accounted for 6.2%; and nuclear power accounted for 4.6%.

### 6.2 Interest from electricity utility businesses

China's electricity spot market starts from 2023. With the rapid construction of new electricity systems, the proportion of PV guaranteed purchased electricity is decreasing, while participation in electricity market transactions is gradually accelerating.

In June 2023, the National Energy Administration released the Blue Paper on the Development of New Electricity Systems, proposing the need to establish a market system adapted to the new electricity system from the following aspects, such as improving the national unified electricity market system, formulating a localized green electricity trading system, perfecting various types of market trading mechanisms, and strengthening the connection of the electricity certificate and carbon market.

In July 2023, the National Development and Reform Commission, the Ministry of Finance, and the National Energy Administration jointly issued the Notice on Doing a Good Job in the Full Coverage of Renewable Energy Green Power Certificates to Promote Renewable Energy Electricity Consumption, which points out that the green certificate is the only proof of the environmental attributes, as well as the production and consumption of China's renewable energy electricity. It also clarifies the trading platform, modalities and benefits of green certificate. With the establishment and standardization of the uniqueness of green certificate, the standard of PV green environmental value trading is established.

The future development trend of China's electricity market is as follows, the national unified market system with multi-level interaction will be further improved, forming a three-tier market, called inter-provincial (regional) market, provincial market and local market. Among them, the inter-provincial (regional) market is a resource-based market, whose main role is to implement the inter-regional framework agreement and realize the mutual assistance of resources. The provincial market is a balancing market, which is mainly used to keep balance of the electricity supply and demand within the provincial area, and to form intra-provincial prices. The local market is a flexible market, mainly addressing the participation in the market of distributed PV,



adjustable users, V2G, user-side energy storage and other massive distributed resources . In short, with the continuous improvement of the electricity market system, the trading space and scenarios of PV power plants will be greatly expanded.

With regard to the green environmental market, green certificates are being gradually linked to the policy of dual-control of energy consumption intensity and total volume. Green electricity consumption certification and energy-saving and carbon reduction management mechanisms are being gradually improved. Green certificates and carbon accounting market management mechanisms are also gradually converging. It provides a channel for PV power plants to obtain green income.

### 6.3 Interest from municipalities and local governments

With the "Carbon Peak & Carbon Neutrality" target, the PV industry is receiving more and more attention. Since June 2023, President Xi Jinping has mentioned the development of green energy such as PV on a number of domestic and international occasions, repeatedly emphasizing the importance of energy transition and green development. At the symposium on promoting the comprehensive revitalization of the Northeast, he emphasized the need to actively cultivate new energy and other strategic emerging industries and to accelerate the development of clean energy.

At a symposium on the high-quality development of the Yangtze River Economic Belt, he re-emphasized the importance of multi-energy complementary and deep integration to accelerate the construction of a new energy system. In addition, at the Asia-Pacific Economic Cooperation (APEC) CEO Summit, he mentioned the rapid growth of China's exports of new energy vehicles and other "New Three"<sup>4</sup>, signaling huge opportunities in the green market. This series of statements not only highlights China's firm determination in energy transformation and green development, but also injects a strong impetus for the development of green energy such as PV, and provides a strong guarantee for the sustained and healthy development of the PV industry.

By now, the installed PV power capacity in Jiangsu Province has exceeded the target of 35GW by 2025, as proposed in the "14th Five-Year Plan for Renewable Energy Development in Jiangsu Province".

In September 2023, Zhejiang Province proposed that by 2025, the annual output of PV cells and modules would reach 150GW, and the cumulative installed capacity of PV and wind power would exceed 40GW.

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<sup>4</sup> "New Three" means "new energy vehicles, lithium batteries and PV modules"





## 7 HIGHLIGHTS AND PROSPECTS

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### 7.1 Highlights

In 2023, China's new installed PV capacity was 216.3GW, up 147.5% year-on-year. Benefited from the first batch of large-scale PV base connected to the grid, centralized PV installed capacity in 2023 exceeded the distributed. Centralized PV new installed capacity was 120.01GW, an increase of 230.7% year-on-year, accounting for 55.5% of new PV installations in 2023. Distributed PV installed 96.29GW, an increase of 88.4%, accounting for 44.5% of the new PV installed capacity in 2023. Among them, commercial and industrial PV installed 52.81GW, up 104.1% year-on-year, accounting for 24.4% of the new PV installations; residential PV installed 43.48GW, up 72.2% year-on-year, accounting for 20.1% of the new PV installations.

PV power generation amounted to 583.3 billion kWh, a year-on-year increase of 36.4%. The utilization rate of PV power generation reached 98%, basically the same as last year.

In 2023, China achieved a lot in the field of PV core technology research and development. China held 7 solar cell efficiency records, 4 of which are new records in 2023. LONGi set a world record for silicon solar cell efficiency of 27.09% and a world record for silicon-perovskite tandem cells efficiency of 33.9%.

In 2023, 8 PV companies were listed.

### 7.2 Prospects

China's goal of achieving a total installed capacity of over 1200GW for wind power and solar power by 2030 has been achieved six years ahead of schedule. By the end of July 2024, the combined installed capacity of wind power and PV power in China reached 1206GW<sup>5</sup>.

China will continue to advance the construction of a new energy system and a new energy electricity system in 2024. Policies related to new energy such as PV will continue to be refined and implemented. In terms of project management, revisions will be made to the management measures for distributed PV power generation projects, and continued efforts will be made to carry out pilot projects aimed at improving the grid-connection capacity for distributed PV power, based on the "Guiding Opinions on Energy Work for 2024" and the progress of other relevant policies.

Secondly, in terms of the utility-scale project, in addition to continue to promote the new energy bases in the desert, Gobi and desert areas, all kinds of new energy + projects, multi-energy complementary projects, distributed PV projects, the "Thousands of PV households Program" is expected to be announced and enter the implementation stage.

Thirdly, in piloting and demonstration respect, we will carry out the assessment of PV county-scale demonstration, the pilot census of wind and solar power generation resources, and continue to carry out special remediation to solve the undue interference in the new energy market.

Fourthly, in terms of strengthening the guarantee mechanism for consumption, the responsibility weights should be assigned to key enterprises. We should optimize the goal of

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<sup>5</sup> Source from National Energy Administration



new energy utilization, attach importance to the consumption responsibility weights and reasonable utilization rates, and promote the high-quality development of wind and solar power.

Fifthly, in green certificates respect, we should continue to promote full coverage and application of green certificates, and strengthen the connection with the domestic carbon market as well as international recognition.

Sixthly, in terms of the electricity market, we should promote the direct trading of new energy such as PV power in the market, deepen the market-oriented reform of renewable energy prices, study and formulate guidance, etc..

Seventhly, in terms of legal construction, the Renewable Energy Law has been included in the current amendment plan of the National People's Congress (NPC) for 2023. In 2024, the Environment and Resource Protection Committee of the NPC and the energy authorities are going to organize the thematic studies and the preparation of draft texts. Additionally, the legislation of the Energy Law is also underway. Through the legislation and amendments to the law, we can better support the sustainable and healthy development of renewable energy such as PV power.

