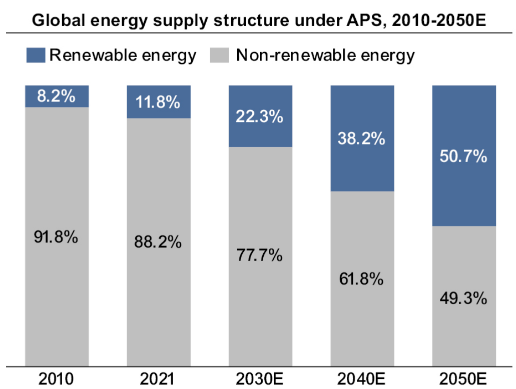
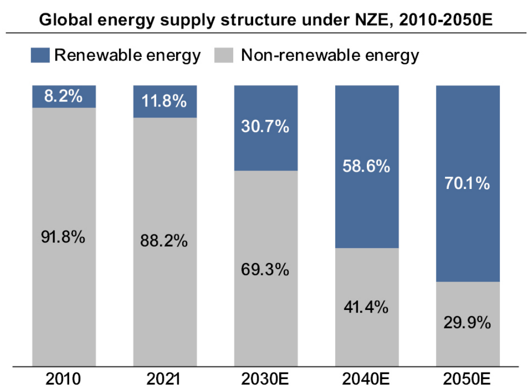
TOYO SOLAR'S MARKET OPPORTUNITIES

The information presented in this section has been derived from an industry report (the "CIC Report") commissioned by TOYO Solar and issued by CIC, an independent research firm to provide information regarding the industry and market position of TOYO Solar in Southeast Asia and the United States. The CIC Report was issued in September 2023 prior to the consummation of the Pre-Merger Reorganization. As a result and following the consummation of the Pre-Merger Reorganization, TOYO Solar became a wholly owned subsidiary of PubCo.

Overview of Global Market Trends for Renewable Energy

With its clean, secure, independent and controllable characteristics, renewable energy is increasingly playing a dominant role in driving the global transition to low-carbon energy. According to the International Energy Agency (IEA), under its Announced Pledges Scenario (APS), which assumes governments will meet their ambitious targets, including achieving net-zero emissions and ensuring energy access, renewables are projected to contribute 50.7% of the total energy supply by 2050. Furthermore, the IEA's Net Zero Emissions by 2050 Scenario (NZE) presents a roadmap for eliminating carbon dioxide emissions in the energy sector by 2050, with renewables expected to account for 70.1% of the total energy supply in the same time frame. The following diagrams illustrate the historical and projected global energy supply structure (in terms of renewable vs non-renewable energy) under APS and NZE, respectively, up to the year of 2050.





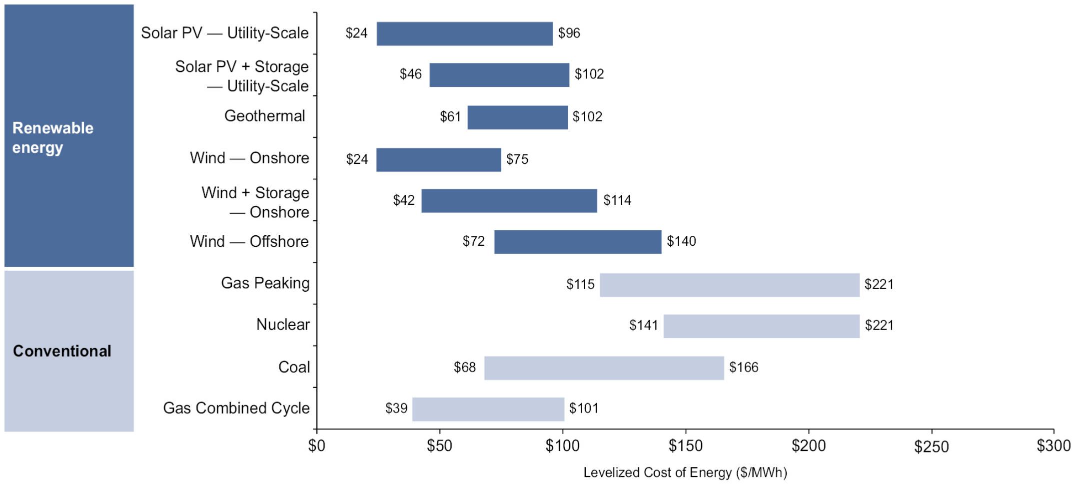
Source: IEA, CIC Report

Overview of Global Market Trends for Solar Energy

Solar energy is a rapidly growing and attractive source of renewable energy that offers many economic and environmental advantages, according to CIC. Based on a forecast made by IEA in June 2023, solar power is expected to account for two-thirds of the renewable electricity net capacity additions worldwide in 2023 and is expected to keep growing in 2024. The growing use of battery energy storage has also further increased demand for solar energy by providing utilities with greater flexibility to store solar-generated power and dispatch it as needed, according to CIC.

The cost of generating electricity from PV solar power systems has decreased significantly, making it competitive with or cheaper than traditional forms of energy production. For instance, the cost of solar generation has decreased approximately 90% over the last decade, according to CIC. According to CIC, the improvements in the levelized costs of energy (LCOE) for utility scale solar PV are mainly due to technological improvements and greater economies of scale. Further, according to a report published by Lazard in April 2023, the solar electricity competes with both natural gas and wind, and costs much less than traditional technologies such as coal and nuclear. The following diagram compares the LCOE among various forms of energy production in April 2023, excluding the impact of subsidies. LCOE measures the average lifetime cost of electricity generation for a power plant, and is derived by dividing the discounted lifetime costs by the discounted total amount of actual energy produced.

Comparison of Levelized Cost of Energy, Excluding Subsidies



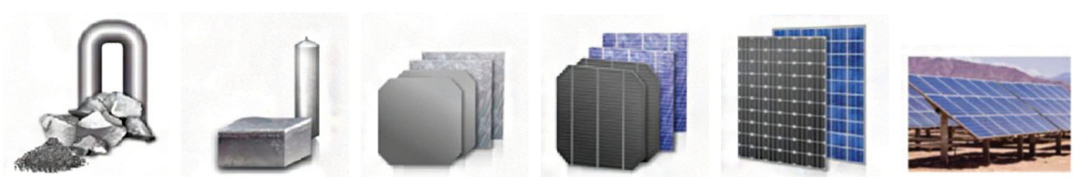
Source: Lazard (April 2023), CIC Report

The cost reduction of solar electricity has enabled the development of solar systems in areas without financial incentives, promoting widespread adoption. Advancements in energy storage technology have further improved the potential of solar energy as a substitute for traditional energy sources, according to CIC. Additionally, solar energy has significant environmental benefits, including zero greenhouse gas emissions and minimal water usage. As a result, solar markets worldwide are expanding and evolving.

Overview of Supply Chain of Solar Power

The decrease in the LCOE for solar power can be attributed to several factors, including the increased maturity of the solar industry's supply chain, ongoing technological advancements, and economies of scale achieved at each stage of the supply chain.

The solar power supply chain, as illustrated in the diagram below, consists of (i) production of polycrystalline silicon materials, (ii) pulling and slicing of monocrystalline ingots and wafers, (iii) production of solar cells, (iv) encapsulation of solar modules, and (vi) and provision of services for solar PV application systems.



Polysilicon Ingot Wafer Cell Module Installation

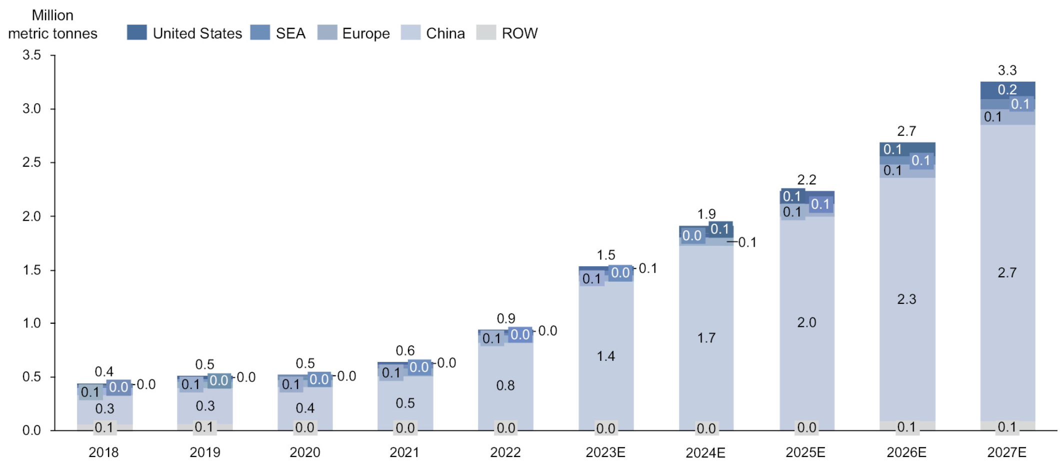
Source: U.S. Department of Energy

Polysilicon Production

The process of polysilicon production involves converting polycrystalline silicon material into ingots or monocrystalline silicon rods through casting or melting. These ingots or rods are then sliced into wafers using wire saws.

As of the end of 2022, the annual manufacturing production for PV-grade polysilicon reached 0.9 million metric tonnes, which can meet the demand for approximately 370GW of crystalline silicon wafers, according to CIC. China dominated the global market for polysilicon production, accounting for approximately 87.4% of the market in 2022, while Europe, Southeast Asia and the United States held the remaining market share, according to CIC. The global polysilicon production is expected to increase from 0.9 million metric tonnes in 2022 to a projected 3.3 million metric tonnes by 2027, indicating substantial growth in the coming years. The following diagram illustrates the historical and projected polysilicon production by region:

Polysilicon Production by Region, 2018 – 2027E

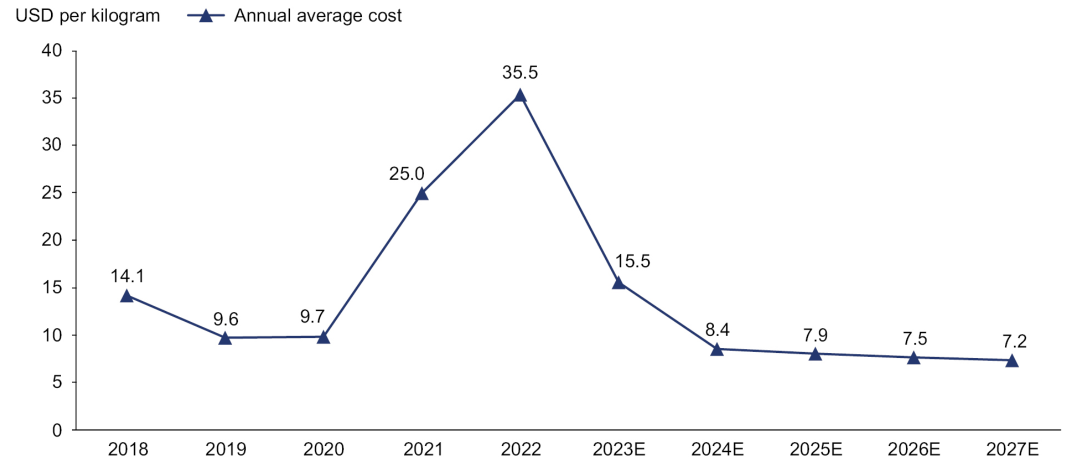


Source: CIC Report

Notes: SEA = Southeast Asia; ROW = Rest of the World

The diagram below illustrates the historical and projected annual average cost of polysilicon. According to CIC, the cost of polysilicon has experienced a significant growth since 2020, rising from $9.7/kg in 2019 to $35.5/kg in 2022. The cost increase is mainly driven by supply disruptions due to COVID-19 restrictions limiting polysilicon production capacity in China, the largest global supplier, and strong ongoing demand growth in the solar PV industry with increasing PV installations globally. According to CIC, the cost is expected to decrease from $35.5/kg in 2022 to $15.5/kg by 2023, and further to $7.2/kg by 2027. This anticipated decrease in cost is primarily driven by a significant increase in polysilicon supply in China and a corresponding decline in the comprehensive energy cost associated with polysilicon production, which encompasses the expenses incurred in the utilization of natural gas, coal, electricity, steam, water, and other resources during the production.

Annual Average Cost of Polysilicon, 2018 – 2027E



Source: CIC Report

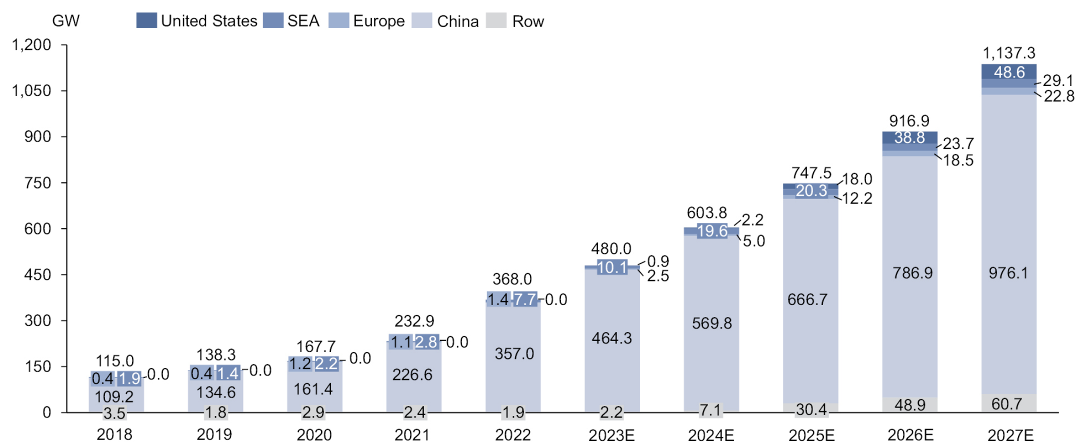
Note: Annual average cost refers to annul average selling price or annal average spot price

Notably, the improvements in manufacturing techniques, such as the implementation of fluidized bed reactors and upgraded metallurgical-grade silicon (UMG-Si) production, are expected to contribute significantly to this expected reduction in energy costs. These advancements allow for greater efficiency in polysilicon production and subsequently lead to cost savings.

Wafer Production

The production of silicon wafers involves the conversion of polycrystalline silicon into ingots or monocrystalline silicon rods, which are subsequently sliced into wafers. The global wafer production is expected to increase from 368.0GW in 2022 to a projected 1,137.3GW by 2027, indicating substantial growth in the coming years. The historical and projected wafer production by region is further illustrated by the diagram below:

Wafer Production by Region, 2018 – 2027E



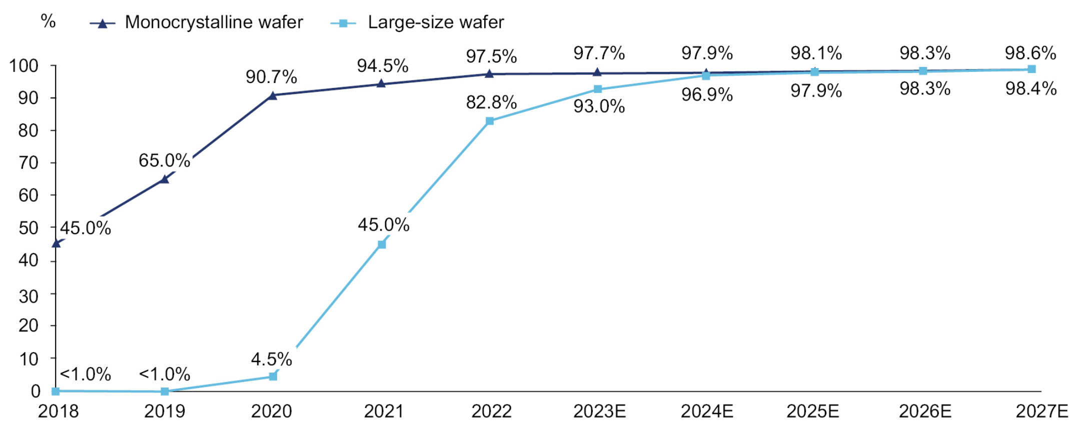
Source: CIC Report

Notes: SEA = Southeast Asia; ROW = Rest of the World

The United States currently lacks wafer production capacity; however, once construction is completed, the volume of production is estimated to reach 48.6GW by 2027. In Southeast Asia, wafer production is relatively limited, contributing only 2.1% to the overall wafer production in 2022. Nevertheless, manufacturers in Southeast Asia are anticipated to accelerate their growth, with volume projected to reach 29.1GW in 2027, as suggested by CIC. Comparatively, Europe accounted for a relatively small proportion of global wafer production, totaling 1.4GW in 2022, but this is expected to grow significantly to 22.8GW by 2027. Meanwhile, China has perpetuated its dominance in global wafer production, representing a substantial market share of 97.0% in 2022.

The shifts in wafer production methods and technologies have substantially reduced manufacturing costs of silicon wafers. The use of diamond wire saws since 2015 has led to reduced silicon consumption. From 2010 to 2022, the average polysilicon usage per watt of finished wafer decreased by 58.2% according to CIC. The shift to monocrystalline wafer production and the wide adoption of larger wafer sizes (182mm and above) since 2020 have also led to reduced cost of silicon wafers, according to CIC. The shift to monocrystalline wafer production has facilitated cost-effective manufacturing of high-efficiency cells, contributing to a reduction in the per-watt cost of solar PV modules. According to CIC, the proportion of monocrystalline wafer in the overall production rapidly increased from less than 45.0% in 2018 to 97.5% in 2022, as illustrated in the diagram below. Also, by directly increasing the size of wafers, the equipment and labor costs of the various sectors of the solar PV industry value chain can be diluted, directly reducing the manufacturing costs of solar cells and modules, which in turn will lower the LCOE of solar power. According to CIC, the proportion of large size wafers (182mm and above) in the overall production rapidly increased from less than 1.0% in 2018 to 82.8% in 2022, and is expected to continue increasing rapidly to 98.6% in 2027.

Proportion of Monocrystalline Wafers and Large-size Wafers (182mm and Above) in Global Wafer Production, 2018 – 2027E

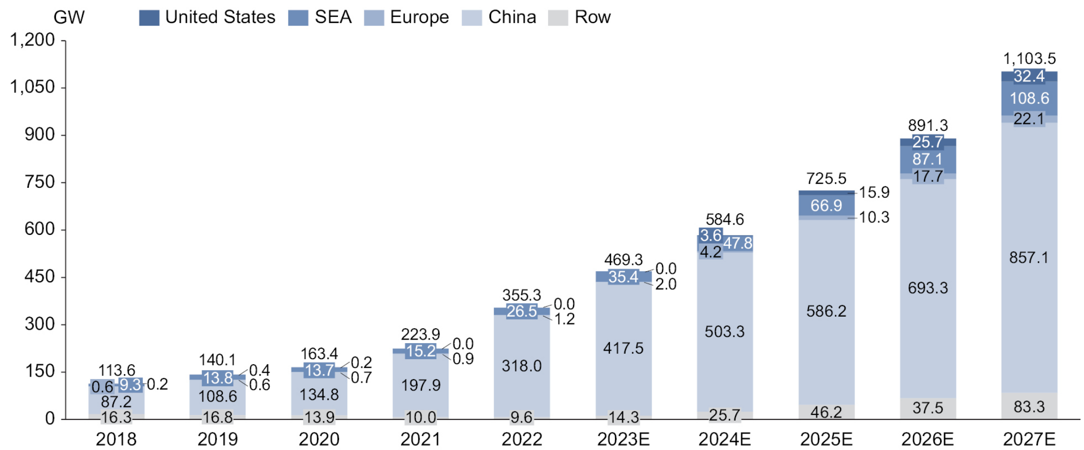


Source: CIC Report

Solar Cell Production

Solar cells are crucial in the conversion of sunlight into electricity. Their production involves intricate processes that demand technical expertise and substantial investments. The manufacturing steps for solar cells vary based on the cell architecture and encompass a range of activities such as pre-check and pretreatment, texturing, acid cleaning, diffusion, etching and edge isolation, post-etching washing, anti-reflective coating deposition, contact printing and drying, as well as testing and cell sorting. Rigorous inspections and electrical testing are conducted to ensure the quality of cells, with automation playing a significant role in streamlining the manufacturing industry. The following diagram illustrates the historical and projected solar cell production by region:

Solar Cell Production by Region, 2018 – 2027E



Source: CIC Report

Notes: SEA = Southeast Asia; ROW = Rest of the World

According to CIC, the United States currently lacks crystalline silicon solar cell production but is anticipated to produce 32.4GW of solar cells by 2027. Manufacturers in Southeast Asia accounted for 7.5% of global solar cell production in 2022, and their production is projected to increase substantially from 26.5GW in 2022 to an estimated 108.6GW by 2027. In terms of Europe, its production capacity remains limited, representing only 0.3% of total cell production in 2022. However, it is expected to grow to 2.0% in 2027, with an estimated solar cell capacity of 22.1GW. China has played a significant role in solar cell production, boasting a dominant market share of 89.5% in 2022. The volume of solar cell production in China has witnessed substantial growth, rising from 87.2GW in 2018 to 318.0GW in 2022, representing a CAGR of 38.2%, and is further expected to reach 857.1GW by 2027, representing a CAGR of 21.9% from 2022 to 2027.

Solar Cell Technology

Crystalline silicon solar cells are categorized into either P-type cells or N-type cells.

- ***P-Type Cells.*** P-type cells with Passivated Emitter and Rear Cell (PERC) technology have gained significant traction and are widely adopted by the industry. In 2022, PERC solar cells achieved a conversion efficiency of 23.2% for mass production, according to CIC.

- ***N-Type Cells.*** N-type cells are projected to become the mainstream technology in the solar cell industry. N-type cells offer several advantages, including high efficiency levels, resistance to degradation, and low temperature coefficients, according to CIC. These features not only enhance solar energy generation but also contribute to cost reduction, making N-type cells a promising avenue for future advancements in solar cell technology.

The representative features of the type P-type cells and N-type cells are summarized as follows:

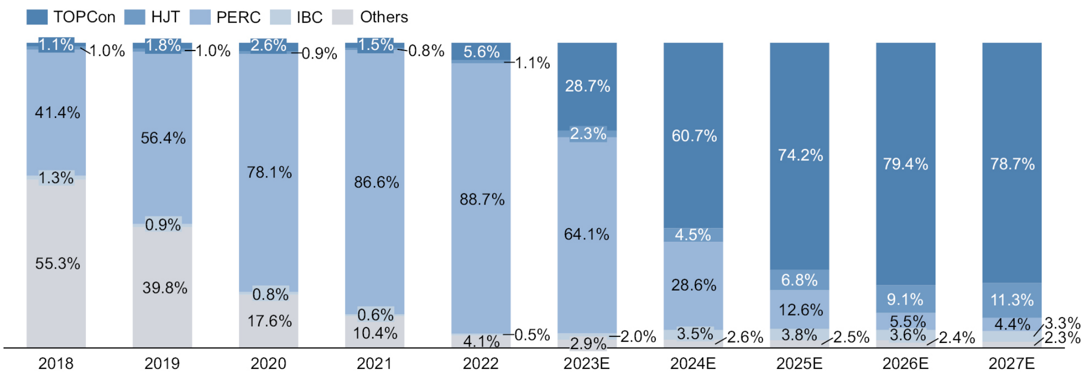
Type	Cell Technology	Features
P-Type	Passivated Emitter and Rear Cell ("PERC")	The addition of a dielectric passivation layer on the backside of the cell, along with the use of localized metal contacts, effectively reduces electron recombination on the rear surface and enhances light reflection. This unique design enables the cell to generate electricity from both sides, a feature known as double-sided power generation.
N-type	Tunnel Oxide Passivated Contact ("TOPCon")	A thin layer of tunnel oxide and a highly doped polycrystalline silicon layer are prepared on the backside of the cell, forming a passivating contact structure. This structure can inhibit minority carrier recombination, thereby enhancing the open-circuit voltage and short-circuit current of the cell. TOPCon and PERC technologies share multiple manufacturing processes, and it is expected that TOPCon will be the preferred technology for upgrading and retrofitting PERC production lines.
	Passivated Emitter Rear Totally-diffused ("PERT")	Similar to the P-type PERC cell structure, the main difference lies in the use of an N-type substrate instead of a P-type substrate, resulting in a cell capable of generating electricity from both sides.
	Heterojunction Technology ("HJT")	The combination of thin-film and high-quality silicon cell technologies has led to the development of an efficient cell technology. Heterojunction cells offer wider bandgap and greater potential for improving cell efficiency compared to homojunction cells, making them a potential mainstream technology in the future.
	Interdigitated Back Contact ("IBC")	The front and back electrodes of the cell are arranged in a cross-shaped pattern, known as a back-contact cell structure. This design eliminates front-side busbars, maximizing the utilization of incident light. However, this technology involves complex manufacturing processes and high production costs, currently offering lower cost-effectiveness compared to other cell technologies.

The advancement of solar cell technology is centered around enhancing light absorption and optimizing the efficiency of converting solar energy into electricity, all while minimizing energy losses. By focusing on the development of N-type cells and leveraging their inherent strengths, researchers and manufacturers can pave the way for improved solar energy generation, increased efficiency, and greater cost-effectiveness, thus driving meaningful progress in the field of solar cell technology, according to CIC.

In particular, the advancements in N-type TOPCon cell technology are driving considerable developments in the solar industry, with increased manufacturing capacity, improvements in efficiency, and cost advantages, as discussed in more details below. These trends are expected to reshape the landscape of solar cell production, contributing to enhanced performance and cost-effectiveness in the field of solar energy generation.

According to CIC, manufacturers produced around 19.9GW TOPCon cells, capturing a substantial 5.6% market share of total module production in 2022. Leading TOPCon cell manufacturers achieved an approximate efficiency of 25% in 2022 and anticipate even further enhancements through the utilization of surface engineering (SE) techniques, with a potential efficiency increase of 0.2% to 0.3%, according to CIC. These efficiency and yield advancements are projected to play a pivotal role in reducing the cost of solar cells and improving the LCOE for solar power generation. Consequently, the TOPCon technology is expected to witness substantial growth and holds significant potential for advancements in the solar industry, according to CIC and as illustrated in the diagram below:

Solar Cell Market Share by Technology, 2018 – 2027E



Source: CIC Report

Notes: TOPCon = Tunnel Oxide Passivated Contact; HJT = Heterojunction Technology; PERC = Passivated Emitter and Rear Cell; IBC = Interdigitated Back Contact

Furthermore, considering the rapid expansion of TOPCon capacity and its anticipated timeline for online deployment, TOPCon cell production is expected to reach 134.8GW in 2023, accounting for 28.7% of the total module production, according to CIC. By 2024, TOPCon cell production is projected to surpass that of PERC technology, leading to a faster transition away from PERC products due to various factors like TOPCon's efficiency and cost advantages, according to CIC.

Solar Module

Solar modules, which consist of interconnected solar cells, are critical components in solar power systems and have a significant impact on the cost of solar energy generation. Over the years, there have been considerable advancements in solar module technology, resulting in increased efficiency and improved performance, according to CIC.

Between 2010 and 2016, the annual efficiency of solar modules saw an average increase of approximately 0.3% to 0.4%, while from 2017 to 2020, this rate accelerated to about 0.5% to 1% per year, signifying a significant shift in the pace of technological advancement. These advancements have been achieved through improvements in optical, electrical, and structural aspects of solar module technology, according to CIC.

Optical optimization techniques aim to minimize light reflection and enhance light absorption through optimization of materials and solder ribbons. Electrical optimization focuses on reducing resistance losses by employing current distribution and interconnection methods such as half-cell design and multi-busbar configurations. Structural optimization involves layout changes and breakthroughs like bifacial modules and large wafer technology.

During the assembly process, solar cells are connected into strings, creating an array that is then encapsulated between glass or back sheet layers. Modules typically feature junction boxes with diodes and extruded aluminum frames. Additionally, there are alternative options available, such as frameless and glass-glass modules, which may incorporate bifacial cells.

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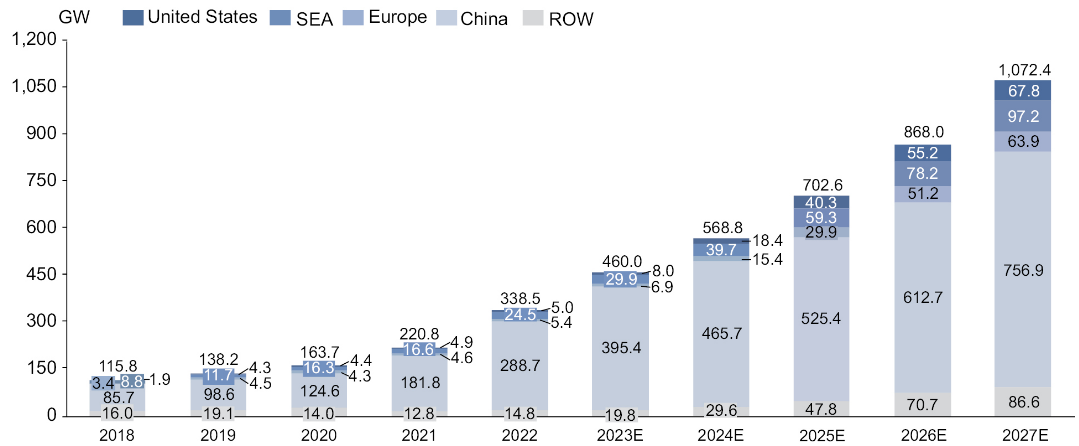
Solar module production integrates these advancements and options to continuously enhance the power generation capacity of modules, ultimately driving down energy costs. In 2022, the global solar PV module production capacity reached an impressive 523.6 GW, with crystalline silicon technology accounting for 98.1% of this capacity and thin-film manufacturing making up the remaining 1.9%, according to CIC. The following diagram illustrates the historical and projected solar module production by region:

Solar Module Production by Region, 2018 – 2027E



Source: CIC Report

Notes: SEA = Southeast Asia; ROW = Rest of the World

According to CIC, among the 38 countries with module assembly facilities, China accounted for approximately 85.3% of the total production. Southeast Asian manufacturers contributed 7.2% to the global production volume. It is worth noting that a significant portion of the manufacturing capacity in these 38 countries was established by Chinese companies with a focus on exporting to the United States. Meanwhile, the United States and Europe had limited module production capabilities, representing only 1.5% and 1.6% of the total production in 2022, respectively. Their production primarily aimed to meet domestic market demands, often facing limitations in PV cell and wafer manufacturing capacity.

The volume of global solar module production is expected to reach 1,072.4GW by 2027, representing a CAGR of 25.9% from 2022. This growth will be primarily driven by technological advancements and increased manufacturing capacity. By 2027, the United States and Southeast Asia are projected to account for 6.3% and 9.1% of the global module production, respectively.

Solar Installation

Improvements throughout the PV supply chain have significantly reduced unit costs of power generation and created up solar PV's dominant position in the era of green energy, according to CIC. Global solar capacity installations have been growing significantly in recent years. According to CIC, solar capacity installations reached 130GW in 2020, followed by 170GW in 2021 and 230GW in 2022, with year-on-year growth rates of 30.8% and 35.3% respectively. It is projected that solar capacity installations in 2023 will increase by 52.2% compared to 2022, reaching 350GW globally.

The United States is the second-largest market in terms of annual and cumulative installations, according to CIC. Solar capacity annual installations in the United States are expected to reach 36.0GW in 2023, according to CIC. The total installed U.S. solar fleet is expected to grow three times larger than it is today, from 140.6GW at the end of 2022 to more than 450.0GW by 2027, according to CIC.

Our Opportunity

Over the past decade, China has emerged as a dominant player in the solar PV manufacturing landscape, particularly in the production of wafers, cells, and modules. China's global share of polysilicon production capacity has nearly tripled during this period, reflecting its significant role and influence in the global solar PV industry, holding a share of over 80% in all manufacturing stages. However, intense competition and excess capacity in the industry have compelled Chinese companies to adopt a low-price strategy. Furthermore, the United States has launched anti-dumping and countervailing duty investigations against Chinese solar companies since November 2011. The subsequent U.S.-China trade war, decoupling efforts, and concerns over the origin of products from Xinjiang Uygur Autonomous Region of China have affected Chinese solar companies' exports to the U.S. market.

The implementation of the Uyghur Forced Labor Prevention Act (UFLPA) by the U.S. Customs and Border Protection has significantly impacted solar panel imports to the United States. According to the UFLPA, goods produced in the Xinjiang Uyghur Autonomous Region of China or by certain entities are presumed prohibited, unless compliance conditions are met to demonstrate the absence of forced labor. However, compliance challenges and uncertainties, such as traceability issues, have affected solar panel imports, potentially causing delays.

In addition to the UFLPA, the Commerce Department initiated anticircumvention inquiries of the Solar 1 Orders on April 1, 2022. These inquiries cover merchandise from countries including Vietnam, Malaysia, Thailand, and Cambodia. Preliminary determinations, issued on December 1, 2022, found that certain PV solar cells and modules produced in these countries using parts from China circumvented the Solar 1 Orders, subjecting them to antidumping and countervailing duty (AD/CVD) liabilities. The Commerce Department announced its final determinations on the circumvention inquiries of solar cells and modules from China on August 18, 2023. The department found that certain Chinese producers were shipping their solar products through Cambodia, Malaysia, Thailand, and/or Vietnam for minor processing to avoid paying AD/CVD. However, on June 6, 2022, President Biden issued an emergency declaration that delayed cash deposit or duty payment obligations until the expiration of the order on June 6, 2024, or termination of the emergency declaration. Importers and exporters who comply with certification procedures can avoid these additional duties.

Further, in April 2021, the Biden administration announced a commitment to cut U.S. greenhouse gas emissions by 50% by 2030, necessitating the addition of 50GW of new solar power generation capacity annually. However, the United States had module production capacities of approximately 9.0GW in 2022, according to CIC. The AD/CVD policy, coupled with China's dominance in the global solar market, has resulted in supply shortages in the U.S. solar market, which heavily relies on imports, according to CIC. To address this shortage, the U.S. government exempted Cambodia, Malaysia, Thailand, and Vietnam from the AD/CVD in September 2022.

At the backdrop of the above regulatory developments, upon commissioning of its 3GW TOPCon solar cell production capacity, TOYO Solar is positioned to become one of the few suppliers that are capable to provide TOPCon solar cell outside of China. With the second phase of the project, adding another 3GW solar cell capacity and totaling up to 6GW, TOYO Solar will further expand its scale advantage and establish a strong position in the market. Additionally, TOYO Solar plans to achieve vertical integration by establishing module and wafer slicing plants. The solar module factory, with a 2GW annual capacity, will be located in the United States, reducing policy risks and better catering to the U.S. market. The 2GW annual capacity wafer slicing factory will be at a selected location. This strategic global supply chain system ensures supply stability, reduced policy risk, and cost-effective production in Southeast Asia.

Competitive Landscape

The U.S. market is a significant focus for us as it is one of the largest solar PV markets globally and continues to grow. However, despite the notable increase in demand, with PV panel imports rising from 5GW in 2018 to 38GW in 2023, according to Bloomberg NEF, domestic production in the United States has not been able to keep up with the expanding demand. Local suppliers only accounted for approximately 15% of the total solar module demand in 2022, revealing a significant supply-demand disparity. This situation has been intensified by the lack of wafer production capacity in 2014 and cell production capacity in 2020. Consequently, there has been no domestic PV cell production since 2021, and solar module production was limited to around 5.0GW in 2022, highlighting the constraints faced by local manufacturers, according to CIC.

In Europe, local suppliers also face challenges in exporting their products due to insufficient local capacity, according to CIC. Although there is some capacity available in 2022, such as 16.1GW of module production capacity, 2.8GW of solar cell production capacity, and 2.4GW of wafer production capacity, these figures only represent 3.1% of the global module production capacity and less than 1% of the global solar cell and wafer production capacities, according to CIC. This falls short of meeting the demand both domestically and in other regions.

Trade policies and tariffs imposed on Chinese PV manufacturers impact their exports to the U.S. market to a certain extent. Tariffs imposed are traced back to polysilicon, with China's polysilicon production capacity accounting for more than 90% of the world. Therefore, in the short term it will make Chinese module products lose part of the price advantage. At the same time, U.S. Customs and Border Protection has banned the import of any products related to Xinjiang Uygur Autonomous Region of China in terms of UFLPA and a number of Chinese PV manufacturers have been included in the ban list.

Manufacturers from Southeast Asia, particularly Malaysia, Vietnam, and Thailand, have emerged as the primary sources of PV panel and cell imports for the United States. These Southeast Asia suppliers offer competitive pricing, ample manufacturing capabilities, and the capacity to meet the growing demand for solar cells and solar modules in the U.S. market. Consequently, they have become the most viable option in the current competitive landscape. The following table illustrates TOYO Solar and its competitors from Southeast Asia:

TOPCon Cell Production Capacity Outside of China, GW, 2023E

Location	Company	Headquarters	Production capacity	Time of roll-off, as of August 18, 2023
Thailand	Trina Solar Co., Ltd	China	2.0	Before April 2023
Vietnam	TOYO Solar	Japan	3.0	August 2023
Thailand	Canadian Solar Inc.	China	8.0	Not Rolled Off
Vietnam	Jinko Solar	China	8.0	Not Rolled Off
India	Adani Green Energy Ltd	India	2.0	Not Rolled Off
India	Waaree Energies Ltd	India	4.0	Not Rolled Off

Source: CIC Report