CHINA PV INDUSTRY DEVELOPMENT ROADMAP

(2021-2022)

China Photovoltaic Industry Association

CCID Thinktank Institute of Integrated Circuits

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Preface

In the context of global warming and the depletion of fossil energy, the international community is paying more and more attention to the development and utilization of renewable energy, and development of renewable energy has become the consensus of all countries in the world. The Paris Agreement became into force on November 4, 2016, highlighting the determination of countries around the world to develop the renewable energy industry. On September 22, 2020, during the general debate at the 75th UN General Assembly, General Secretary Xi Jinping declared that China "will strive to peak carbon dioxide emission by 2030 and achieve carbon neutrality by 2060". On December 12, 2020, General Secretary Xi Jinping declared at the Climate Ambition Summit that "by 2030, China will lower its carbon dioxide emissions per unit of GDP by over 65 percent from the 2005 level, increase the share of non-fossil fuels in primary energy consumption to around 25 percent, increase the forest stock volume by 6 billion cubic meters from the 2005 level, and bring its total installed capacity of wind and solar power to over 1.2 billion kilowatts." In order to achieve the above goals, it is imperative to develop renewable energy. Among all kinds of renewable energy, solar energy is witnessing the fastest growth because it is clean, safe and inexhaustible. The development and utilization of solar energy is of great significance to adjusting the energy structure, promoting the revolution of energy production and consumption, and promoting the ecological civilization construction.

In 2016, General Secretary Xi Jinping pointed out at the Symposium on Network Security and Information Technology that to make core technology breakthroughs, we should "formulate a road map, timetable and brief, clarify the short-term, medium-term and long-term goals, and make promotion in echelons, categories and stages and by following the laws of technology". As a global PV manufacturing power, China should formulate the PV industry development roadmap for purpose of guiding the sustainable and healthy development of PV industry in China, thus making due contributions to the development of the global PV industry.

Therefore, with guidance from the Ministry of Industry and Information Technology, China Photovoltaic Industry Association and CCID Thinktank Institute of Integrated Circuits have organized experts to compile the China PV Industry Development Roadmap ("the Roadmap"). The Roadmap contains not only the development direction of PV technologies but also information on industry, market and other aspects, reflecting the current consensus of experts, scholars and entrepreneurs on the future development of PV industry. In view of the uncertainties in the future industrial development due to many factors, including policies, technologies, markets, enterprises and economic environment, adjustment will be made to the Roadmap for the development of PV industry as appropriate so that it can accurately reflect the latest development of the PV industry, reasonably predict the future industrial development trend, and thus truly lead the industry. It is also hoped that the Roadmap can become a wind vane for the development of global PV industry.

I would like to conclude by wishing brighter prospects for the PV industry.

Wang Shijiang

Secretary General of China Photovoltaic Industry Association

Introduction

After decades of development, the PV industry has become one of the rare strategic emerging industries in China which has established international competitive advantages, has achieved end-to-end automatic control, and is expected to take the lead in becoming a high-quality development model. It is also an important engine to drive the energy revolution in China. At present, the PV industry in China ranks among the top in the world in terms of manufacturing scale, industrial technology level, application market expansion and industrial system construction.

In order to lead the development direction of the industry and guide the healthy and sound development of the PV industry in China, with guidance from the Electronic Information Department of the Ministry of Industry and Information Technology, China Photovoltaic Industry Association and CCID Thinktank Institute of Integrated Circuits have released five versions of China PV Industry Development Roadmap. On this basis, we organized industry experts to compile the China PV Industry Development Roadmap (2021-2022) (“the Roadmap (2021-2022)”), which covers all links upstream and downstream of the PV industry chain, including polysilicon, silicon rod/ingot/wafer, cell, module, inverter and system, with a total of 41 key indexes. According to the physical conditions of the industry, together with the technological evolution process and the existing enterprise technological transformation conditions, the Roadmap (2021-2022) provides the summary of development in 2021 and prediction of the development trends in 2022, 2023, 2025, 2027 and 2030. These indexes, which reflect the development status and development trend of industry, technology and market, are forward-looking to a certain extent and can serve as a reference for friends from all walks of life. We will make appropriate adjustments to these indexes according to the industrial development and changes so that they can reflect the physical conditions of the industry in a more timely and more accurate manner and better guide the development of the industry.

During the compilation of the Roadmap (2021-2022), industrial authorities, industrial experts and various enterprises in the industry chain have offered their help, and hereby we would like to express our gratitude. Due to the time constraints and our limited experience and ability, if anything inaccurate is found, please inform us so that we can make further improvement in subsequent revisions.

China Photovoltaic Industry Association

CCID Thinktank Institute of Integrated Circuits

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The PV industry is an industry derived from the combination of semiconductor technology and new energy demand. Promotion of the PV industry is of great significance to adjusting the energy structure, promoting the revolution of energy production and consumption, and promoting the ecological civilization construction. In China, the PV industry has been listed as one of the national strategic emerging industries, and guided by the industrial policies and driven by the market demand, the PV industry is developing rapidly and has become one of the few industries in China that are internationally competitive and have leading advantages. The figure below shows the composition of the PV industry chain.

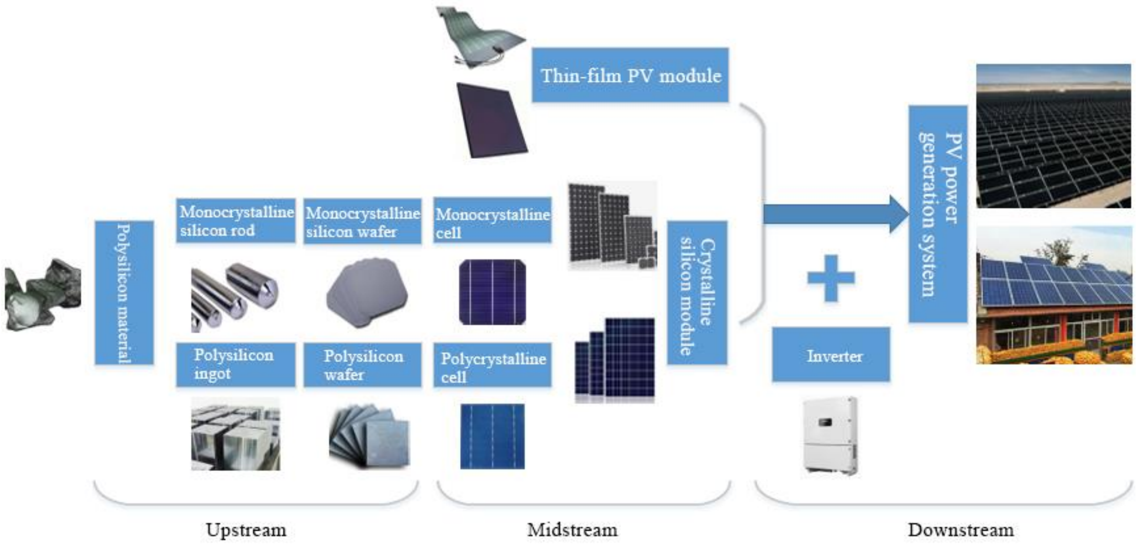

Figure 1. Composition of PV industry chain

I Roadmap compilation description

(I) Coverage

The compilation of the *Roadmap* aims to provide support for the establishment of industrial policies by the State, direction for industrial technology development and reference for strategic decision-making in enterprises. Based on the current PV technology and industry development, indexes representing the development level of this field are extracted from various links of PV industry chain, including polysilicon, silicon rod/ingot, silicon wafer, cell, module, inverter and system. These indexes cover all levels of industry, technology and market.

(II) Determination of index value

On the basis of the previous five versions, this revision to the Roadmap follows the principle of being objective, scientific, universal and forward-looking, and similarly, extensive solicitation of opinions, especially recommendations from key enterprises and experts, is conducted in the form of questionnaire, field investigation and symposium. In this way, the development status and trend of key indexes in all links between 2021 and 2030 are determined. In this revision, the questionnaire survey focuses on the major PV enterprises in all links of the industry chain. Moreover, opinions from enterprises and experts have been solicited through e-mails and in other written forms, and more than two symposiums have been initiated for detailed analysis on the rationality and necessity of individual indexes in order to determine the respective index values. Considering that the uncertainty of future development will make it more difficult to predict the index values, every effort is made to ensure that the Roadmap being compiled can accurately predict the short-term development direction, with the medium- and long-term predictions more representing a reflection of the future trend from all sectors of the industry. In the future, we will update the Roadmap on regular basis for purpose of approaching the "true value", better reflecting the latest development of the industry and effectively guiding the development of the industry.

II Development of PV industry in China

In terms of the PV market, in 2021, an additional 54.88GW installed capacity of PV power is connected to the grid in China, a year-on-year increase of 13.9%, and the cumulative PV grid-connected installed capacity reached 308GW. Both the new and cumulative installed capacity ranked first in the world. The annual PV power generation is 325.9 billion kWh, a year-on-year increase of 25.1% and accounting for about 4.0% of the total power generation in China. It is estimated that the new installed capacity of PV power in 2022 will be over 75GW, and the cumulative installed capacity is expected to reach about 383GW.

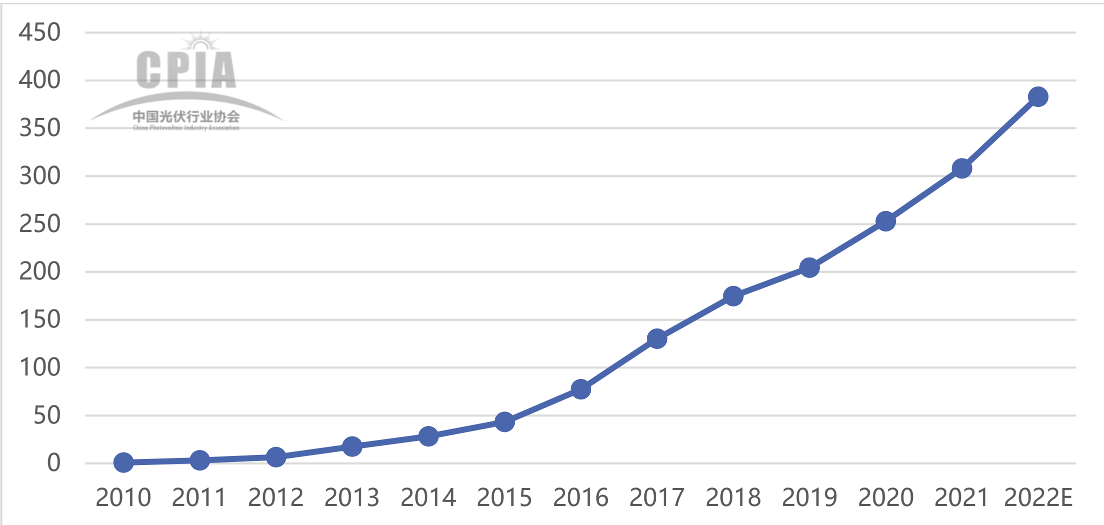

Figure 2. Cumulative installed capacity of solar PV power generation in China between 2010-2022 (in GW)

In terms of product efficiency, in 2021, the p-type monocrystalline cells in mass production adopted the PERC technology, with an average conversion efficiency of 23.1%, 0.3% higher than that in 2020, and the leading enterprises can achieve a conversion efficiency up to

23.3%; the polycrystalline black silicon cells produced with the PERC technology have a conversion efficiency of 21.0%, 0.2% higher than that in 2020; the conventional polycrystalline black silicon cells have poor improvement in the conversion efficiency, which is about 19.5% in 2021 and only 0.1% higher than that in 2020.

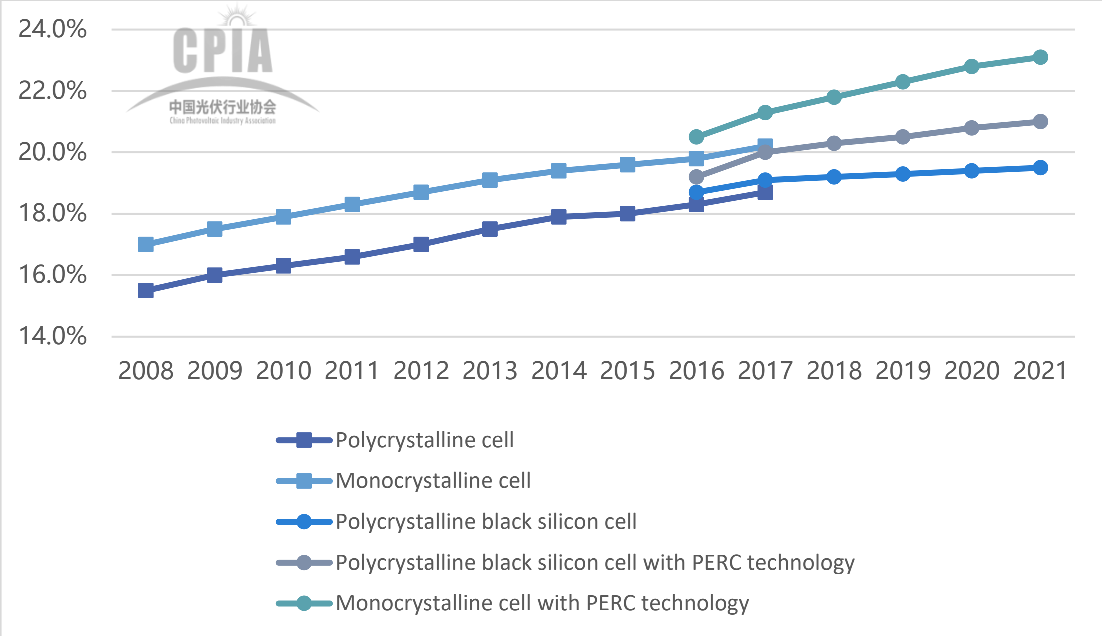

Figure 3. Development trend of conversion efficiency of cells in mass production in China between 2008-2021

III Key indexes in links of industry chain

(I)Polysilicon[1]

1. Reduction power consumption

Polysilicon reduction means the process in which high-purity silicon material is generated through the reduction reaction between trichlorosilane and hydrogen. The reduction power consumption includes power consumption in the process of silicon core preheating, deposition, thermal insulation, end ventilation and so on. In 2021, the proportion of dense materials per furnace remains 70%-80%, and the average reduction power consumption of polysilicon is decreased by 6.1% from that in 2020 to 46kWh/kg-Si. In the future, with the continuous optimization of gas composition, the operation and stable production of large-furnace type, and the trial production with loose materials by monocrystalline silicon

[1] Unless otherwise specified in this section, all indexes apply to the silicon rod manufactured with the trichlorosilane method. The process division, energy consumption types, measurement and calculation methods in the polysilicon production process shall comply with the Norm of Energy Consumption Per Unit Products of Polysilicon Enterprise GB29447.

manufacturers, the reduction power consumption will continue to decline, and it is expected to drop to 42kWh/kg-Si by 2030.

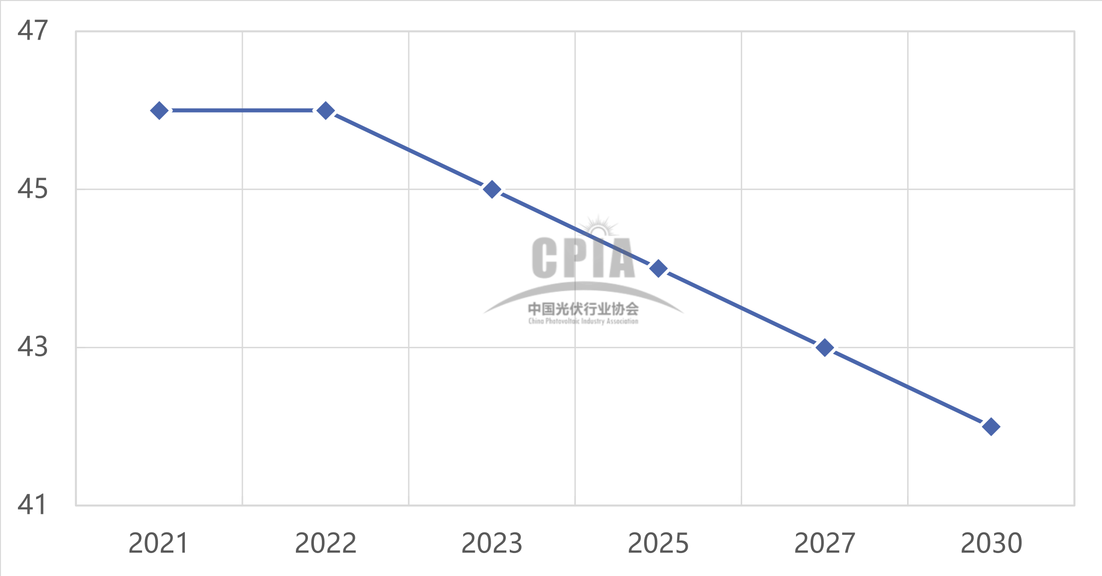

Figure 4. Change trend of reduction power consumption between 2021-2030 (in kWh/kg-Si)

2. Comprehensive power consumption

Comprehensive power consumption means all the power consumed for manufacturing per unit polysilicon products, including the power consumption in synthesis, hydrogen production from electrolysis, distillation, reduction, vent gas recovery and hydrogenation. Depending on the production process, the comprehensive power consumption may vary to a certain extent. In 2021, the average comprehensive power consumption for manufacturing polysilicon has decreased to 63kWh/kg-Si, a year-on-year decrease of 5.3%. In the future, with the improvement of production equipment technology, system optimization capacity and production scale, it is expected to drop to 55kWh/kg-Si by 2030. At present, the comprehensive power consumption for manufacturing silicon grains with the silane FBR method is 40%-50% lower than that for manufacturing silicon rods with the trichlorosilane method.

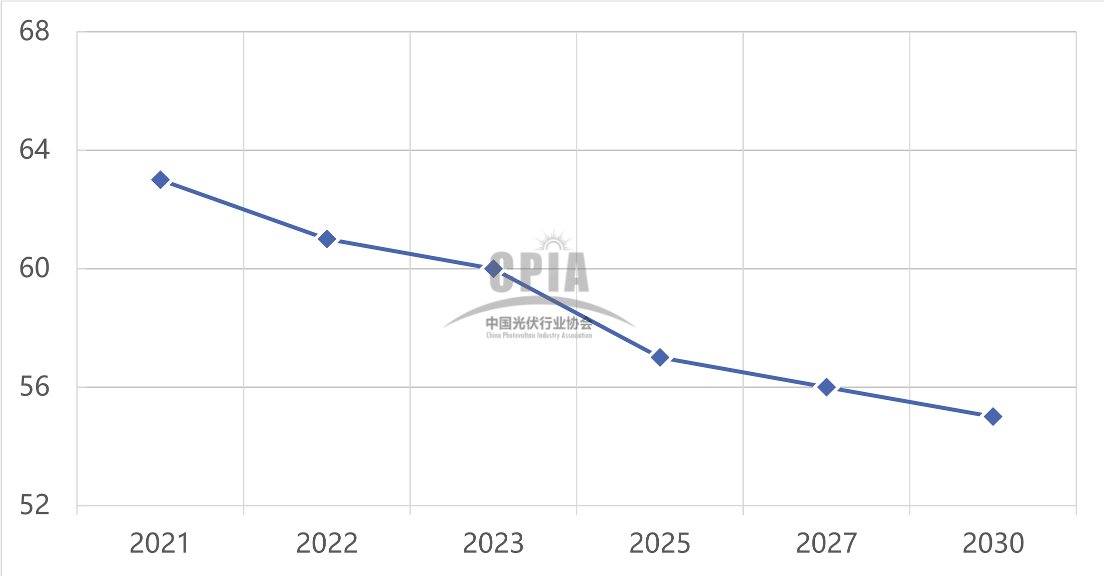

Figure 5. Change trend of comprehensive power consumption between 2021-2030 (in kWh/kg-Si)

3. Comprehensive energy consumption

The comprehensive energy consumption for manufacturing polysilicon includes the natural gas, coal, electricity, steam, water, etc. consumed in the production process of polysilicon. In 2021, the average comprehensive energy consumption by polysilicon enterprises is 9.5kgce/kg-Si, a year-on-year decrease of 17.4%. With technological progress and comprehensive utilization of energy, it is expected to drop to 7.6kgce/kg-Si by 2030.

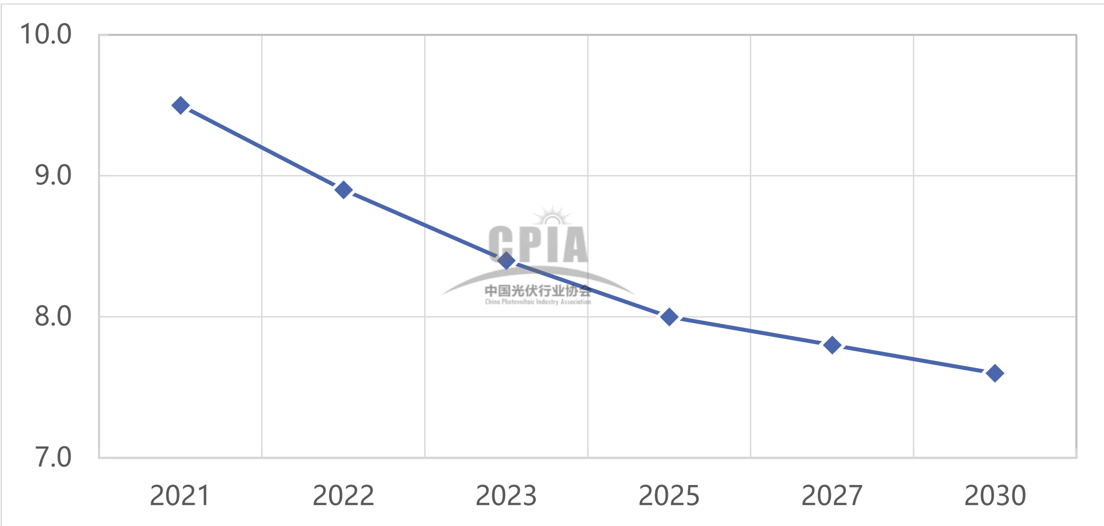

Figure 6. Change trend of comprehensive energy consumption between 2021-2030 (in kgce/kg-Si)

4. Unit consumption of silicon

Unit consumption of silicon means the amount of silicon consumed for manufacturing per unit high-purity silicon products, mainly including the synthesis and hydrogenation processes. For calculation, all silicon containing materials, including purchased silicon powder, trichlorosilane and silicon tetrachloride, are taken as pure silicon, and the chlorosilane sold is taken as pure silicon based on the silicon content and is deducted from the total amount. In 2021, the silicon consumption is 1.09kg/kg-Si, substantially the same as that in 2020, and there is little change in the past five years. With the improvement in hydrogenation level and in the by-product recovery and utilization rate, it is expected to be reduced to 1.07kg/kg-Si by 2030.

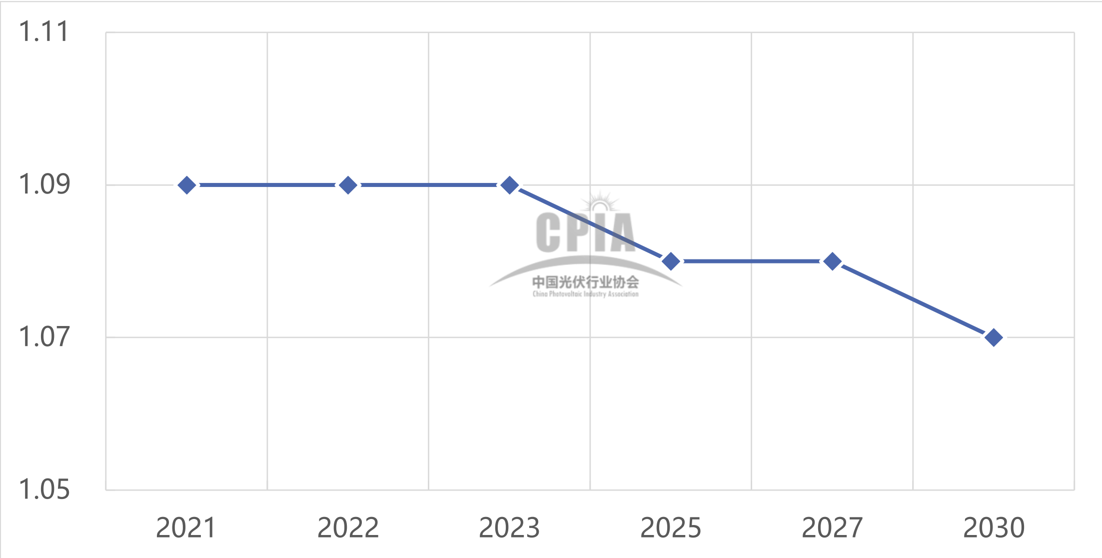

Figure 7. Change trend of unit consumption of silicon between 2021-2030 (in kg/kg-Si)

5. Market share of silicon rod and silicon grain

At present, the mainstream polysilicon manufacturing technologies mainly include trichlorosilane method and silane FBR method, with silicon rods and silicon grains produced respectively. The production process with trichlorosilane method is relatively proven. In 2021, the production capacity and output of silicon grains with the silane FBR method increase slightly, and the market share of silicon grain increases by 1.3% on year-on-year basis, reaching 4.1%. The silicon rod has a market share of 95.9%. In the future, if the production capacity of silicon grain is further expanded, and with the improvement in production process and the expansion of downstream applications, the market share will be further increased.

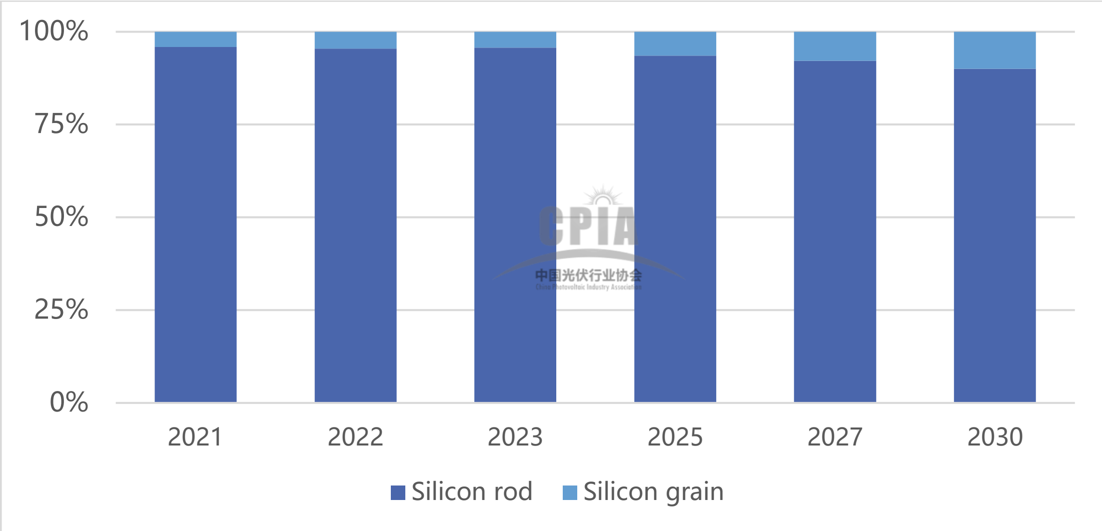

Figure 8. Change trend of market share of silicon rod and silicon grain between 2021-2030

(II)Silicon wafer[2]

1. Power consumption by pulling rod

The power consumption by pulling monocrystalline silicon rod means the power consumption for manufacturing the monocrystalline silicon rod with the vertical pulling method, which can be reduced by improving the hot zone, thermal insulation performance, equipment automation and intelligence, and the continuous pulling rod technology. In 2021, the average power consumption by pulling rod is reduced from 26.2kWh/kg-Si in 2020 to 23.9kWh/kg-Si (square rod). It is expected to drop to 20.9kWh/kg-Si by 2025.

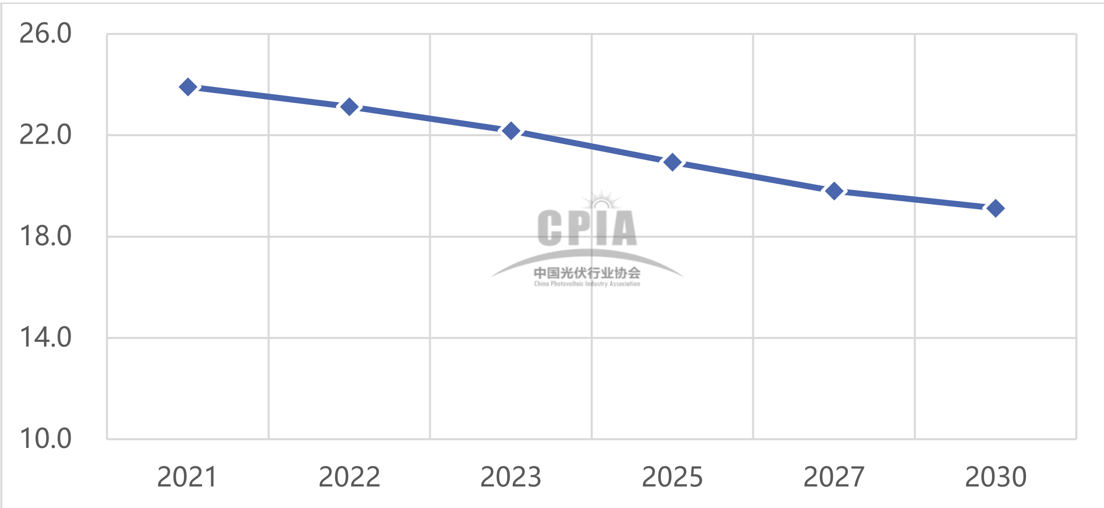

Figure 9. Change trend of power consumption by pulling rod between 2021-2030 (in kWh/kg-Si)

[2] Unless otherwise specified, the indexes in this link are based on the manufacturing of 166mm silicon wafer.

2. Single-furnace charge for pulling rod

The single-furnace charge for pulling rod means the total charge of a crucible used for repeated pulling rod, in which the service time of the crucible is one of the key factors. In 2021, the single-furnace charge for pulling rod is about 2800kg, which is significantly higher than the 1900kg in 2020, mainly due to the increase of the size of the hot zone and the number of rods pulled. In the future, with the continuous improvement of crucible manufacturing process and rod pulling technology and the optimization of crucible use, there is still much room for increase of the charge.

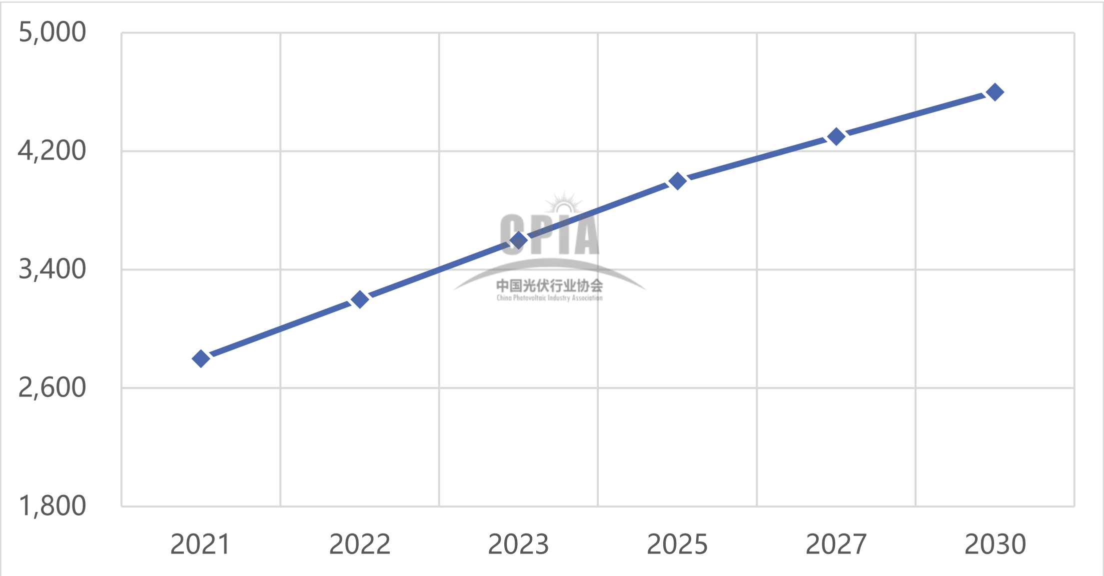

Figure 10. Change trend of single-furnace charge for pulling rod between 2021-2030 (in kg)

3. Silicon consumption

Silicon consumption means the amount of polysilicon raw materials consumed for manufacturing each kilogram of square rods (including the scrap re-charge) (calculated on annual basis). The silicon consumption by ingot casting in 2021 is 1.10 kg/kg. With limited investment in ingot casting research and development, the value is expected to change little in the next few years. In 2021, the silicon consumption by pulling rods is 1.066 kg/kg. The reduced loss in cleaning and crushing, the environmental control in production, the reduced proportion of remaining material of crucible, the optimized precision control in machining, the reduced machining allowance, and the improved grading and treatment technology of degraded silicon materials will contribute to the continuous reduction of the silicon consumption by pulling rod.

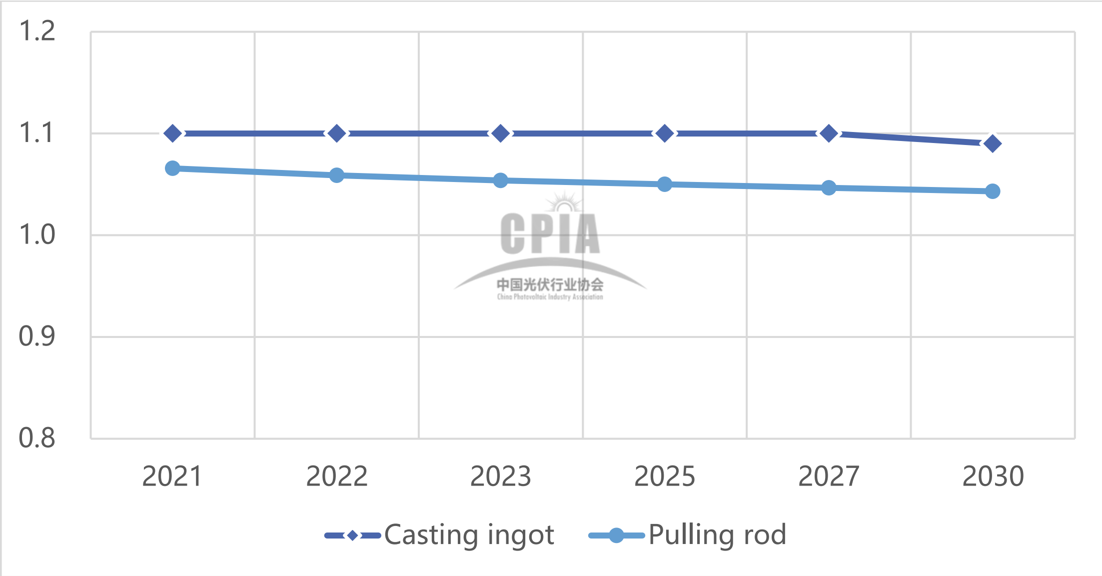

Figure 11. Change trend of silicon consumption by casting ingot between 2021-2030 (in kg/kg)

4. Silicon wafer thickness

The thinner silicon wafers are better for lowering the silicon consumption and wafer cost, although they will affect the fragmentation rate. At present, the slicing process can completely meet the needs of thinner wafers, but the thickness of silicon wafers shall also meet the requirements of downstream cell and module manufacturing end. The thickness of silicon wafer will influence the automation, yield and conversion efficiency of the cells. In 2021, the average thickness of polysilicon wafers is 178μm. With the small demand, there is no drive for thinning, it is predicted that the thickness will remain 170μm after 2025, although there may be possibility of thinning afterwards. The average thickness of p-type monocrystalline silicon wafer is about 170μm, 5μm thinner than that in 2020. At present, the n-type silicon wafers for TOPCon cells are with an average thickness of165μm, those for HJT cells about 150μm, those for IBC cells about 130μm, and those for MWT cells about 140μm.

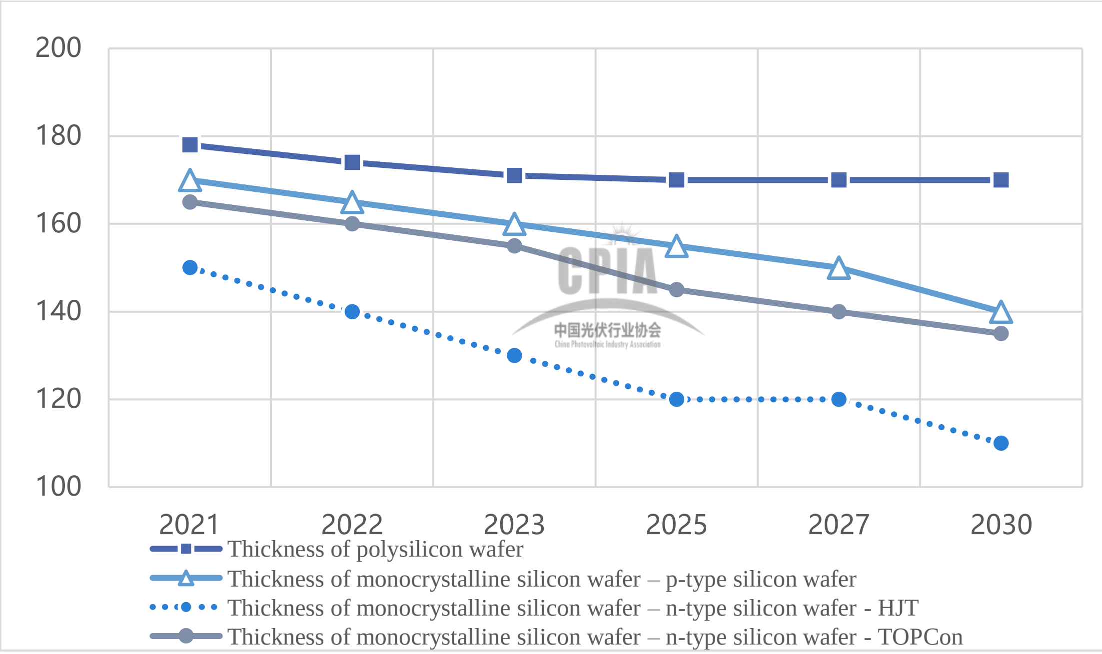

Figure 12. Change trend of silicon wafer thickness between 2021-2030 (in μm)

5. Diameter of diamond wire bus

The cutting quality and cutting loss of silicon wafers are associated with the diameter of cutting wire bus and the particle size of grinding medium, so the smaller wire diameter and medium particle size can help to reduce the cutting loss and production costs. In 2021, the diameter of diamond wire bus is 43-56μm. The diameter of diamond wire bus used for monocrystalline silicon wafers has significantly decreased and is still decreasing. With the large number of defects and impurities in polysilicon wafer, the fine wire tends to break. Therefore, the diameter of diamond wire bus for polysilicon wafer is larger than that for monocrystalline silicon wafer, and the diameter of diamond wire bus for polysilicon wafer is decreasing moderately as the demand for polysilicon wafer slows down.

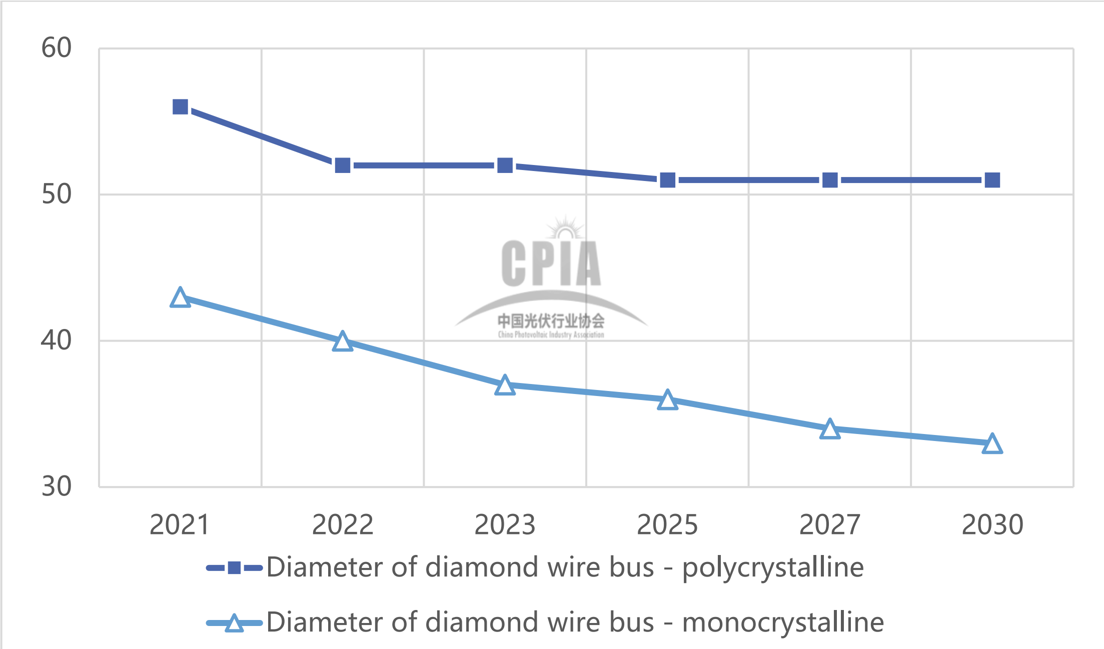

Figure 13. Change trend of diameter wire bus diameter between 2021-2030 (in μm)

6. Market share of different types of silicon wafers[3]

In 2021, the monocrystalline silicon wafer (p-type + n-type) has a market share about 94.5%, where the market share of p-type monocrystalline silicon wafer increases from 86.9% in 2020 to 90.4%, and that of n-type monocrystalline silicon wafer is about 4.1%. As the downstream demand for monocrystalline products increases, the monocrystalline silicon wafer will have further increase in the market share, and the share of n-type monocrystalline silicon wafer will continue to increase. The market share of polysilicon wafers will decrease from 9.3% in 2020 to 5.2% in 2021, and is gradually decreasing in the future, despite a certain demand in the segment market. The ingot monocrystalline silicon wafer has achieved a market share of 0.3%, which, however, will not increase significantly in the future.

[3] The market share in this link means the proportion of various products in the total shipments (including exports) of domestic silicon wafer enterprises.

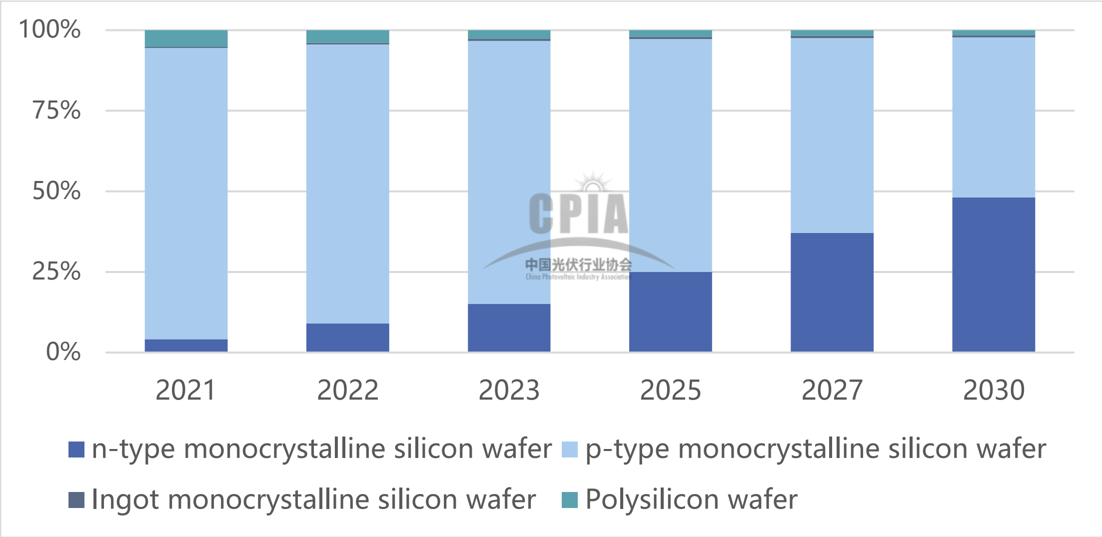

Figure 14. Change trend of market share of different types of silicon wafers between 2021-2030

7. Market share of silicon wafers of different sizes

In 2021, there are silicon wafers of different sizes available, including 156.75mm, 157mm, 158.75mm, 166mm, 182mm, 210mm, etc., each holding a certain market share. Among them, those of sizes 158.75mm and 166mm have a total market share up to 50%, and the market share of those of size 156.75mm has decreased to 5%, and will continue to decrease in the future; 166mm is the maximum size scheme that can be upgraded for the existing cell production line, so it will be the transition size in the next 2 years; in 2021, the total market share of those of sizes 182mm and 210mm sizes has increased rapidly from 4.5% in 2020 to 45%, and will continue to grow rapidly in the future.

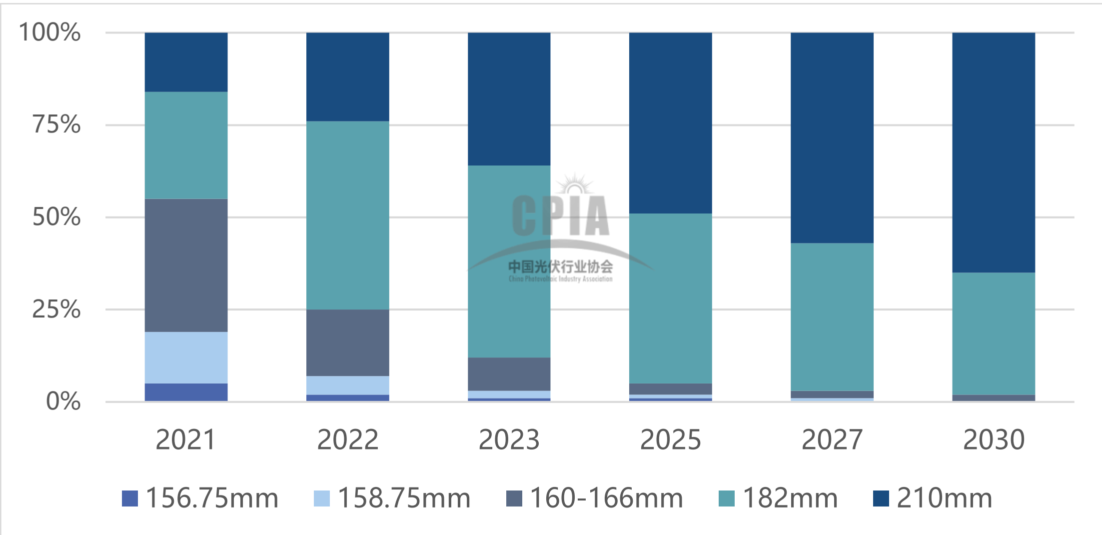

Figure 15. Change trend of market share of silicon wafers of different sizes between 2021-2030

Notes: the 156.75mm silicon wafers include the M2 monocrystalline silicon wafer, standard polysilicon wafer and 157mm polysilicon wafer;

The 160-166mm silicon wafers mainly include the 161.7mm full-square, 161.7mm quasi-square, 163mm quasi-square and 166mm quasi-square silicon wafers.

(III) Cell[4]

Table 1. Abbreviations and definitions of various crystalline silicon cells

Abbreviation	Definition of various crystalline silicon cells
Al-BSF	Aluminium Back Surface Field - in order to improve the efficiency of solar cells, after the preparation of p-n junction, an aluminum film is deposited on the back surface of silicon wafer to prepare P+ layer, so it is called aluminum back surface field cell.
PERC	Passivated Emitter and Rear Contact - a passivated layer is formed on the cell back by using special materials as a rear reflector, which will improve the absorption of long-wave light, increase the potential difference between p-n electrodes, reduce electron recombination and improve efficiency.
TOPCon	Tunnel Oxide Passivated Contact - a layer of ultra-thin silicon oxide is prepared on the cell back, and then a thin layer of doped silicon is deposited. Both of them together form a passivated contact structure.
HJT	Heterojunction Technology – the cell contains both crystalline and amorphous silicon. The appearance of amorphous silicon can achieve better passivation effects.
IBC	Interdigitated Back Contact - place both the positive and negative electrodes on the cell rear to reduce the shadow loss caused by the reflection of part of the incident light by the front electrode.
PERT	Passivated Emitter Rear Totally-diffused – an improvement of PERC technology to achieve total diffusion on basis of the passivation formed for enhanced effects of the passivation.
MWT	Metal-wrap through - the front electrode is introduced to the rear of the cell by forming an opening in the cell and fill it with conductive paste so that both the positive and negative electrodes are located in the cell rear so that the cell module will feature low shading, low degradation under stress and no lead.
HBC	Heterojunction Back Contact - a new solar cell structure is formed with the combination of Heterojunction Technology (HJT) cell structure and Interdigitated Back Contact (IBC) cell structure. This cell structure can achieve higher cell efficiency by combining the large short-circuit current of IBC cell and the advantage of high open-circuit voltage of HJT cell.
TBC	Tunneling Oxide Passivated Back Contact - a new solar cell structure is formed with the combination of Tunnel Oxide

[4] Unless otherwise specified, the indexes in this link are based on the manufacturing of 166mm cells.

	Passivated Contact (TOPCon) cell structure and Interdigitated Back Contact (IBC) cell structure. This cell structure can achieve higher cell efficiency by combining the large short-circuit current of IBC cell and the characteristics of excellent passivated contact of TOPCon.

1. Average conversion efficiency of various cell technologies

In 2021, all the p-type monocrystalline cells in mass production adopt PERC technology, and they have achieved the average conversion efficiency of 23.1%, which is 0.3% higher than that in 2020; the polycrystalline black silicon cells with PERC technology have achieved the conversion efficiency of 21.0%, 0.2% higher than that in 2020; the conventional polycrystalline black silicon cells have poor improvement in the conversion efficiency, which is about 19.5% in 2021 and only 0.1% higher than that in 2020, and there is little room for their future efficiency improvement; the ingot monocrystalline PERC cells have achieved the average conversion efficiency of 22.4%, 0.7% lower than that in 2020; the n-type TOPCon cells and the HJT cells have achieved the average conversion efficiency of 24% and 24.2% respectively, much higher than those in 2020; the IBC cells have achieved the average conversion efficiency of 24.1%. With technological progress in the future, the TBC and HBC cell technologies may continue to make progress. In the future, with the reduction of manufacturing cost and the improvement of yield, the n-type cell will be one of the main development directions of cell technology.

Table 2. Change trend of average conversion efficiency of various cell technologies between 2021-2030

	Class	2021	2022	2023	2025	2027	2030
p-type polycrystalline	BSF p-type polycrystalline black silicon cell	19.5%	19.5%	19.7%	-	-	-
	PERC p-type polycrystalline black silicon cell	21.0%	21.1%	21.3%	21.5%	21.7%	21.9%
	PERC p-type ingot monocrystalline cell	22.4%	22.6%	22.8%	23.0%	23.3%	23.6%
p-type monocrystalline	PERC p-type monocrystalline cell	23.1%	23.3%	23.5%	23.7%	23.9%	24.1%
n-type monocrystalline	TOPCon monocrystalline cell	24.0%	24.3%	24.6%	24.9%	25.2%	25.6%
	HJT cell	24.2%	24.6%	25.0%	25.3%	25.6%	26.0%
	IBC cell	24.1%	24.5%	24.8%	25.3%	25.7%	26.2%

Notes: 1. The rear contact n-type monocrystalline cell is currently at the pilot stage;

2. Only the front efficiency.

2. Market share of various cell technologies

In 2021, the newly established mass production line is still dominated by the PERC cell production line. With the continuous release of new production capacity of PERC cells, the market share of PERC cells grows to 91.2%. As the product demand from domestic household projects begins to shift to efficient products, the overseas market with high demand for conventional polycrystalline products also shifted to efficient products. The market share of conventional cells (BSF cells) is decreased to 5% in 2021, 3.8% lower than that in 2020. The relative cost of n-type cells (mainly including HJT cells and TOPCon cells) is relatively high, and they are in still small mass production scale. At present, the market share is about 3%, which is substantially the same as that in 2020.

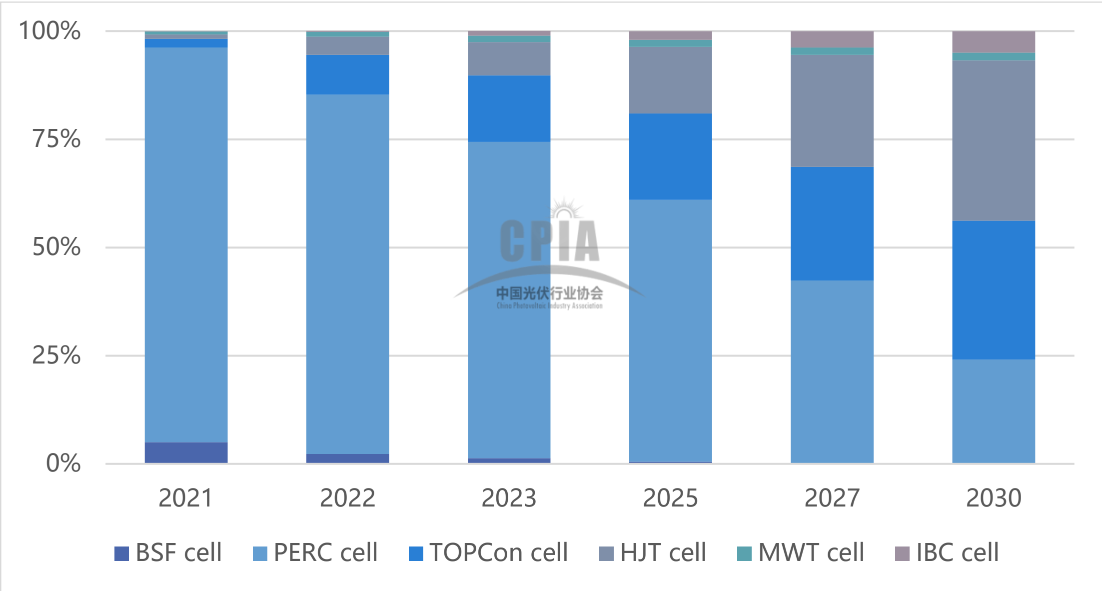

Figure 16. Change trend of market share of various cell technologies between 2021-2030

3. Aluminum paste consumption of cell

The aluminum paste consumption is mainly the aluminum paste consumed by the aluminium back surface field in the crystalline silicon cell. With the rapid development of double side PERC cell and the technological progress of PERC cell, the average aluminium paste consumption of cell has decreased significantly, which is about 787mg/cell for the single side PERC cell and about 251mg/cell for the double side PERC cell in 2021. With the technological progress of PERC cell in the future, there is still much room for the decline of aluminium consumption per cell.

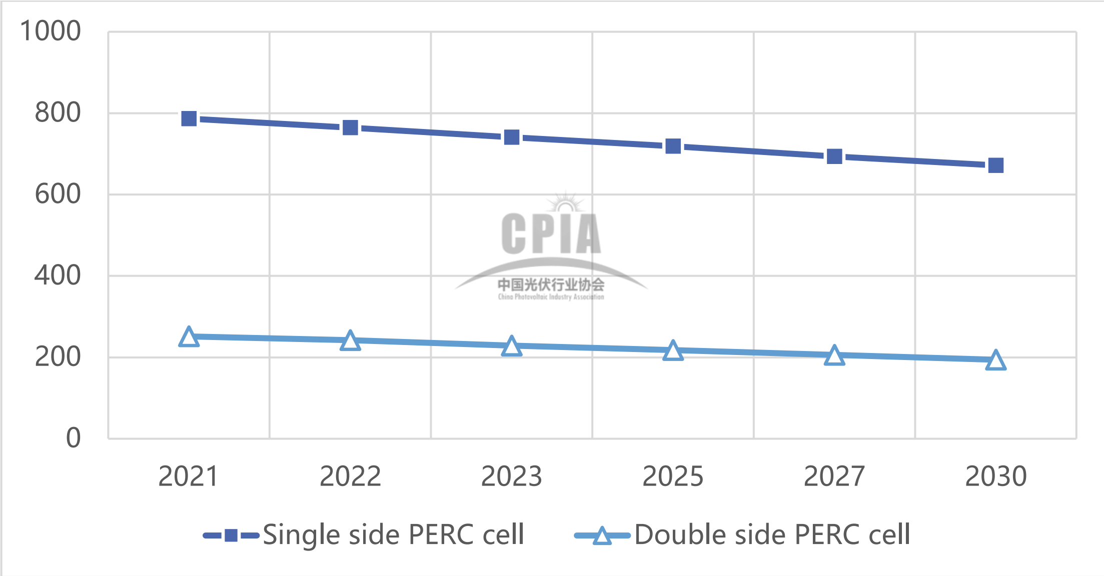

Figure 17. Change trend of aluminium paste consumption of single/double side PERC cell between 2021-2030 (in mg/cell)

4. Silver consumption of cell

At present, the silver paste of cells consists of high-temperature silver paste and low-temperature silver paste. The high-temperature silver paste is used for p-type cell and TOPCon cell, while the low-temperature silver paste is used for HJT cell. The cost of silver paste accounts for a high proportion in the cell cost. At present, the silver paste consumption on the front surface is reduced mainly with the multi-busbar technology and by reducing the grid line width. In 2021, the silver paste consumption of p-type cell on the front surface is about 71.7mg/cell, a year-on-year decrease of 8.3%, and the silver paste consumption on the rear surface is about 24.7mg/cell; the average silver (aluminium) paste[5] (95% silver) consumption on the front surface of TOPCon cell is about 75.1mg/cell, and about 70mg/cell on the rear surface for leading enterprises; the consumption of low-temperature silver paste on both sides of the HJT cell is about 190mg/cell, a year-on-year decrease of 14.9%. The large consumption and high price of silver paste is one of the reasons for the high cost of HJT cell, and the consumption of low-temperature silver paste is being reduced through process optimization.

[5]Silver paste is used for the busbar on the front surface of TOPCon cell, and silver-aluminium paste for the fine grid.

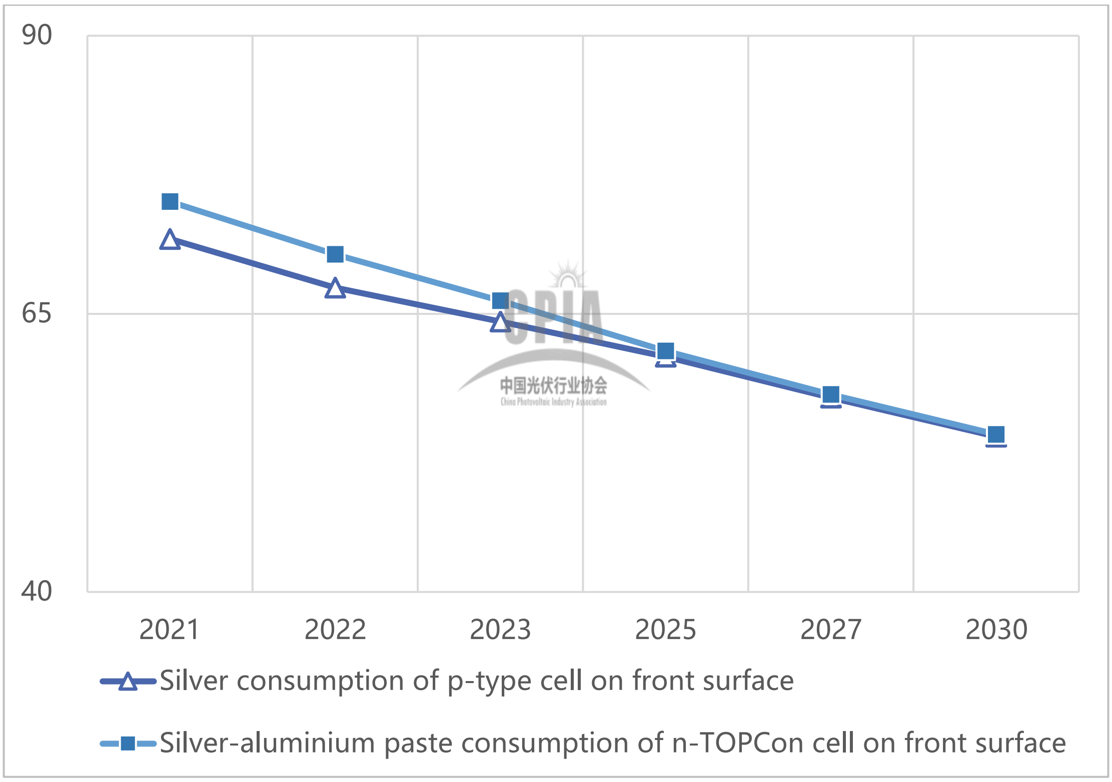

Figure 18. Change trend of silver paste consumption on front surface between 2021-2030 (in mg/cell)

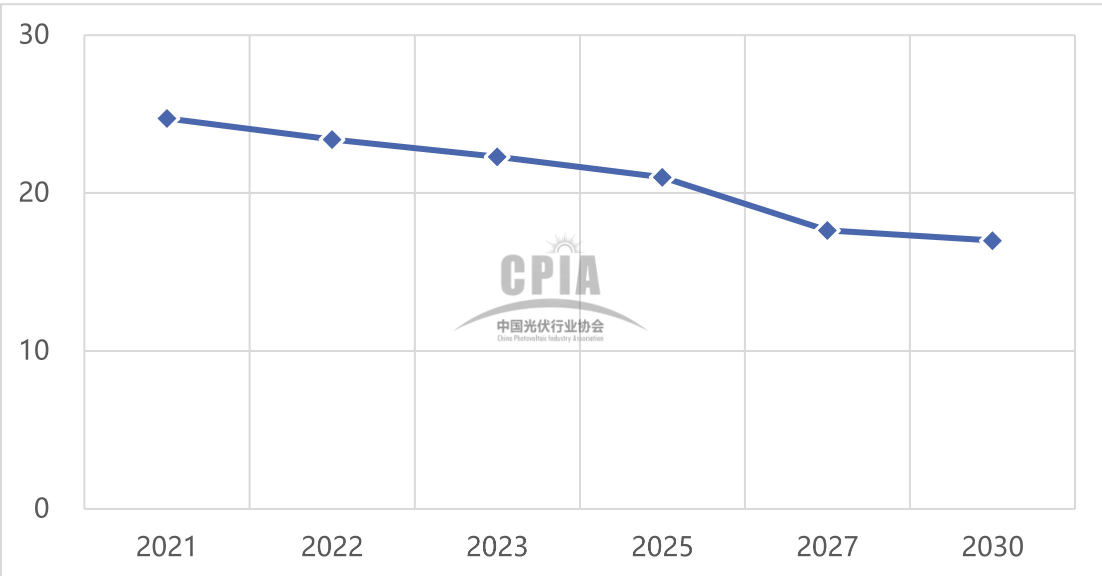

Figure 19. Change trend of silver paste consumption on rear surface of p-type cell between 2021-2030 (in mg/cell)

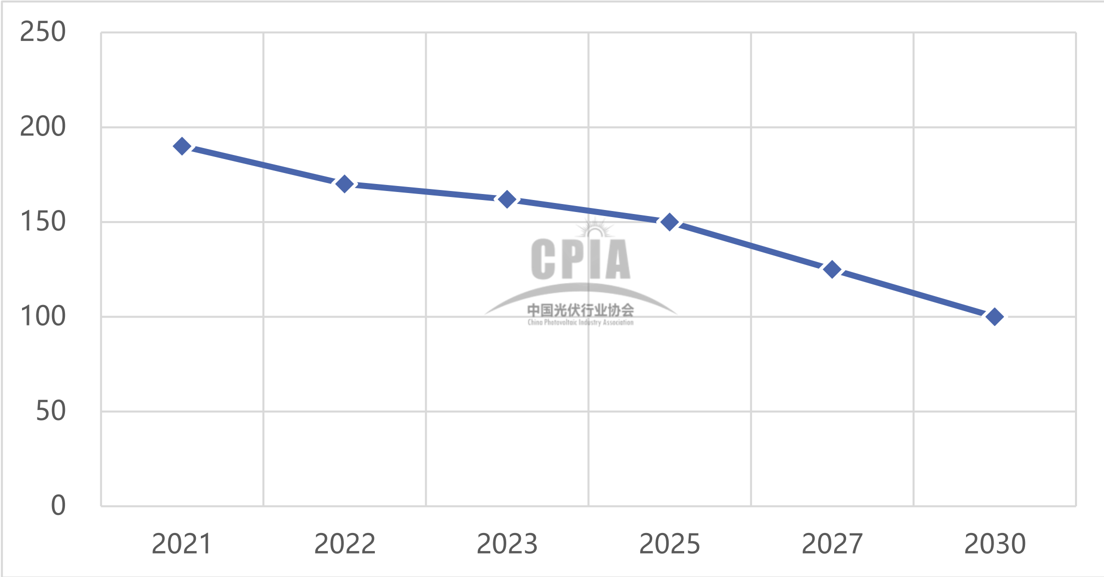

Figure 20. Change trend of low-temperature silver paste consumption on both sides of HJT cell between 2021-2030 (in mg/cell)

5. Market share of metal electrode technologies on front surface of cell

At present, metal electrodes are still mainly silver electrodes which have a market share of 99.9% in 2021. Considering the high silver price, some enterprises and research institutions are making efforts to develop electrode technologies using such base metals as copper instead of silver, mainly including silver-coated copper powder paste combined with the screen printing technology and copper electroplating technology. The cost effectiveness of electrode with copper electroplating technology for HJT cell still needs to be improved, and the technology is at relatively low utilization rate.

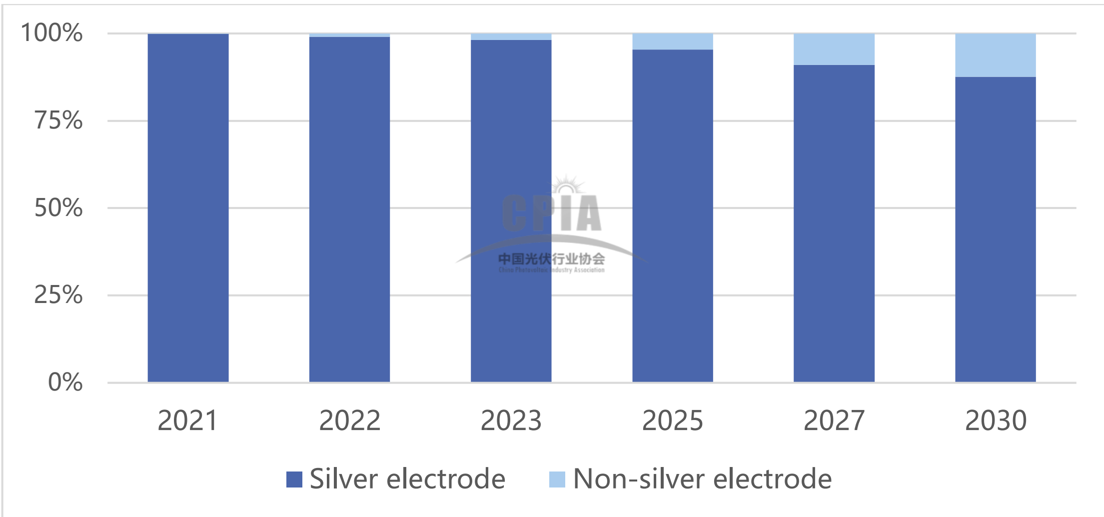

Figure 21. Change trend of market share of metal electrode technologies on front surface of cell

6. Market share of grid line printing technologies

At present, almost all metal grid lines for the cell are prepared with the screen printing technology, which have a market share of 99.9% in 2021. The manufacturers and equipment factories are also developing other grid line printing technologies, including stencil printing, inkjet, electroplating and laser transfer. It is expected that the screen printing technology will remain the mainstream technology in the next 10 years. With the increasing demand for narrower grid lines, new grid line preparation technologies for the cell will emerge.

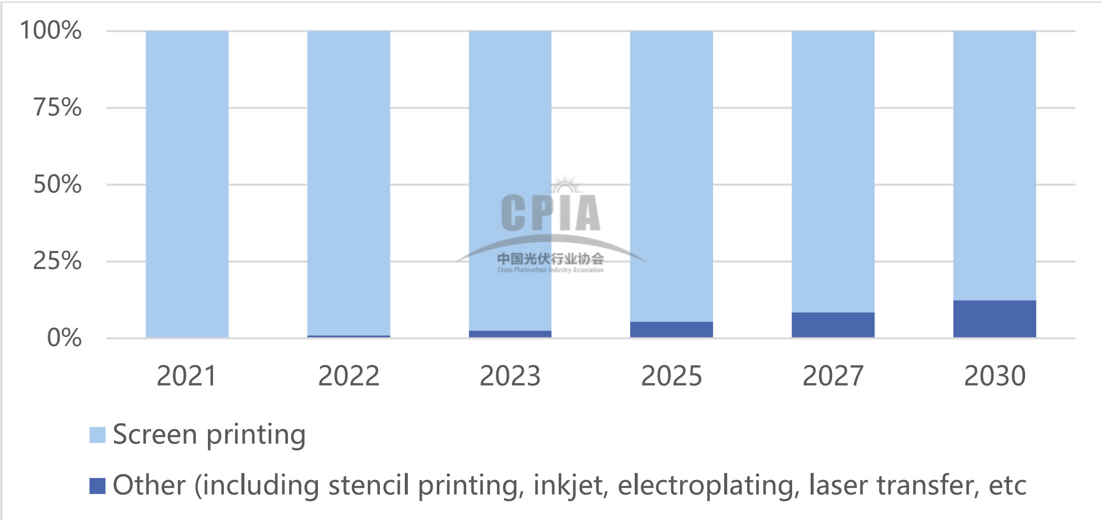

Figure 22. Change trend of market share of grid line printing technologies between 2021-2030

7. Market share of rear surface passivation technologies for PERC cell

The rear surface passivation technologies for PERC cell mainly include PECVD AlOx+SiNx and ALD AlOx+SiNx. Among them, PECVD deposition technology has a market share about 55.4% in 2021; ALD deposition technology with more accurate layer thickness control and better passivation effect has a market share about 41.4% in 2021. In addition to the PECVD and ALD rear surface passivation technologies, silicon oxynitride (SiONx) rear surface passivation technology is available on the market. Affected by the intellectual property right and other non-technical factors, the market share of SiONx deposition technology may be expected to increase.

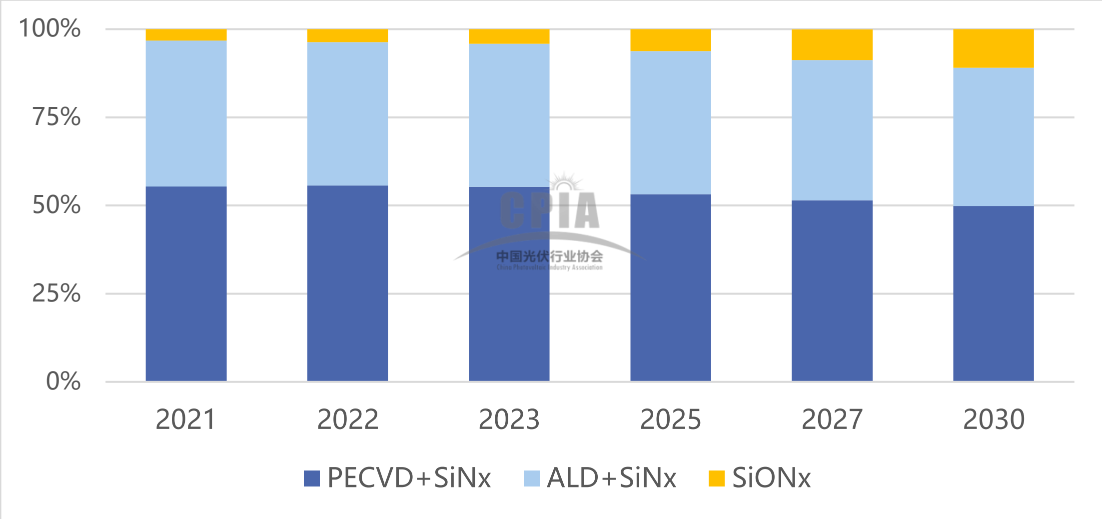

Figure 23. Change trend of market share of rear surface passivation technologies of PERC cell between 2021-2030

8. Grid line width on front surface of cell

The metal electrode on front surface of crystalline silicon solar cell consists of the busbars for confluence and series connection and the grid lines for accumulating carriers. Provided that the series resistance of the cell is not increased, narrowing the grid line can help to reduce the shading loss and reduce the consumption of silver paste on the front surface. In 2021, the width of grid line is generally controlled at 32.5μm, and the accuracy of printing equipment at ±7.7μm. With the improvement of paste technology and printing equipment accuracy, the width of grid line will still decrease to a certain extent. It is expected that by 2030, the accuracy of printing equipment can be improved to ±5.7μm, and the width of grid line may be reduced to 21.8μm or so.

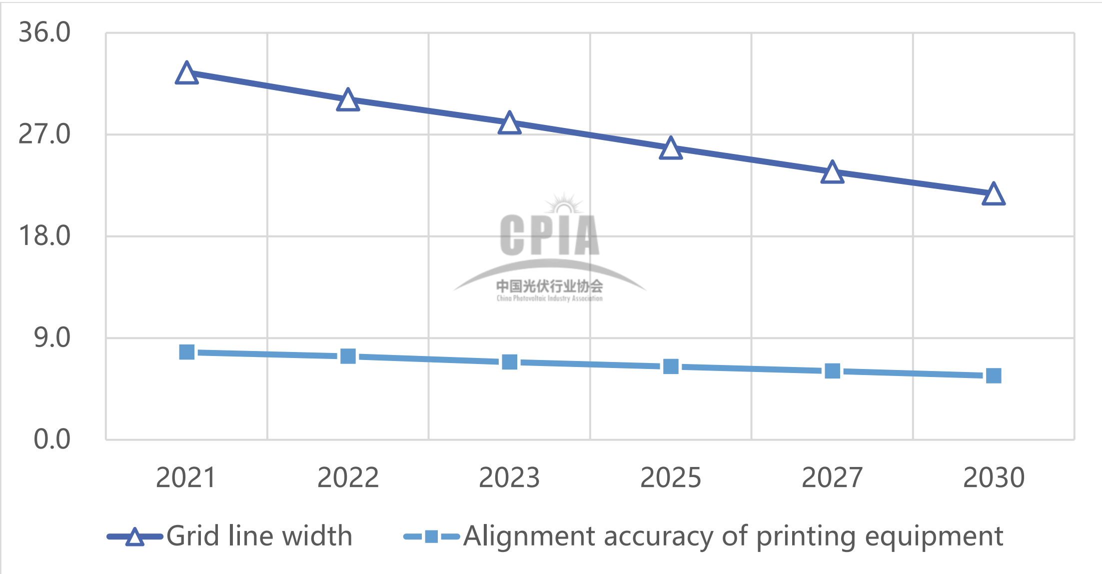

Figure 24. Change trend of grid line width on front surface of cell and alignment accuracy between 2021-2030 (in μm)

9. Market share of various busbars[6]

Without increasing the shading area of the cell or affecting the series welding process of the module, increasing the number of busbars can help to shorten the current transmission path of grids in the cell, reduce the power loss of the cell, and improve the uniformity of cell stress distribution so that the fragmentation rate can be reduced and the impacts by broken grids and cracks on the power of the cell. In 2021, as the size of mainstream cells increases, the 9-busbar and above technology will prevail in the market, with the market share increasing by 22.8% from the level in 2020 to 89%. It is expected that the market share of 9-busbar and above cells will continue to increase by 2030. Busbar-free technologies include MWT, IBC, HBC, etc.

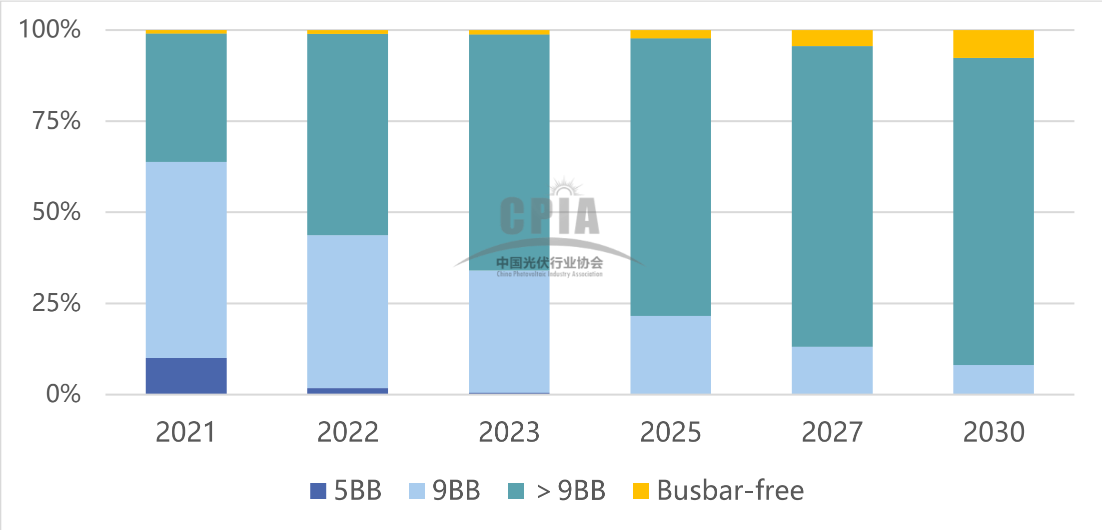

Figure 25. Change trend of market share of various busbar technologies between 2021-2030

(IV) Module[7]

1. Power of different types of modules

In 2021, the power of conventional polycrystalline black silicon module is about 345W and that of PERC polycrystalline black silicon module is about 420W. The modules using 166mm and 182mm PERC monocrystalline cells have achieved the power of 455W and 545W respectively; the modules using 55×210mm and 66×210mm PERC monocrystalline cells have achieved the power of 550W and 660W respectively. The modules using 166mm and 182mm TOPCon monocrystalline cells have achieved the power of 465W and 570W respectively. The modules using 166mm HJT cells have achieved the power of 470W. The modules using 72×166mm and 89.5×166mm MWT monocrystalline cells have achieved the

[6] It means the proportion of various busbars in the total shipments of domestic cell enterprises.

[7] Unless otherwise specified, the indexes in this link are based on the 166mm cell encapsulation.

power of 465W and 575W respectively. The modules using the 210mm shingled TOPCon monocrystalline cells have achieved the power of 645W.

Table 3. Change trend of power of different types of modules between 2021-2030

Average power of half-cell module using 72 crystalline silicon cells (W)		2021	2022	2023	2025	2027	2030
Polycrystalline	BSF polycrystalline black silicon module (157mm)	345	345	350	-	-	-
	PERC p-type polycrystalline black silicon module	420	425	425	430	435	440
	PERC p-type ingot monocrystalline module	450	450	455	460	465	470
p-type monocrystalline	PERC p-type monocrystalline module	455	460	460	465	470	475
	PERC p-type monocrystalline module (182mm)	545	550	555	560	565	570
	REPC p-type monocrystalline module (210mm) (55 cells)	550	555	560	565	570	575
	REPC p-type monocrystalline module (210mm) (66 cells)	660	665	670	675	680	685
n-type monocrystalline	TOPCon monocrystalline module	465	470	475	485	490	495
	TOPCon monocrystalline module (182mm)	570	575	580	590	600	610
	HJT module	470	475	480	490	500	510
	IBC module (158.75mm)	355	360	365	375	380	385
MWT encapsulation	MWT monocrystalline module (72 cells)	465	470	488	505	513	520
	MWT monocrystalline module (94.5 cells)	575	580	590	595	600	605
Shingled	TOPCon monocrystalline module (210mm)	645	650	655	660	665	670

Notes: 1. This index is based on the single glass single side module using 9BB cells, and for the double side module, only the power on front surface is considered;

2. Based on the p-type monocrystalline modules (210mm) with 55 cells and 66 cells; IBC modules with 60 cells; MWT modules with 72 cells and 94.5 cells; shingled modules (210mm) with 69 cells, and other modules using 72 cells;

3. Unless specially specified, this index is based on the 166mm cell;

4. Except the shingled module (with 6 strips), the above modules are all half-cell modules.

2. Market share of single/double side power generation modules

In 2021, with the recognition from the downstream application end of the power generation gains of double side power generation modules and the US exemption of the 201 tariff on double side power generation modules, the market share of double side modules is increased by 7.7% to 37.4% compared with that in 2020. It is estimated that by 2023, the market share of single/double side modules will be substantially the same.

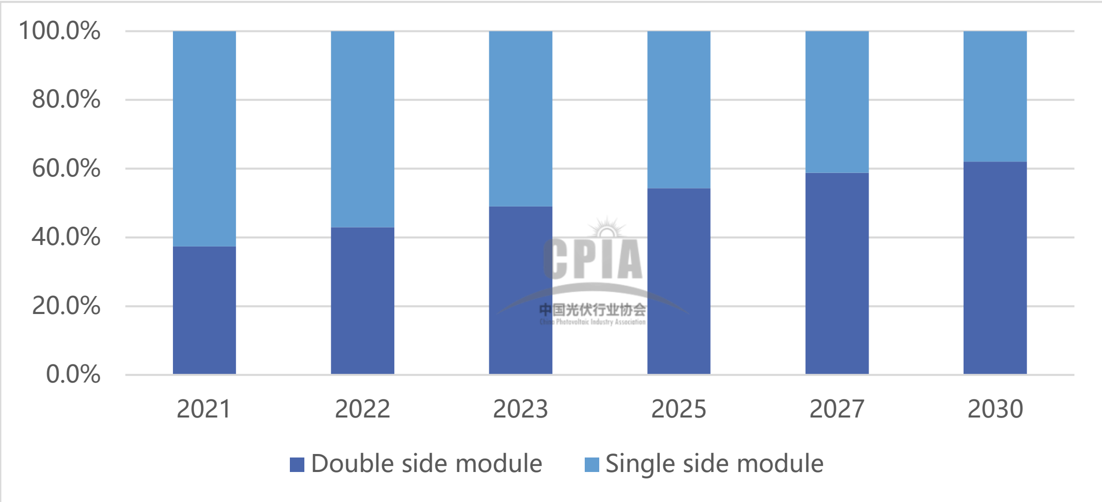

Figure 26. Change trend of market share of single/double side modules between 2021-2030

3. Market share of full-cell, half-cell and shingled modules

In 2021, the half-cell modules have a market share of 86.5%, a year-on-year increase of 15.5%. As the module encapsulation method with half or smaller cells can improve the module power, it is expected that the market share will continue to increase in the future.

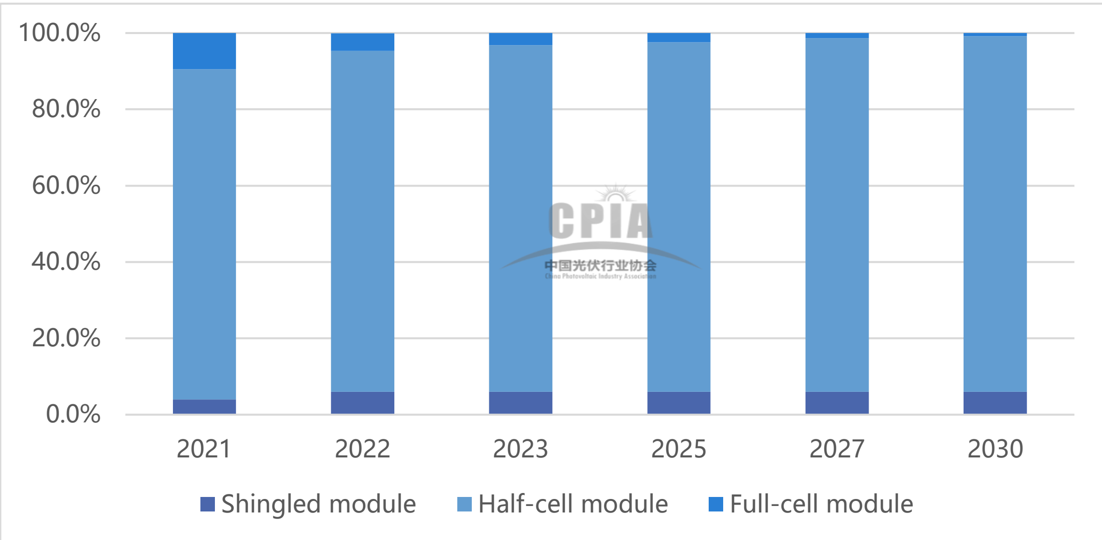

Figure 27. Change trend of market share of full-cell, half-cell and shingled modules between 2021-2030

4. Market share of modules adopting different cell interconnection technologies

At present, the cell interconnection technologies available on the market include the lead-containing welding strip, lead-free welding strip, conductive paste and back contact, among which the conductive paste and back contact are new (lead-free) connection modes for cell interconnection technologies in the market. Featuring low cost, excellent welding reliability and excellent conductivity, the lead-containing welding strip is still the main interconnection mode at present, with a market share of 93.7% in 2021. Interconnection with the conductive paste is mainly used in shingled modules, while interconnection with back contact is mainly used in IBC and MWT modules. Due to the cost and other reasons, the conductive paste or other new interconnection technologies are not widely applied, and interconnection with the lead-containing welding strip will still be the main mode by 2030.

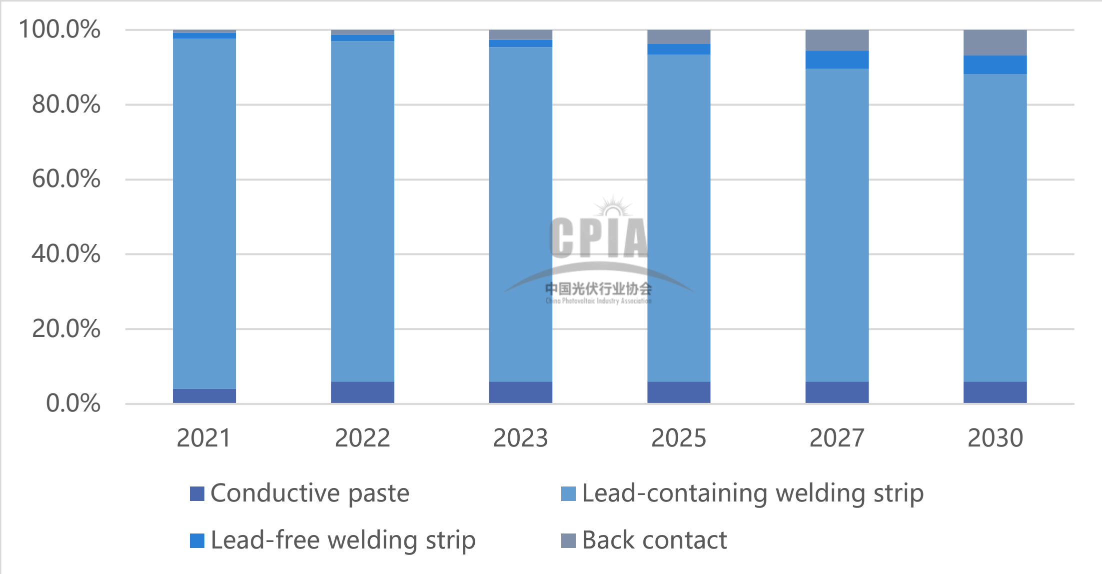

Figure 28. Change trend of market share of modules adopting different cell interconnection technologies between 2021-2030

5. Transmittance of tempered coated glass for 3.2mm module encapsulation

The crystalline silicon solar cells are within the spectral response range of 300-1200nm. The anti-reflection coated glass can effectively reduce the reflection loss of sunlight with this wave band and improve the transmittance of glass. At present, considering the balance between light transmittance and cost, the module manufacturers require light transmittance between 93.5% and 94%. In 2021, the tempered coated glass is mostly single-layer coated, with an average light transmittance about 93.9%. From 2022, the new glass production capacity substantially adopts the double-layer coating, and the light transmittance can be above 94.2%. In the future, with the technological progress, there is certain room for the improvement in light transmittance.

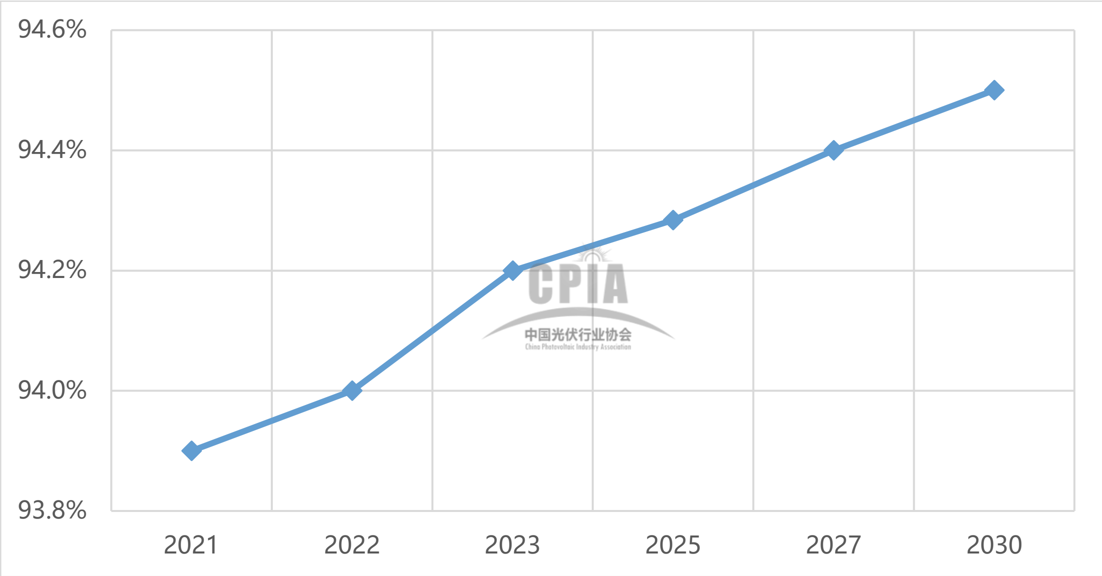

Figure 29. Change trend of light transmittance of tempered coated glass for 3.2mm module encapsulation between 2021-2030

6. Market share of modules using front surface covers made of different materials

At present, the front surface covers available on the market are mainly made of the coated glass, non-coated glass and other materials (resin, organic adhesive, front surface cover glass with depth structure, etc.). Among them, the front surface cover glass modules with depth structure are mainly used in airports and other particular locations requiring glare protection. The coated cover glass has the advantages of excellent transmittance, surface contamination resistance and aging resistance. Most of the power plants use the coated cover glass. In 2021, it has a market share of 97.1%, a year-on-year increase of 0.6%. The diversification of PV applications in the next few years will lead to the growth of market share of some other cover materials.

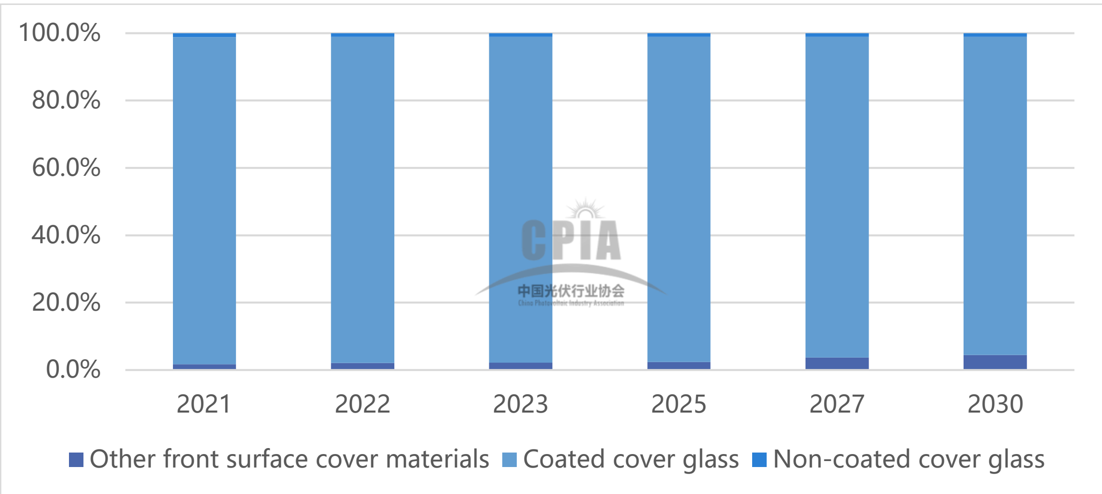

Figure 30. Change trend of market share of modules using front surface covers made of different materials between 2021-2030

7. Market share of modules using front surface cover glasses of different thickness

At present, the front surface cover glass is mainly ≤2.5mm, 2.8mm, 3.2mm thick. The glass with thickness ≤2.5mm is mainly used in the double glass modules. In 2021, with the increased market demand for double side modules, the front surface cover glass with thickness ≤ 2.5mm has a market share about 32%, a year-on-year increase of 4.3%, while the market share of front surface cover glass with thickness of 3.2mm decreases. With the continuous development of lightweight modules, double glass modules and new technologies, while ensuring the reliability of modules, the cover glass is becoming thinner, and the market share of front surface cover glass with a thickness of 2.5mm and below will gradually increase.

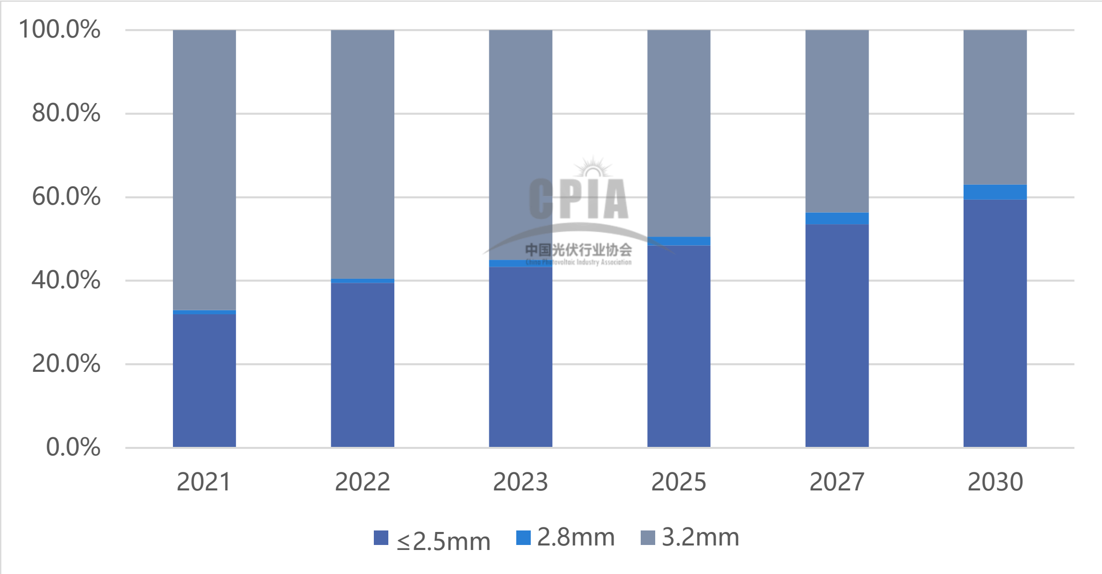

Figure 31. Change trend of market share of modules using front surface cover glass with different thickness between 2021-2030

8. Market share of various encapsulation materials

At present, the encapsulation materials available mainly include the transparent EVA film, white EVA film, polyolefin (POE) film, coextruded polyolefin composite film EPE (EVA-POE-EVA) film and other encapsulation films (including PDMS/Silicon film, PVB film, TPU film), etc. Among them, the POE film features excellent PID resistance and is usually used for double glass modules; the coextruded EPE film has not only the excellent water resistance of POE film, but also the excellent adhesion property of EVA, and it can be used as a substitute of POE film for double glass modules. The white EVA film can improve the reflectivity, so when using the white EVA film, the glass backsheet can be used to substitute the organic backsheet to reduce the module cost. In 2021, the transparent EVA film is still the main encapsulation material for single glass modules, with a market share about 52%, 4.7% lower than that in 2020. In 2021, the total market share of POE film and coextruded EPE film has increased to 23.1%, which will continue increasing with the increasing market share of double glass modules in the future.

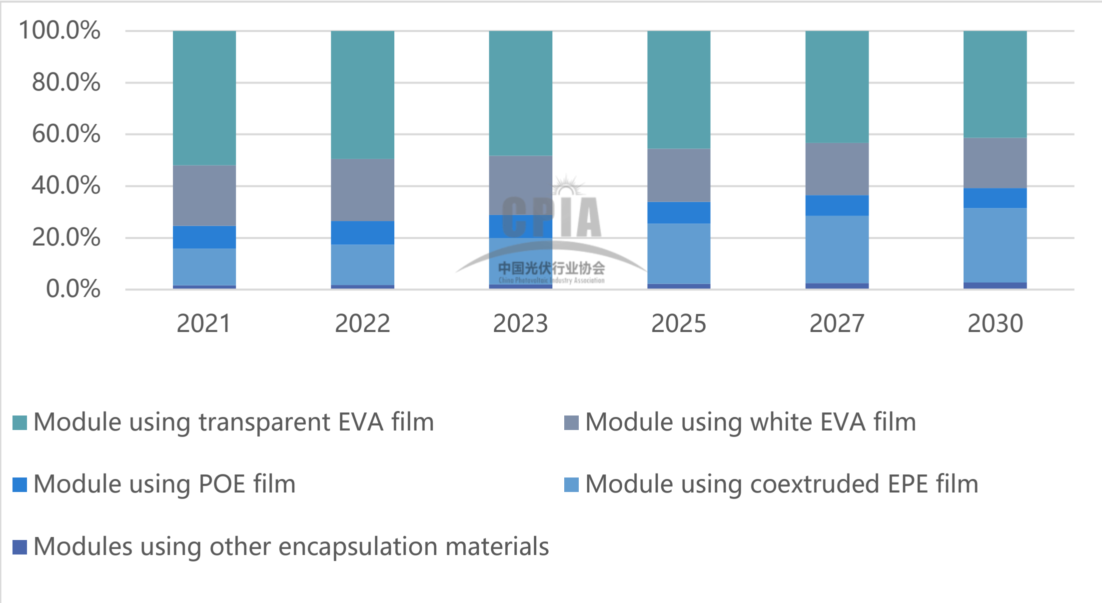

Figure 32. Change trend of market share of various encapsulation materials between 2021-2030

9. Market share of various backsheet materials

At present, the backsheets available include fluorine-containing backsheet, fluorine-free backsheet, glass backsheet and other backsheets. In 2021, the fluorine-containing backsheet is dominating the market, with a share of 65.9%, followed by the glass backsheet which is with a market share of 24.4%. However, in the next few years, considering the power output, environmental protection and cost, the market share of fluorine-containing backsheets tends to decline, while that of the fluorine-free backsheet, glass backsheet and other backsheets will undergo growth to varying degrees.

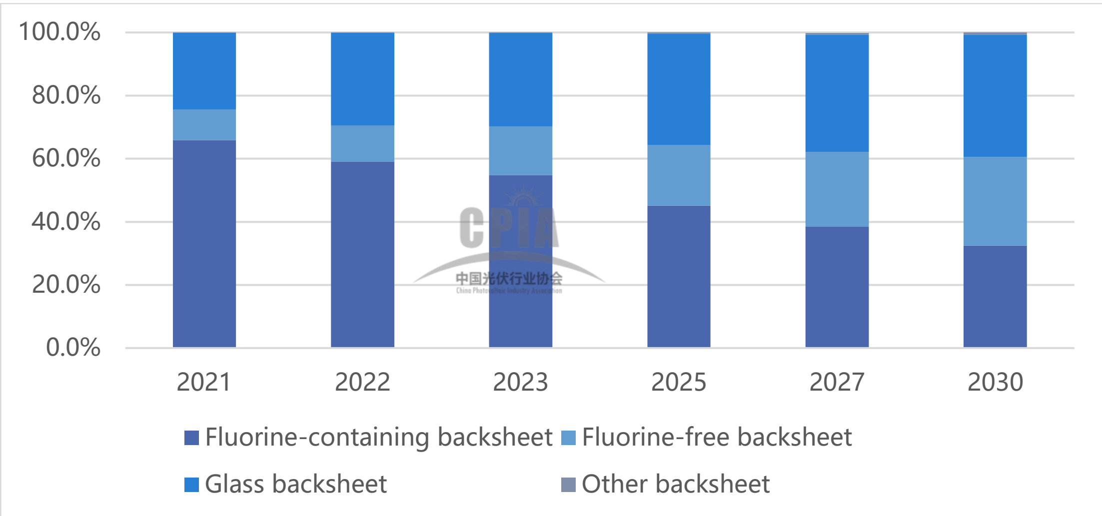

Figure 33. Change trend of market share of various backsheet materials between 2021-2030

(V) Thin film solar cell/module

Thin film solar cells feature little degradation, light weight, low material consumption, low preparation energy consumption and Building Integrated PV (BIPV). At present, commercially available thin film solar cells mainly include copper indium gallium selenium (CIGS), cadmium telluride (CdTe) and gallium arsenide (GaAs) cells. At present, the global CdTe thin film cells have achieved a laboratory efficiency record of 22.1%, laboratory efficiency record about 19.5% for the modules, and average efficiency of 15-18% for the production line; the copper indium gallium selenium (CIGS) thin film solar cells have reached a laboratory efficiency record of 23.35%, laboratory efficiency about 19.64% for the modules, and an average efficiency of 15-17% for the module production line; III-V thin film solar cells, which feature ultra-high conversion efficiency, excellent stability and radiation resistance, have development potential in special application markets. However, due to the high cost, they are still not widely accepted in the market and are in small production scale; the perovskite solar cells have good conversion efficiency in the laboratory but are poor in stability. At present, they are still in laboratory experiments and at the pilot stage.

1. Conversion efficiency of CdTe thin film solar cell/module

In 2021, the maximum conversion efficiency of small-area CdTe cells (< 1cm^2) in laboratories in China is about 20.5%. The maximum conversion efficiency of the CdTe modules (with an area of 1200×600mm^2) in mass production is 16.6%, and the average conversion efficiency of those in mass production is 15.3%, which is 0.2% higher than that in 2020 and is expected to reach 16.5% in 2022.

Table 4. Change trend of conversion efficiency of CdTe thin film solar cells/modules in China between 2021-2030

Conversion efficiency of CdTe thin film solar cell/module (%)	2021	2022	2023	2025	2027	2030
Maximum conversion efficiency of small CdTe cells in labs	20.5%	21.0%	21.50%	23%	24.70%	27.0%
Maximum conversion efficiency of CdTe modules in mass production	16.6%	17.5%	18.8%	20.4%	22.0%	24.5%
Average conversion efficiency of CdTe modules in mass production	15.3%	16.5%	17.8%	19.4%	21.0%	23.5%

(VI) Inverter[8]

1. Market share of various inverters

In 2021, the PV inverter market is still dominated by centralized inverter and string inverter, and the distributed inverter has a relatively small market share. Among them, the string inverter has a market share of 69.6%, the centralized inverter 27.7%, and the distributed inverter about 2.7%. Affected by several factors, including changes in application and technological progress, there is great uncertainty in market share of different types of inverters in the future.

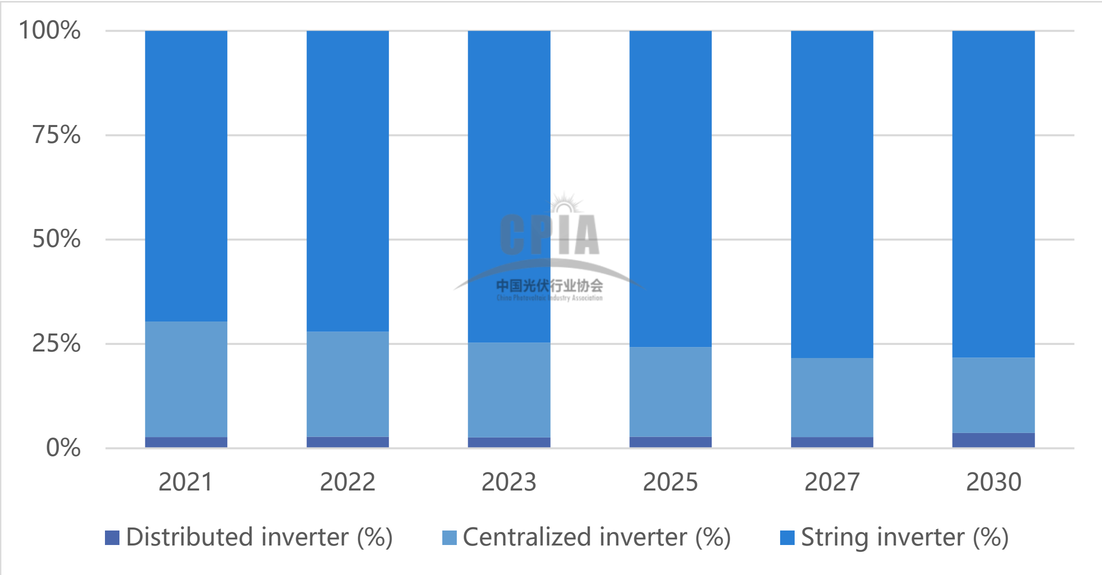

Figure 34. Change trend of market share of various inverters between 2021-2030

2. Mainstream rated power of inverter

The rated output power of inverter means the output power that can be continuously and stably provided for a long time at a certain ambient temperature. In 2021, the centralized inverter has a power of 3125kW/unit, 250kW/unit for the string inverter for centralized power station, 3150kW/unit for the distributed inverter, and 8kW/unit at 220V and about 20-30kW/unit at 380V for the household-type PV inverter. However, depending on the unit building area in different regions, the inverter power may also vary. With the diversification of distributed PV applications in the future, many roof types will be involved, and the power levels of inverters used will also vary greatly. In addition to technological innovation, optimal LCOE cost, compatibility with high-power modules and other factors should also be considered for the improvement of rated power of the inverter in the future. Therefore, the mainstream rated power of the inverter available depends on the market demand.

[8] The parameters in inverter link represent the domestic shipment.

Table 5. Mainstream rated power of inverter in China between 2021-2030 (in kW/unit)

Unit power	2021	2022	2023	2025	2027	2030
Centralized inverter	3125	3300	4400	4500	5000	6250
String inverter – for centralized power station	250	320	350	375	390	400
Distributed inverter	3150	3150	4200	4400	5000	6250

3. Power density of inverter

Power density of the inverter means the ratio of the rated output power of the inverter to the weight of the inverter itself. With the upgrading of power electronic devices and the innovation of inverter manufacturers in inverter structure, the power density of inverter has increased significantly. In 2021, the centralized inverter has a power density of 1.17kW/kg, 2.39kW/kg for the string inverter for the centralized power station, and 1.17kW/kg for the distributed inverter.

Table 6. Change trend of power density of inverter in China between 2021-2030 (in kW/kg)

Power density	2021	2022	2023	2025	2027	2030
Centralized inverter	1.17	1.18	1.28	1.39	1.56	1.65
String inverter – for centralized power station	2.39	2.66	2.79	3.00	3.20	3.50
Distributed inverter	1.17	1.17	1.48	1.48	1.80	1.90

(VII) System

1. Global new installed PV capacity

Many countries around the world have put forward the climate goal of “zero carbon” or “carbon neutrality”, and the development of renewable energy represented by PV has become a global consensus. In addition, PV power generation has become the most competitive power supply form in more and more countries. It is expected that the global PV market will maintain rapid growth. In 2021, a record high additional global installed PV capacity of 170GW is expected. In the future, driven by several factors, including the continuous decline of PV power generation costs and global green recovery, the global new installed PV capacity will still grow rapidly. Driven by the “carbon neutrality” goal, the clean energy transformation and green recovery in many countries, it is expected that the global annual average new installed PV capacity will be above 220GW during the 14th Five-year Plan period.

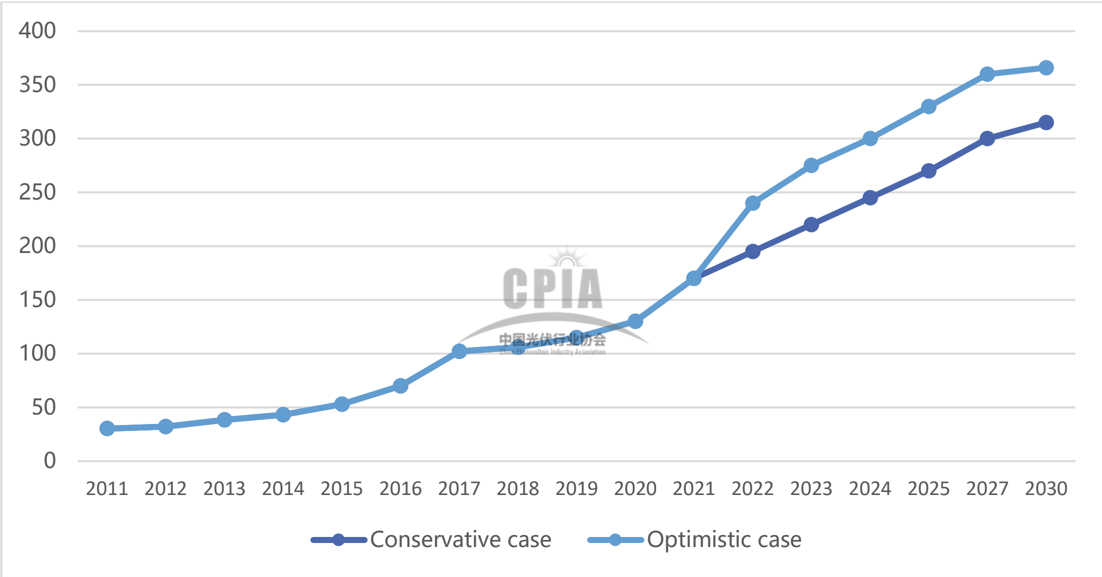

Figure 35. Global annual new installed PV capacity between 2011-2021 and prediction of new installed capacity between 2022-2030 (in GW)

2. Domestic new installed PV capacity

In 2021, an additional installed PV capacity of 54.88GW is provided, a year-on-year increase of 13.9%, including a new installed capacity of 29.28GW for the distributed PV power, accounting for 53.4% of the total new installed PV capacity, being above 50% for the first time in history. In 2021, household installed capacity has reached 21.6GW, a record high, accounting for about 39.4% of the new installed PV capacity in China in 2021. On December 12, 2020, President Xi Jinping declared at the Climate Ambition Summit that by 2030, China will increase the share of non-fossil fuels in primary energy consumption to around 25%. In order to achieve this goal, during the “14th Five-year Plan” period, the average annual new installed PV capacity in China may be above 75GW.

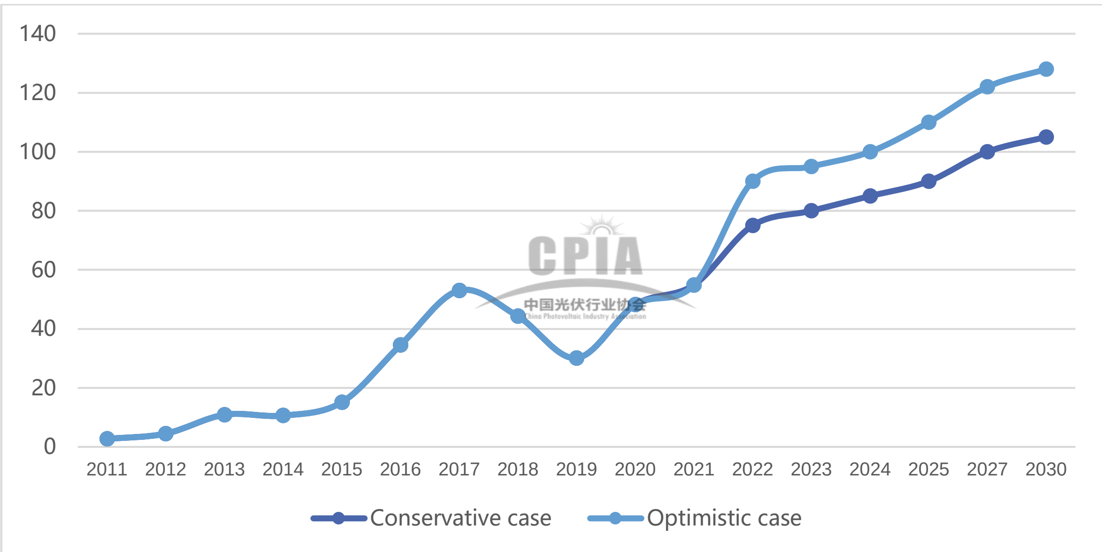

Figure 36. Domestic annual new installed PV capacity between 2011-2021 and prediction of new installed capacity between 2022-2030 (in GW)

3. PV application market

In 2021, the large-scale ground power station has a market share of 46.6%, and the distributed power station 53.4%. The market share of the distributed power station is above that of the centralized type for the first time, in which the household PV can account for 73.8% in the distributed market. In 2021, as the supply chain price increases, the installed capacity of centralized power stations is smaller than expected. With the construction of large-scale wind-PV power base projects, it is expected that among the new installed capacity in 2022, the share of installed capacity of large-scale ground power stations will again be above that of distributed power stations; in terms of distributed PV market, the county-wide promotion and other industrial and commercial distributed and household PV construction will continue to support the distributed PV power market. Despite the share decline, the total installed capacity will still continue to increase. During the 14th Five-year Plan period, a development pattern of both centralized and distributed PV power stations will be formed. With the grid parity applied to all the PV power, in addition to the promotion of the “carbon neutrality” goal and the development mode of large bases, the centralized PV power stations may undergo a new round of development. In addition, with the integrated development of PV in construction, transportation and other fields and the county-wide promotion, the distributed PV projects will still maintain a certain market share.

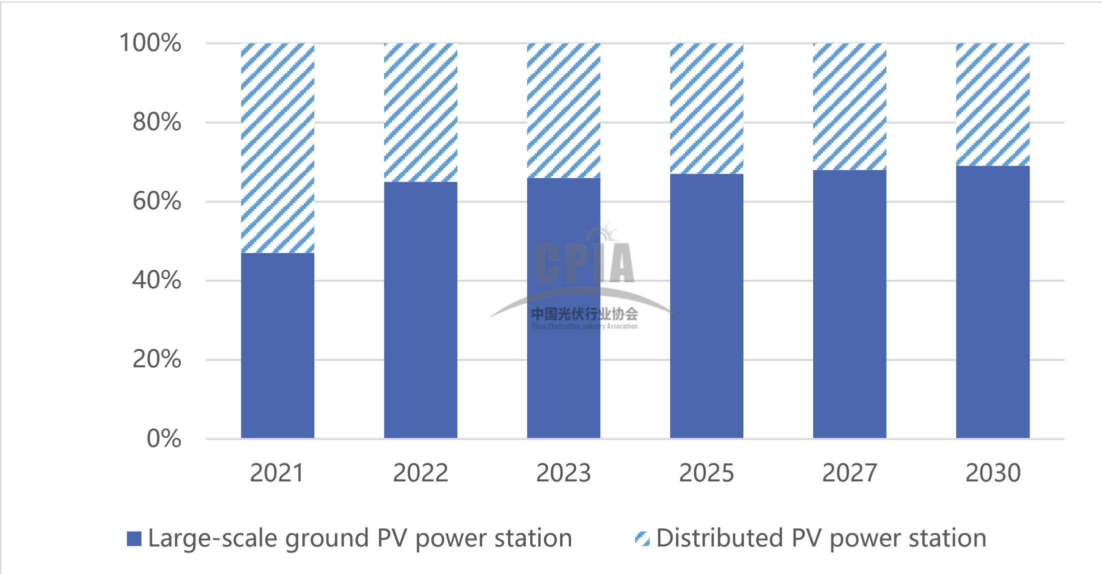

Figure 37. Change trend of various PV application market between 2021-2030

4. Initial total investment and operation and maintenance cost of PV system in China

（1）Initial total investment (CAPEX) of ground PV systems[9]

The initial total investment (CAPEX) of ground PV systems in China mainly consists of the costs of key equipment, including modules, inverters, supports, cables, primary and secondary equipment, as well as land costs and grid access, construction, installation and management costs. Among them, the primary equipment includes the box-type transformer, main transformer, switchgear and booster station (50MW, 110kV), and the secondary equipment includes monitoring, communication and other equipment. Land costs include land rent during the whole life cycle and vegetation restoration costs or related compensation costs; the grid access cost only includes the opposite side transformation for delivery of 50MW, 110kV power for 10km; the management expenses include preliminary management, survey, design, bidding and other expenses. The construction and installation costs mainly include labor costs, earthwork costs and conventional reinforcement and cement costs, and there is little room for decline in the future. With technological progress and mass production benefits, the costs of such key equipment as modules and inverters still have some room for decline. The costs of grid access, land and preliminary development of the project belong to non-technical costs, which vary greatly depending on the regions and projects. Reducing the non-technical costs will help accelerate the promotion of grid parity of PV power.

In 2021, the CAPEX of ground PV systems in China is about RMB 4.15 yuan/W, RMB 0.16 yuan/W or 4% higher than that in 2020. Among them, the modules have attracted about 46% of the CAPEX, 7% higher than that in 2020. The non-technical costs account for about 14.1% (excluding financing costs), 3.2% lower than that in 2020. It is estimated that in 2022, with the gradual release of new capacity in all links of the industry chain and the return of module prices to a reasonable level, the CAPEX of PV systems can be reduced to RMB 3.93 yuan/W.

[9] This index is based on the investment in construction of a 50MW ground PV system with access to 110kV. The capacity ratio is taken to be 1:1.

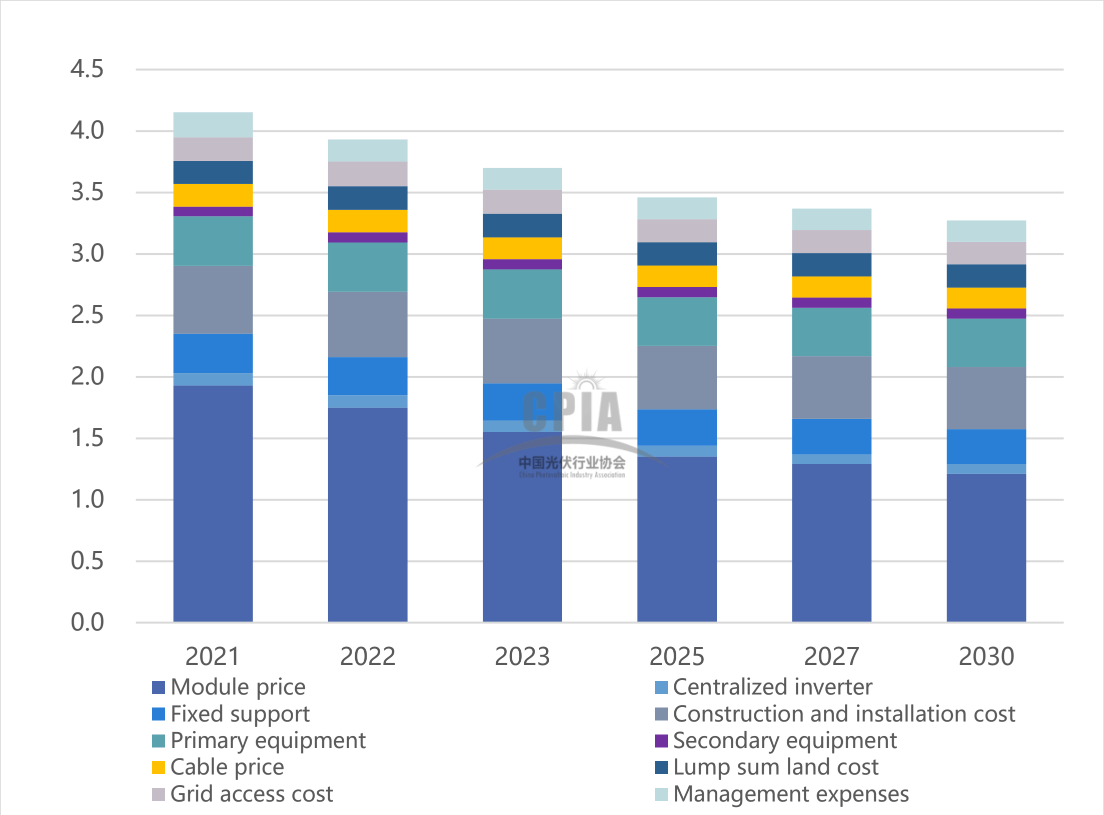

Figure 38. Change trend of initial total investment of ground PV system in China between 2021-2030 (in RMB yuan/W)

（2）Initial total investment of industrial and commercial distributed PV systems

The initial total investment of industrial and commercial distributed PV systems in China mainly consists of the CAPEX of modules, inverters, supports, cables, construction and installation costs, grid access, roof leasing, roof reinforcement, and primary and secondary equipment. The primary equipment includes the box-type transformer, switch box and prefabricated cabin. The initial CAPEX of industrial and commercial distributed PV systems in China is RMB 3.74 yuan/W in 2021 and is expected to drop to RMB 3.53 yuan/W in 2022.

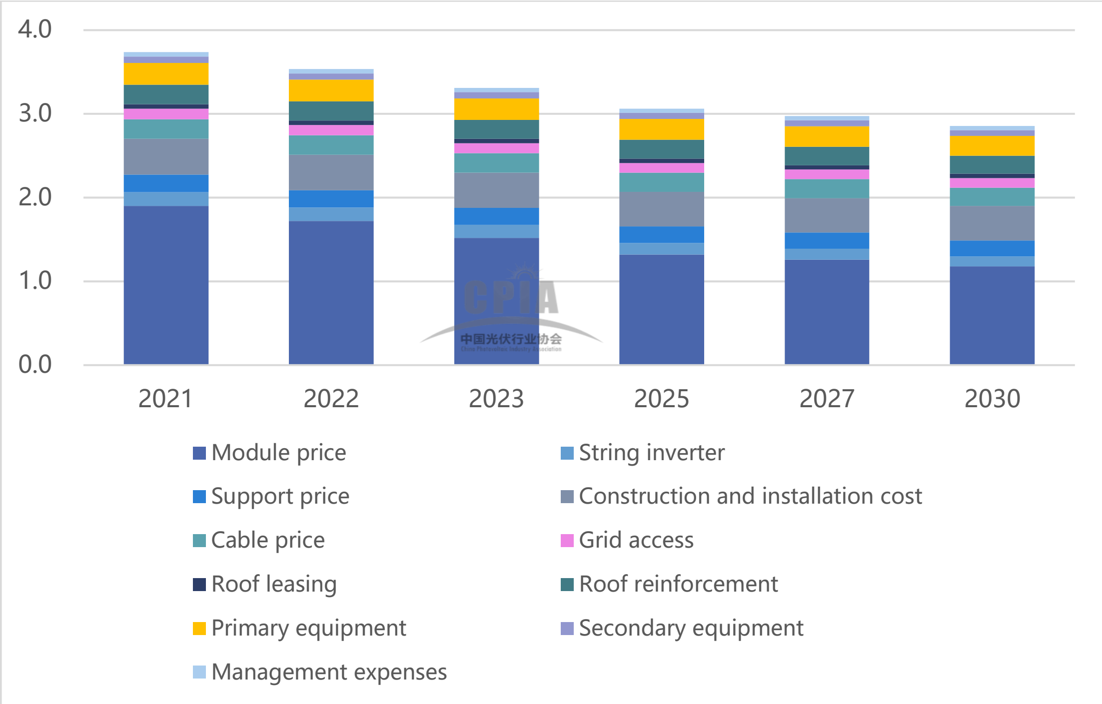

Figure 39. Change trend of initial total investment (CAPEX) of industrial and commercial distributed PV systems in China between 2021-2030 (in RMB yuan/W)

（3）Operation and maintenance cost of power station[10]

Operation and maintenance of the power station is short for the operation and maintenance of the solar PV power generation system. Based on the system safety, it provides scientific and reasonable management on the power station by means of preventive maintenance, regular maintenance and regular equipment performance tests in order to ensure the safe, stable and efficient operation of the entire PV power generation system of the power station, thus ensuring the return for the investors. It is also the basis of the power station transaction and refinancing. In 2021, the operation and maintenance cost of the distributed PV system is RMB 0.051 yuan/W/year, and that of the centralized ground power station is RMB 0.045 yuan/W/year, slightly lower than those in 2020. It is expected that the operation and maintenance costs of ground PV power stations and distributed systems will continue to remain at this level and decrease slightly in the next few years.

[10] The operation and maintenance of the power station only includes the basic operation and maintenance, excluding the part included in the replacement of fixed assets.

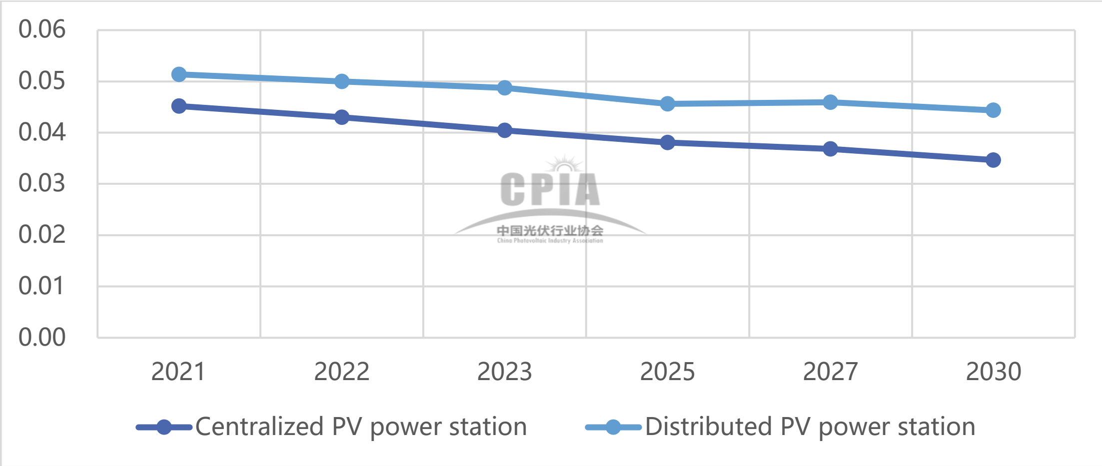

Figure 40. Change trend of operation and maintenance costs of PV power stations in China between 2021-2030 (in RMB yuan/W/year)

5. LCOE estimation for different equivalent utilization hours[11]

Levelized Cost of Electricity (LCOE) is usually used to measure the cost of unit electricity generated during the whole life cycle of a PV power station, and can be used for comparison with the electricity cost from other sources. In the total investment model, LCOE is related to the initial investment, operation and maintenance cost and power generation hours. In 2021, in the total investment model, the LCOE of the ground PV power station for equivalent utilization hours of 1800h, 1500h, 1200h and 1000h are RMB 0.21, 0.25, 0.31 and 0.37 yuan/kWh respectively.

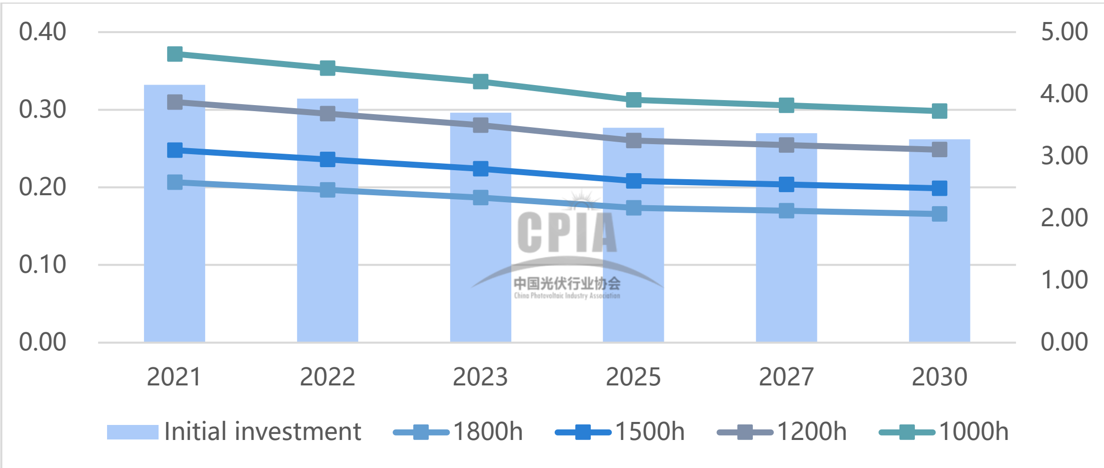

Figure 41. LCOE estimation for different equivalent utilization hours of ground PV power stations between 2021-2030 (in RMB yuan/kWh)

[11] ①This estimate only considers the total investment scenario, excluding the financing cost; ②The LCOE value is calculated with the LCOE calculation formula specified in Specification for Photovoltaic Power Generation System Performance, wherein the discount rate is taken to be 5%, the residual value of the power station is taken to be 5%, and the VAT is deducted by 5-year installment; ③The capacity ratio is taken to be 1:1.

In 2021, in the total investment model, the LCOE of the distributed PV power generation system for equivalent utilization hours of 1800h, 1500h, 1200h and 1000h are RMB 0.19, 0.22, 0.28 and 0.33 yuan/kWh respectively. At present, the distributed PV systems in China are mainly located in Shandong, Hebei, Henan, Zhejiang and other provinces, and they have economic efficiency in most parts of the country.

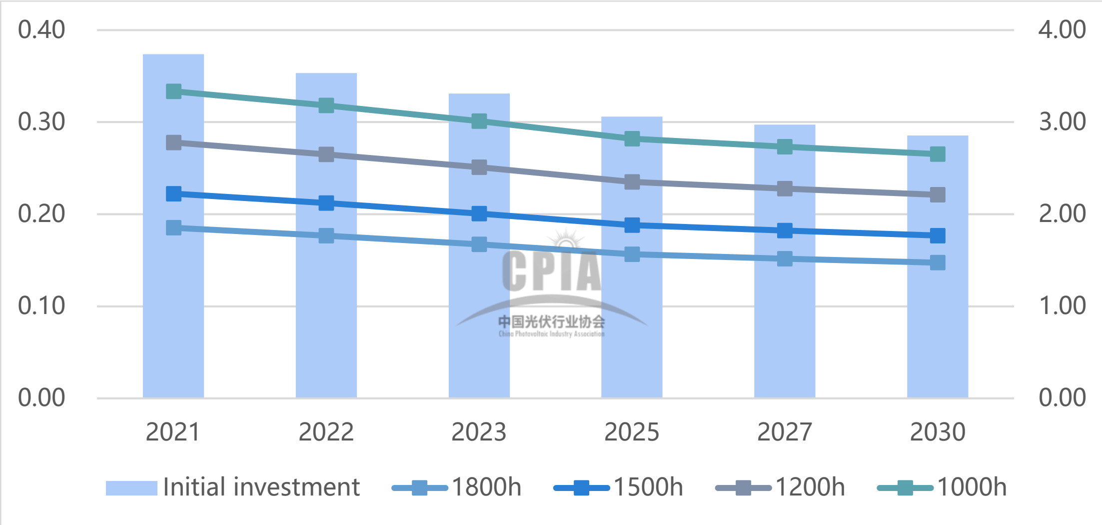

Figure 42. LCOE estimation for different equivalent utilization hours of distributed PV power stations between 2021-2030 (in RMB yuan/kWh)

6. Market share of various system voltage grades[12]

In 2021, the DC voltage grade of 1500V has a market share about 49.4% and 50.6% for the DC voltage grade of 1000V. In 2021, the installed capacity of household distributed PV systems is 21.6GW, all of which adopt the DC 1000V system, and the installed capacity of the industrial and commercial distributed PV systems is 7.7GW, 80% of which adopt the DC 1000V system.

[12] This index covers both the ground power station and the distributed PV system.

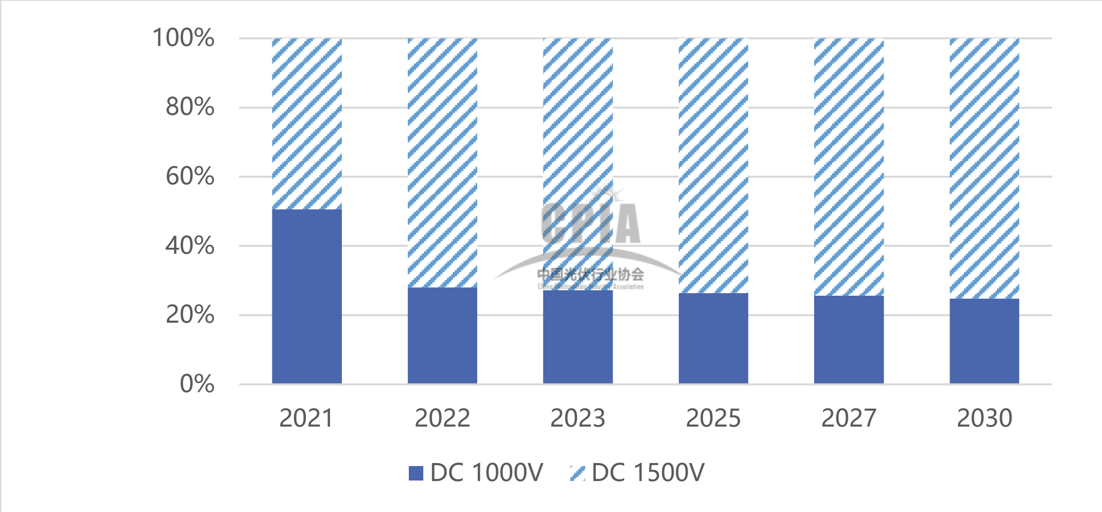

Figure 43. Change trend of market share of various system voltage grades between 2021-2030

7. Market share of tracking system

The tracking systems include the single-axis tracking system and the double-axis tracking system (excluding the adjustable fixed system). The single-axis tracking system is composed of the horizontal single-axis system and inclined single-axis system. At present, the market is dominated by the single-axis tracking system. Despite the advantage of power generation gain, the tracking system has a market share of only 14.6% in 2021 due to its relatively high cost, 4.1% lower than that in 2020. In the future, with the decline of its cost and the solution to reliability issues, the market share will increase steadily.

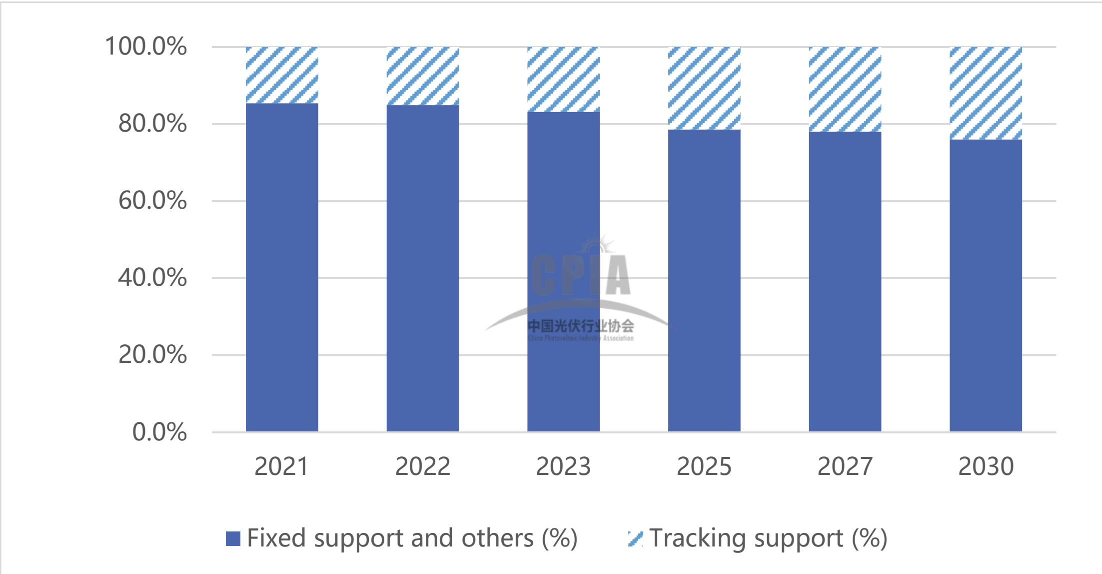

Figure 44. Change trend of market share of tracking systems between 2021-2030

China Photovoltaic Industry Association (CPIA) is a national association approved by the Ministry of Civil Affairs of the People's Republic of China. Its members mainly include enterprises, institutions, social organizations and individuals engaged in the research, development, manufacturing, teaching, testing, certification, standardization and service of PV products, equipment, relevant auxiliary ingredients (parts) and PV product application. It is a national, industrial and non-profit social organization. At present, the CPIA has 504 members. China Photovoltaic Industry Association is established for purpose of protecting the legitimate rights and interests of its members and the benefits of the entire PV industry, strengthening the industry self-discipline and ensuring fair competition in the industry; improving the construction of standard system and creating a good development environment; promoting the technical exchange and cooperation and improving the independent innovation capability of the industry; playing the role of bridge and link between the government and enterprises, and carrying out various activities to serve the enterprises, the industry and the governments; promoting international exchanges and cooperation, organizing the industry to take an active part in international competition and dealing with trade disputes.

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CCID Thinktank Institute of Integrated Circuits is a consulting service body affiliated to China Center for Information Industry Development and it specializes in industrial, market and investment research and planning related to integrated circuit, solar PV, new display and other industries. With solid theoretical foundation, rich policy research experience and extensive industry expertise, CCID Thinktank Institute of Integrated Circuits provides consulting services related to industrial policies, planning, investment, platform operation and investment promotion in the semiconductor field for the ministries and commissions of the central government, large funds, central enterprises, local governments and park management committees. As a main business support entity of National Office for Integrated Circuit

Leading Group, Electronic Department of the Ministry of Industry and Information Technology, High Tech Department of National Development and Reform Commission, National Energy Administration, Information Bureau of Central Network Information Office and National Integrated Circuit Industry Investment Fund Corporation, CCID Thinktank Institute of Integrated Circuits has participated in drafting a series of important policy documents, including Circular of the State Council on Printing and Distributing Several Policies to Encourage the Development of Software Industry and Integrated Circuit Industry (document No. 18), Opinions of the State Council on Promoting the Healthy Development of PV Industry, Three-year Action Plan for New Displays, Circular of the State Council on Printing and Distributing Several Policies to Further Encourage the Development of Software Industry and Integrated Circuit Industry (document No. 4), National Outline for Promoting the Development of Integrated Circuit Industry, Specifications for Photovoltaic Industry, Opinions on Further Optimizing the Market Environment for Merger and Reorganization of PV Enterprises and the 13th Five-year Plan for Solar Energy Development.

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