Technology Collaboration Programme
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International Energy Agency
Photovoltaic Power Systems Programme

Task 1 Strategic PV Analysis and Outreach

PVPS

National Survey Report of PV Power Applications in CHINA

2021

IEECAS

CHINA ECOPV ALLIANCE

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 IEA PVPS participating countries are Australia, Austria, Belgium, Canada, Chile, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance (SEPA), the Solar Energy Industries Association (SEIA) 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 2020. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

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COVER PICTURE

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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 2021 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2021, although commissioning may have taken place at a later date.

1.1 Applications for Photovoltaics

Many countries around the world have put forward the climate goal of "carbon neutrality". The development of renewable energy, including photovoltaic, has become a global consensus, promoting the global photovoltaic market to continue to maintain rapid growth. China is no exception. In 2021, China's newly installed grid-connected photovoltaic capacity reached 54.88GW, a year-on-year increase of 13.9%, of which the installed capacity of distributed photovoltaic power plants was 29.28GW, a year-on-year increase of 88.7%, and accounting for 53.4% of the total new installed capacity, and breaking 50% for the first time in history. The installed capacity of centralized photovoltaic power plants was 25.6GW, a year-on-year decrease of 21.7%,

As of 2021, the cumulative grid-connected photovoltaic capacity reached 305.99GW, an increase of 20.9%. Among them, the cumulative installed capacity of centralized photovoltaic power stations is 198.48GW, and the cumulative installed capacity of distributed photovoltaic power stations is 107.51GW. The annual photovoltaic power generation reached 325.9 billion kWh, a year-on-year increase of 25.1%, and the number of utilization hours nationwide reached 1163 hours, a year-on-year increase of 3 hours.

1.2 Total photovoltaic power installed

Table 1: Annual PV power installed during calendar year 2021

		Installed PV capacity in 2021 [MW]	AC or DC
	Decentralized	29280	DC
	Centralized	25600	DC
	Off-grid		
	Total	54880	DC

Table 2: Data collection process

If data are reported in AC, please mention a conversion coefficient to estimate DC installations.	N/A
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 2021 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)	http://www.nea.gov.cn/
	Additional comments on market and data collection, especially the estimated accuracy of data.

Table 3: The cumulative installed PV power in 4 sub-markets

Year	Off-grid [MW] (including large hybrids)	Grid-connected distributed [MW] (BAPV, BIPV)	Grid-connected centralized [MW] (Ground, floating, agricultural…)	Total [MW]
1999				
2000				
2001	4.50	0.01	0.00	4.51
2002	18.50	0.01	0.00	18.51
2003	10.00	0.07	0.00	10.07
2004	8.80	1.20	0.00	10.00
2005	6.40	1.30	0.20	7.90
2006	9.00	1.00	0.00	10.00
2007	17.80	2.00	0.20	20.00
2008	29.50	10.00	0.50	40.00
2009	17.80	34.20	108.00	160.00
2010	27.00	190.00	283.00	500.00
2011	20.00	680.00	2000.00	2700.00
2012	40.00	1360.00	1800.00	3200.00
2013	40.00	10950.00		10990.00
2014	40.00	2050.00	8550.00	10640.00
2015	20.00	1390.00	13740.00	15150.00
2016	10.00	4230.00	30310.00	34550.00
2017	0	19440.00	33420.00	52860.00
2018	0	20960.00	23300.00	44260.00
2019	0	12200.00	17900.00	30100.00
2020	0	15500.00	32700.00	48200.00
2021	0	29280.00	25600.00	54880.00

Table 4: Other PV market information

	2021
Number of PV systems in operation in your country	Total installed 54.88GW except for Distributed PV 29.28GW (53.4%); Ground Mounted LS-PV 25.6GW(46.6%)
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（2020）	2021
Total power generation capacities [GW]	2200.58 GW	2380 GW
Total renewable power generation capacities (including hydropower) [GW]	955.41 GW	1120 GW
Total electricity demand [TWh]	7620 TWh	8300 TWh
New power (solar+wind) generation capacities installed [GW]	534.96 GW	635 GW
New renewable power generation capacities (including hydropower) [GW]	138.53 GW (hyd. 13.23 GW, wind 71.67 GW, PV 48.2GW, Bio 5.43GW)	134.02 GW (hyd. 23.49 GW, wind 47.57 GW, PV 54.88 GW, Bio 8.08 GW)
Estimated total PV electricity production (including self-consumed PV electricity) in [GWh] (or [TWh])	261.1 TWh	325.9 TWh
Total PV electricity production as a % of total electricity consumption	3.5%	3.9%
Average yield of PV installations (in kWh/kWp)	1300 kWh/kWp	1300 kWh/kWp

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

Table 6: Typical module prices (Units：RMB Yuan)

Year	Lowest price of a standard module crystalline silicon (optional)	Highest price of a standard module crystalline silicon (optional)	Typical price of a standard module crystalline silicon (mandatory)
2010	N/A		11.11
2011	N/A		7.69
2012	N/A		3.85
2013	N/A		3.42
2014	N/A		3.25
2015	N/A		2.99
2016	N/A		2.65
2017	N/A		2.14
2018	N/A		1.81
2019	N/A		1.68
2020	N/A		1.57
2021	N/A		1.93

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]
Off-grid 1-5 kW	A stand-alone PV system is a system that is installed to generate electricity to a device or a household that is not connected to the public grid. (write the typical off-grid application and since in your country)	N/A
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.	5.0-5.5
Residential BIPV 5-10 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected households. Typically, on villas and single-family homes.	N/A
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.	5.0-5.5
Small commercial BIPV 10-100 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	N/A
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.	5.0-5.5
Large commercial BIPV 100-250 kW	Grid-connected, building integrated, distributed PV systems installed to produce electricity to grid-connected commercial buildings, such as public buildings, multi-family houses, agriculture barns, grocery stores etc.	N/A
Industrial BAPV >250 kW	Grid-connected, roof-mounted, distributed PV systems installed to produce electricity to grid-connected industrial buildings, warehouses, etc.	5.0-5.5
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.	4.0-4.5
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.	4.0-4.5

Table 8: National trends in system prices for different applications

Year	Residential BAPV Grid-connected, roof-mounted, distributed PV system 5-10 kW **[currency/W]**	Small commercial BAPV Grid-connected, roof-mounted, distributed PV systems 10-100 kW **[currency/W]**	Large commercial BAPV Grid-connected, roof-mounted, distributed PV systems 100-250 kW **[currency/W]**	Small centralized PV Grid-connected, ground-mounted, centralized PV systems 10-20 MW **[currency/W]**
2009				30
2010				20
2011		18		15
2012		14		12
2013		12		10
2014	13	8		8
2015	6-7	6-7		7-8
2016	6.0-6.5	6.0-6.5		5.5-6.0
2017	5.5-6.0	5.5-6.0		5.0-5.5
2018	5.5-6.0	5.5-6.0		5.0-5.5
2019	5.0-5.5	5.0-5.5		4.5-5.0
2020	5.0-5.5	5.0-5.5		4.0-4.5
2021	4.5-5.0	4.0-4.5		4.0-4.5

2.3 Financial Parameters and specific financing programs

Table 10: PV financing information in 2021

Different market segments	Loan rate [%]
Average rate of loans	4.76%
Average cost of capital – industrial and ground-mounted installations	3.5-5 Yuan/W

2.4 Specific investments programs

Table 11: Summary of existing investment schemes

Investment Schemes	Introduced in China
Third party ownership (no investment)	N/A
Renting	N/A
Leasing	N/A
Financing through utilities	N/A
Investment in PV plants against free electricity	N/A
Crowd funding (investment in PV plants)	N/A
Community solar	N/A
International organization financing	N/A
Other (please specify)	N/A

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 16 instructions: in the table below, mark "yes" if there are measures within this category on-going or commenced in your country. If not such measure exists in your country, leave the "-".

Table 9: Summary of PV support measures

Category	Residential		Commercial + Industrial		Centralized	
Measures in 2021	**On-going**	**New**	**On-going**	**New**	**On-going**	**New**
Feed-in tariffs	Yes Feed-in tariffs desulfurized coal benchmark price+ 0.03 yuan/kWh (include tax)		Yes 1. In a certain number of hours Desulfurized coal benchmark price (include tax) 2. The part of medium and long-term trading of electricity is determined by the market.			
Feed-in premium (above market price)						
Capital subsidies						
Green certificates	-	-	-	-	-	-
Renewable portfolio standards with/without PV requirements	-	-	-	-	-	-
Income tax credits	-	-	-	-	-	-
Self-consumption	-	-	-	-	-	-
Net-metering	No	No	No	No	No	No
Net-billing	No	No	No	No	No	No
Collective self-consumption and virtual net-metering	No	No	No	No	No	No
Commercial bank activities e.g. green mortgages promoting PV	Yes		Yes		Yes	
Activities of electricity utility businesses	Yes		Yes		Yes	

Sustainable building requirements						
BIPV incentives	Yes		Yes		Yes	
Other (specify)	-	-	-	-	-	-

3.1 National targets for PV

On September 2020, Chairman Xi Jinping made an important speech at the 75th United Nations General Assembly, to achieve carbon peak by 2030 and carbon neutralization by 2060. In March 2021, the central financial and Economic Commission put forward the basic idea of "building a new power system with new energy as the main body", which is to build a clean, low-carbon, safe and efficient energy system, implement renewable energy substitution actions, deepen power system reform and build a new power system with new energy as the main body.

On March 12, 2020, Xinhua News Agency announced the outline of the '14th-Five-Year-Plan' for China's national economic and social development and the long-term objectives for 2035. According to the plan, nine clean energy bases and four offshore wind power bases will be developed during the '14th-Five-Year-Plan' period.

Looking forward to 2022, China's new photovoltaic installed capacity is expected to be between 85GW and 100GW, and the installed capacity trend is stable.

From a domestic perspective, the scale of various sectors of the industry has grown steadily, the export value and export volume have both increased, the amount of photovoltaic power generation has increased, and the rate of waste light has decreased.

In 2021, the market share of half-chip module was about 86.5%, with a year-on-year increase of 15.5 percentage points. The efficiency of n-type modules such as TOPCon and HJT was improved, which further improved the module power. According to statistics, compared with PERC, the efficiency of n-type modules is increased about 1% on average, and the power is increased by 15W-20W for the same size.

In 2020, the penetration rate of bifacial modules was 29.7%. In 2021, with the recognition of the application for the power generation gain of bifacial modules and the impact of the exemption of 201 tariff of bifacial modules from the United States, the bifacial module market increased by 7.7 percentage points to 37.4% compared with 2020. It is estimated that it will reach about 50% in 2023, becoming a mainstream component packaging technology.

3.2 Direct support policies for PV installations

Since September 2020, when China put forward the goal of carbon peaking and carbon neutralization, China has successively defined the target of the proportion of non fossil energy in energy consumption at the main time points, which will be more than 20%, 25% and 80% in 2025, 2030 and 2060 respectively.

The National Energy Administration proposed in March 2021 that the development direction of new energy is to achieve large-scale, high proportion, market-oriented and high-quality development. Three main quantitative indicators are proposed in the "14th

Five Year Plan" renewable energy development plan: the installed capacity of renewable energy accounts for more than 50% of the total installed power, the proportion of renewable energy increment in the total electricity consumption increment exceeds 50%, and the proportion of renewable energy increment in the primary energy consumption increment exceeds 50%.

The document of renewable energy consumption guarantee mechanism in 2021 reflects the constraint of responsibility weight and the guidance of responsibility sharing. In May 2021, the National Development and Reform Commission and the National Energy Administration issued the Notice on Responsibility Weights and Related Matters of Renewable Energy Electricity Consumption in 2021 (FGNY [2021] No. 704), which clarifies the mechanism for issuing responsibility weights of provinces on an annual basis. This document also reflects the guidance of sharing responsibility for renewable energy consumption, and will gradually narrow the difference of weight indicators among regions.

Vigorously promote the development of photovoltaic bases, and actively promote the construction of large-scale wind power, photovoltaic bases focusing on desert, Gobi and desert regions. In November 2021, the National Energy Administration announced the first batch of large base projects, with a scale of about 97GW. By the end of 2021, the construction scale was about 70GW.

3.3 Self-consumption measures

Table 10: Summary of self-consumption regulations for small private PV systems in 2021

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Savings on the electricity bill + bonus
	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…)	None

	11	PV system size limitations	6 mw
	12	Electricity system limitations	None
	13	Additional features	None

3.4 Collective self-consumption, community solar and similar measures

N/A

3.5 Tenders, auctions & similar schemes

2021 is the first year that, except for household, photovoltaic generation is fully realized without subsidies.

Therefore, the provincial energy competent department will organize the implementation of bidding for the projects with guaranteed grid connection in 2021, and the project development owners and grid prices will be competitively allocated in the Notice on Matters Related to the New Energy Grid Price Policy in 2021 (FGJG [2021] No. 833), and then only the project development owners will be competitively allocated. In 2021, the state will continue to support household photovoltaic in the form of electricity subsidy in accordance with the principle of "payment based on income". The electricity subsidy standard determined by the national price authority is 0.03 yuan/kWh.

In October 2021, the Notice on Further Deepening the Marketization Reform of the Feed in Tariff for Coal fired Power Generation was issued. There are four points involved in photovoltaic power generation. First, the current benchmark price for coal fired power generation continues to serve as the linkage basis for the formation of new energy power generation and other prices, which means that the new regulations will not affect the stock of photovoltaic power generation and the price of guaranteed purchased electricity for newly arranged incremental projects in 2021. Second, expand the fluctuation range of the market transaction price. If photovoltaic power generation goes to the medium and long-term transaction market price, the fluctuation range will become larger, and if it goes to the spot price, it will not be affected (because the medium and long-term price fluctuation range becomes larger, it will affect the spot market price on the other hand). Third, cancel the industrial and commercial catalog sales electricity price, which will affect the income of the self-consumption part of distributed photovoltaic, that is, the income of the self-use part will change. Fourth, keeping the price of electricity for residents and agriculture stable means that the household photovoltaic benefits and policies remain unchanged.

In 2021, the photovoltaic power generation market increased on a large scale, and the new installed capacity increased from 48.2GW in 2020 to 54.88GW. It is expected that the scale of photovoltaic market in 2022 will continue to increase significantly on the basis of 2021.

3.6 Other utility-scale measures including floating and agricultural PV

Energy storage has gradually become the standard configuration of wind power and photovoltaic power stations. As of September 2021, each province has issued a competitive configuration scheme, and at least 14 provinces have proposed the requirements for energy storage configuration. To sum up, all provinces basically require photovoltaic power stations to be equipped with 5%~20% power and 1~2h electrochemical energy storage. Moreover, the configuration requirements are constantly improving. For example, Shandong required 10% * 2h energy storage configuration in 2020, and increased it to 20% * 2h in 2021. August 2021, the Notice on Encouraging Renewable Energy Power Generation Enterprises to Build or Purchase Peak shaving Capacity to Increase the Scale of Grid Connection issued by the two ministries and commissions put forward that in the part of market-oriented scale, 15%~20% * 4-hour chemical energy storage system should be configured.

In 2021, in the centralized photovoltaic, the floating and photovoltaic agricultural photovoltaic complementation accounted for a large proportion. For example, Zhejiang Wenzhou Taihan 550MW fishing optical complementary project, which was connected to the grid in December, is the largest single power station. The project covers an area of about 4.7 square kilometers. Combining fishery breeding with photovoltaic power generation, the project can "generate electricity on the upper side and fish on the lower side". After grid connection, the average annual power generation will reach 650 million kWh, and the installed capacity of clean energy power generation in Wenzhou power grid will increase by about 26%.

Guangdong Luoding 500MW agricultural photovoltaic project is the largest single agricultural optical complementary project. It uses over 6.67 square kilometers of barren hills and slopes and general agricultural land for development and construction.

In August 2022, the Ministry of Industry and Information Technology and other five departments jointly issued the Action Plan for Accelerating the Green and Low Carbon Innovative Development of Electric Equipment. According to the plan, we will promote the integrated construction of BIPV in new plants and public buildings; support the combined development of agriculture (animal husbandry) and PV, fishery and PV, and encourage the development of photovoltaic power stations in desert, gobi, barren mountain, coastal beach, coal mining subsidence area, mine waste dump and other areas.

3.7 Social Policies

3.7.1 PV Poverty Alleviation

In March 2018, the Ministry of Finance, the National Development and Reform Commission, the National Energy Administration, and the State Council Office of Poverty Alleviation issued the Notice on the Announcement of the Supplementary Renewable Energy Tariffs (PV Poverty Alleviation Project). The eligible PV poverty alleviation projects will be included in the catalogue of renewable energy tariffs.

In 2020, the established policy was maintained. As the last year of Poverty Alleviation, The official website of the Poverty Alleviation Office of the State Council released the latest progress of recent key poverty alleviation work, which summarized the national poverty alleviation work as of March 20, and highly affirmed the key role of photovoltaic poverty alleviation in winning the battle against poverty. The government will build not only distributed photovoltaic and photovoltaic power plants for poor family and village.

On June 17, 2020, the Ministry of Finance announced the final accounts data of the National Renewable Energy Fund for 2019 and the budget data for 2020. Among them, photovoltaic subsidies account for about 51%, accounting for the largest proportion, followed by wind power, accounting for about 43%, and biomass energy, accounting for about 6%. Among the photovoltaic subsidy projects, photovoltaic poverty alleviation projects, natural person distributed projects with a single installed capacity of less than 50KW, and photovoltaic projects determined by bidding in 2019-2020 shall be allocated in full priority (distributed at a proportion of 100%); The "leader" project determined by the state (connected to the grid before the end of 2019) gives priority to ensuring that 50% of the subsidy funds payable by the project are allocated; Other renewable energy projects included in the list are estimated to be distributed in the proportion of 30% - 40%.

3.8 Retrospective measures applied to PV

N/A

3.9 Retroactive measures applied to PV

N/A

3.10 Indirect policy issues

3.10.1 Rural electrification measures

By the end of 2015, China already announced that whole China has been electrified and there is no un-electrified people at all. So, there is no government supported projects for off-grid rural electrification any more since 2016.

PV industry applications, like communication, signal system for navigation, railways, highways, remote weather stations, remote satellite TV, etc., are sponsored by industry units and there is no special policy for such sector. The market is about several MW annually.

PV commercial products, like solar street lights, lawn lights, moveable solar chargers, solar watches, solar fans, etc., are all directly selling on market without any government subsidy. The market size is about few MW each year.

3.10.2 Support for electricity storage and demand response measures

In July 2021, the National Development and Reform Commission issued the Notice on Further Improving the Time of use Tariff Mechanism, which requires: 1) Reasonably determine the price difference between peak and valley electricity prices; 2) Establish peak electricity price mechanism. In principle, the floating rate of peak price shall not be less than 20% on the basis of peak price.

The policy releases the signal that the spot electricity trading market continues to expand. At present, six western provinces in China have experimented with spot trading of electric power, which is equivalent to taking the medium and long term agreements as disguised spot trading, and decomposing them into days or even hours before implementation.In the future, the scope, scale, price and mechanism of spot electricity trading market will be further refined.

In addition, this policy has accelerated the development of new energy and new power systems with energy storage. Accelerate the construction of new power systems, select Fujian, Zhejiang and Qinghai as provincial demonstration areas, and focus on the research of integrated development plans of large power grids, distributed and micro power grids at the sending and receiving ends, as well as policies and market mechanisms to adapt to the development of new energy.

3.10.3 Support for electric vehicles (and VIPV)

In November 2020, the State Council officially issued the new energy vehicle industry development plan (2021-2035), which proposed to promote the efficient coordination between new energy vehicles and renewable energy. Promote the information sharing and integration of new energy vehicles and meteorological and renewable energy power forecasting systems, coordinate the coordinated scheduling of new energy vehicle energy utilization, wind power generation and photovoltaic power generation, and improve the application proportion of renewable energy. Encourage the construction of "optical storage, charging and discharging" (distributed photovoltaic power generation---energy storage system---charging and discharging) multi-functional integrated station. Support qualified regions to carry out commercial demonstration operation of fuel cell vehicles. There will be more and more integration of new energy vehicles and photovoltaic, which will bring new development opportunities to photovoltaic sheds.

In January 2022, China's first snow wax truck made in Shandong was officially put into use on Winter Olympic Beijing 2022. On January 12, the snow wax truck had entered the Chongli cross-country ski center competition area. The vehicle was in full load working condition with 24-hour continuous power supply. It provided wax service for 200-300 pairs of skis every day. There has never been power failure, interruption of use, etc. The snow wax car roof is equipped with Shangmai light photovoltaic module eArc, enabled the Beijing Winter Olympic Games in the whole process.

3.10.4 Curtailment policies

In 2021, China will continue to strengthen the construction of new energy grid connection supporting projects, give priority to meeting the needs of new energy consumption nearby, and ensure that new energy can be combined. Build 14 provincial key transmission channels to improve the new energy consumption capacity. The 750 kV and below new energy grid connection and transmission projects throughout the year met

the grid connection requirements of 1161 centralized and 420,000 distributed new energy power generation projects.

Accelerate the construction of trans provincial grid transmission channels. In 2021, the State Grid completed two ultra-high voltage DC transmission projects and one AC project. A total of 15 AC and 14 DC ultra-high voltage transmission projects have been completed. The designed transmission capacity of ultra-high voltage DC will exceed 100 million kilowatts, further promoting the large-scale optimization of new energy allocation. In 2021, the UHV DC power transmission reached 404.6 billion kWh, up 10.4% year on year. By the end of 2021, the trans regional DC transmission capacity of the whole network was 14 million kilowatts higher than that in 2020.

In addition, May 2021, the National Development and Reform Commission and the National Energy Administration jointly issued the Notice on the Weight of Renewable Energy Power Consumption Responsibility and Related Matters in 2021 (FGNY [2021] No. 704), giving the weight of renewable energy power consumption responsibility in 2021 and 2022 for each province. This weight is a binding indicator in the current year, and each province will evaluate it according to this! This weight is also the basis for calculating the guarantee scale of each province.

During the 13th Five Year Plan period, the National Development and Reform Commission and the National Energy Administration jointly released the Clean Energy Consumption Action Plan (2018~2020), which proposed: From 2018 to 2020, the national average light rejection rate should be within 5%, and for key regions, Xinjiang and Gansu, it should be limited to 10%.

3.10.5 Other support measures

In November 2020, the Ministry of Ecology and Environmental Protection released the "Implementation Plan for the Setting and Allocation of the Total Amount of National Carbon Emission Trading Quotas (Power Generation Industry) from 2019 to 2020 (Draft for Comments)". In July 2021, the national unified carbon emission trading market was officially launched, making it the largest carbon emission trading market in the world. At present, the national carbon trading market covers nearly 4.5 billion tons of annual carbon dioxide emissions, accounting for about 40% of China's total emissions. It is estimated that by 2025, it will cover about 8500 enterprises, accounting for about 70% of China's total emissions.

In 2021, photovoltaic recycling will become the focus of attention. In March, the National Development and Reform Commission and other ten ministries and commissions jointly issued the Guiding Opinions on the Comprehensive Utilization of Large Solid Wastes during the "Fourteenth Five Year Plan", proposing to explore standardized recycling and recyclable and high-value recycling approaches for solid wastes in emerging industries such as "retired" photovoltaic modules and wind turbine blades. In July, the National Development and Reform Commission issued the "Fourteenth Five Year" Circular Economy Development Plan (FGHZ [2021] No. 969), which included "promoting the classified utilization and centralized disposal of retired photovoltaic modules" into the plan, guided the concentrated development of renewable resources processing and utilization projects.

3.11 Financing and cost of support measures

In April 2020, the National Development and Reform Commission issued the announcement on the continuation of the enterprise income tax policy for the western development (Announcement No. 23 of the Ministry of Finance in 2020), which made it clear that: From January 1, 2021 to December 31, 2030, enterprises in encouraged industries located in the western region will be subject to enterprise income tax at a reduced rate of 15%.

In January 2021, the National Development and Reform Commission issued 'the catalogue of encouraged industries in the western region (2020 Edition)'. Wind power and PV projects have become one of the most important encouraged directions in the catalogue, and have entered the encouraged catalogue in all western regions.

According to the latest version of the catalogue, in 12 provinces (autonomous regions and cities), wind power and PV projects are encouraged projects, and can enjoy a 15% income tax preference. In addition, the catalogue of some provinces also includes items such as PV modules, silver powder for PV cells, PV power station detection, PV tracking support, PV glass, etc.

4 INDUSTRY

4.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

4.1.1 Polycrystalline silicon material

Mainland China's polycrystalline silicon production remained continued increase in 2021 to reach $50.6*10^4$ tons output, accounting 78.8% of global total output.

In terms of production capacity, China's polysilicon production capacity will account for 80.5% of the global production capacity in 2021, an increase of 5.3% compared with 75.2% in 2020. In terms of output, China's polysilicon output accounted for 78.8% of global output in 2021, an increase of 2.8% compared with 76% in 2020.

Table 11: Silicon feedstock, ingot and wafer producer's production information for 2021

Manufacturers	Process & technology	Total Production Output	Product destination	Price
Sichuan Yongxiang Co., Ltd.	mc-Si	$10.94*10^4$		
Jiangsu Zhongneng（GCL Silicon）	mc-Si	$10.46*10^4$		
Xinjiang Great New Energy Co., Ltd.	mc-Si	$8.66*10^4$		

Xinte Energy Co., Ltd	mc-Si	$7.82*10^4$		
East Hope Co. Ltd	mc-Si	$6.0*10^4$		
Asia Silicon Co., Ltd	mc-Si	$2.2*10^4$		
Rest	mc-Si	$4.52*10^4$		
Total	mc-Si	$50.6*10^4$		

Source：CPIA,2022.3

4.1.2 Silicon wafer

In 2021, mainland China's wafer production capacity was about 407.2GW, was an increase of 69.7% year-on-year, benefited from investment to expand production of monocrystalline silicon wafer, and the increase in production capacity brought by technological progress and cost control. China's wafer production is about 226.6GW, an increase of 40.4% year-on-year, accounting for 97.3% of global wafer production. In 2021, China's silicon wafer export volume is about 22.6GW, an decrease of 16.3% year-on-year, accounting for about 10% of China's silicon wafer output. Among them, the export volume of monocrystalline silicon wafer was about 21.1GW, a year-on-year decrease of 11.7%, and the export volume of polycrystalline silicon wafer was about 1.5GW, a year-on-year decrease of 51.6%.

4.2 Production of photovoltaic cells and modules (including TF and CPV)

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.

4.2.1 Solar cell

In 2021, the total production capacity of China's solar cell was 360.6GW, a year-on-year increase of79.2%, accounting for 85.1% of global production capacity, up 4.4% year-on-year; the output was about 197.9GW, a year-on-year increase of 46.8%, about 88.4% of the annual global production, up 5.9% year-on-year.

Table 17: Solar Cell producer's production information for 2021 (Top 10)

Manufacturers	Maximum production capacity	Total Production Output [MW/yr]
Tongwei Solar	40800	32930

LONGi Group	42480	25440
Aikosolar Ltd.	36000	19470
JA Solar Holdings Co., Ltd.	30600	18940
Trina Solar Co.,	29400	18900
Runergy New Energy Technology Co., Ltd.	19800	12630
JinkoSolar Holding Co., Ltd.	13150	8960
Canadian solar	9750	7070
Uniex New Energy Co.,ltd.	8200	5640
Jiangsu Zhongyu	9000	5000
Total	239,180	154,980

4.2.2 PV module

In 2021, the total production capacity of PV module was about 359.1GW, and the output was 181.8GW, a year-on-year growth of 47% and 45.9%.

The value of PV module export amounted to approximately US$24.61 billion in 2021, a year-on-year increase of 44.8%, accounting for 86.6% of total PV product exports; export volume was approximately 98.5GW, a year-on-year increase of 25%, make an new record of mudule export, accounted for 54.2% of the total output.

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

Table 18: PV module production and production capacity information for 2021(Top 10)

Wafer-based PV module manufactures	Maximum production capacity	Total Production Output [MW/yr]
LONGi Group	48000	32671
JA Solar Holdings Co., Ltd.	36500	24124
Trina Solar Co.,	43800	22510
JinkoSolar Holding Co., Ltd.	38104	18889

Canadian Solar	20000	12185
Risen Energy Co.,Ltd.	19100	8627
Suntech Power Holdings	10000	6886
Chint Solar	10000	5674
TCL Zhonghuan Renewable Energy Technology Co.,Ltd	8000	4763
Hengdian Group DMEGC Magnetics Co., Ltd	5000	3413
Total	238,504	139,742

Note: only include the production bases of enterprises in Chinese Mainland

Source: CPIA, 2022.3

Table 19: Thin-film PV module production and capacity information for 2021

Thin film PV module manufactures	Maximum production capacity (MW)	Technology
Advanced Solar Power (Hangzhou) Co., Ltd.	120	CdTe
Zhongshan Ruike New Energy Co., Ltd.	100	CdTe
CNBM Solar	100	CdTe
Hanergy Group	600	CIGS
Hangzhou Jinjiang Group	150	CIGS
Triumph Science & Technology Co., Ltd (CNBM)	100	CIGS
Hangzhou Shangyue Optoelectronics	50	CIGS
Nanjing Sunflare Solar	10	CIGS
Total	1230	

Source：CPIA,2022.4

4.3 Manufacturers and suppliers of other components

- PV inverters (for grid-connection and stand-alone systems) and their typical prices

In 2021, the new installed photovoltaic in China reached 54.88GW, with a year-on-year growth of 13.9%. The cumulative grid connected installed capacity reached 306GW, ranking first in the world in terms of new and cumulative installed capacity. Among them, 25.6GW and 29.28GW of centralized and distributed photovoltaic were added respectively. For the first time, more than half of the new installed capacity of distributed photovoltaic has been added, and the development trend of both centralized and distributed is obvious. Among them, the residential PV market showed explosive growth, with an annual increase of 21.6GW, a year-on-year growth of 113%, make a new record. Under the continuous influence of policy and market orientation, the distributed and residential will remain a high growth in 2022.

Considering the inverter supply cycle, project carry forward and capacity ratio, the inverter sold in China market was about 63GW in 2021. According to incomplete statistics of CPIA, the total output of inverter in China in 2021 is about 155GW (excluding the OEM output of foreign brands), with a year-on-year increase of 55%.

- Storage batteries

According to incomplete statistics of CNESA, by the end of 2021, the cumulative installed capacity of China's electric energy storage projects that have been put into operation is 46.1GW, with a year-on-year growth of 30%. Among them, the cumulative installed capacity of pumped storage is the largest, reaching 39.8GW, with a year-on-year decrease of 3%; the market increment mainly comes from new energy storage, and the cumulative installed capacity has reached 5.73GW. In 2021, the installed capacity of new power storage projects put into operation in China will exceed 10GW for the first time, reaching 10.5GW. Among them, pumped storage capacity increased by 8GW, a year-on-year increase of 437%; The new energy storage capacity reached 2.4GW, up 54% year on year.

- Battery charge controllers
- DC switchgear
- Supporting structures

Due to the low market threshold of the traditional photovoltaic support industry, with the rapid development of the national photovoltaic industry, the number of companies participating in the support structure has increased sharply, market competition is fierce, product quality is unbalanced, and the overall profit industry development speed is not high.

The characteristics of China's supporting structure industry are: the industry concentration has further increased, the average profit rate of the industry has decreased, the industry has moved to overseas markets, and the development of the tracking system has accelerated. In addition, as the installed capacity of China's centralized decrease, the market share of tracking system was only 14.6%, down 4.1% year on year.

5 PV IN THE ECONOMY

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

5.1 Labour places

Table 12: Estimated PV-related full-time labour places in 2021

Market category	Number of full-time labour places
Research and development (not including companies)	N/A
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	N/A
Distributors of PV products and installations	N/A
Other	N/A
Total	N/A

5.2 Business value

Table 13: Rough estimation of the value of the PV business in 2021 (VAT is excluded)

Sub-market	Capacity installed [MW]	Average price [Yuan/W]	Value	Sub-market
Off-grid	0			
Grid-connected distributed	29280	4.15	121,512,000,000	
Grid-connected centralized	25600	4.15	106,240,000,000	
Value of PV business in 2021				227,752,000,000

6 INTEREST FROM ELECTRICITY STAKEHOLDERS

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 254 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 eight cities (leagues) and urban and rural residents' lives of 14.29 million in the region, while supplying power to North China, Yulin in Shaanxi, and Mongolia across provinces, regions and borders.

According to the information released by the National Bureau of Statistics, by the end of 2021, the proportion of power structure is: thermal power accounts for the largest proportion of 66%, followed by hydropower, accounting for 19%, wind power accounts for 6%, and photovoltaic power accounts for the lowest proportion of 3.9%.

6.2 Interest from electricity utility businesses

In 2021, the national solar photovoltaic power generation exceeded 300 billion kWh, reaching 325.9 billion kWh, with a year-on-year growth of 25.1%. The proportion of solar photovoltaic power generation in the total power generation reached 3.9%. In 2021, the average utilization hours of solar generation in China was 1163 hours, a year-on-year increase of 3 hours. The average utilization hours of solar photovoltaic generation in 16 provinces and regions exceed 1200 hours.

In 2021, the trading scale was greatly improved. The new energy market trading electricity in the State Grid Business Zone reached 237.5 billion kWh, a year-on-year increase of 51.1%, accounting for 29.2% of the total new energy power generation, a year-on-year increase of 7.6 percentage points. The new energy inter provincial trading electricity reached 130 billion kWh, a year-on-year increase of 42.1%, accounting for 54.7% of the new energy trading electricity.

6.3 Interest from municipalities and local governments

Household PV has become the main force in the development of distributed PV since 2020. According to the data released by the National Renewable Energy Information Center, the installed capacity of household PV projects included in the scale of national financial subsidies, by the end of 2021, is 21.6 GW, accounting for 73.8% of the new installed capacity of all distributed PV.

At the same time, China's third and fourth tier cities are making great efforts to develop photovoltaic industry and strive to build a 100 billion level photovoltaic industry cluster during the 14th Five Year Plan period, such as Jiaxing in Zhejiang Province, Taizhou and Yancheng in Jiangsu Province, and Chuzhou in Anhui Province. Centering

on one or two leading enterprises, these cities drive the investment and production of the whole industrial chain around them, and drive the coordinated development of the whole industrial chain.

7 HIGHLIGHTS AND PROSPECTS

7.1 Highlights

7.1.1 Development goals

In 2021, China's photovoltaic installed capacity has grown rapidly. According to data released by the National Energy Administration, the cumulative total installed capacity of photovoltaic power generation in China in 2021 was 305.99GW, a year-on-year increase of 20.9%. As photovoltaics gradually enter the era of parity and 14-five-year plan, the installed capacity will show a more rapid growth trend.

7.1.2 Improvement of financing environment

According to the incomplete statistics of CPIA, on stock market, 27 enterprises in China's photovoltaic industry completed 28 financing projects in 2021, with a corresponding financing scale of 105.83 billion yuan. Among them, 21 refinancing projects raised 75.8 billion yuan, up 30% year on year; There were 7 IPO financing projects, raising 30.1 billion yuan, up 129.2% year on year.

7.1.3 Market

In 2021, total annual installation is reach to 54.88GW. Among them, the distributed PV is 29.28GW, shared 53.35%.

Table 22 PV Installation by Sectors in 2021

Market Sec.	Annual (MWp)	Cumulative (MWp)	Share %
Distributed	29280	107510	53.35
Power Plant	25600	198480	46.65
Off-grid		360	
Total	54880	305990	100

Source: CPIA 2022.4

7.1.4 Industry

China has been the largest producer of PV modules in the world since 2007. PV productions of whole manufacture chain in 2021 are shown in Table 23:

Table 23 PV Production and China Share in 2021

Sectors	World	China	Share（%）
Poly-Silicon (10^3Ton)	64.2	50.6	78.8
Silicon Wafer (GW)	232.9	226.6	97.3
PV Cells(GW)	223.9	197.9	88.4

PV Modules (GW)	220.8	181.8	82.3

Source: CPIA

7.1.5 R&D

CPVS has been publish the Solar Cell Best-Efficiency Table of China for three years since 2017. Last month, CPVS published the 2021 Solar Cell Best-Efficiency Table of China:

Table 2 Lab. Level Highest Cell Efficiency

No	Technology	Cell Efficiency (%)	Area (cm2)
Silicon			
1	HJT	26.30±0.39	274.3 (t)
2	HJT	25.82±0.39	274.5 (t)
3	HJT	25.54±0.38	274.5 (t)
4	*n*-TOPCon	25.4±0.51	267.6 (t)
5	HJT	25.26±0.35	274.5 (t)
6	*n*-TOPCon	25.23±0.38	247.57 (da)
7	*n*-TOPCon	25.11±0.38	267.6 (t)
Thin film chalcogenide			
8	CZTSSe (Cell)	12.96±0.10	0.1072 (ap)
Perovskite			
9	Perovskite (minimodule)	21.4±0.4	19.32 (da)
10	Perovskite (minimodule)	20.1±0.4	63.98 (da)
Organic			
11	Organic (Cell)	18.2±0.2	0.0322 (da)
12	Organic (minimodule)	14.5±0.3	19.31 (da)
1. LONGi 2. LONGi 3. Maxwell/Sundrive 4. Jinko 5.Maxwell/Huasun 6. Jinko 7. Jinko 8. NJU 9. Microquanta 10. UtmoLight 11. SJTU/BUAA 12. ZJU/Microquanta			

Source: CPVS 2022.7

7.2 **Prospects**

2021 is the first year of “The 14th Five-Year National Plan”. In 2021, the cost of PV is already reached to the level of grid-parity, except PV home systems, the other PV projects will have no subsidy anymore and the Grid Co. will purchase PV electricity with

the price the same as coal-fire power plants. Since 2021, the total PV market quota will not be controlled by NDRC or NEA, the PV installed capacity will be arranged by provincial government according to the " Mandatary Share of Non-Hydro Renewable Energy Power", issued by NEA, just like RPS in western countries. For the target of 2030 reach to CO2 peak and 2060 reach to "carbon neutral", PV market will be expanded further more. It is estimated that during the 14th 5-year plan (2021-2025), annual PV installation in China will be at least 80GW. Photovoltaic will help clean and low-carbon development in many fields.