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The Photovoltaic Breakthrough

In 2022, worldwide new photovoltaic installations reached 240GW, doubling from 2019. Mainstream institutions predict that 380GW will be installed this year, with growth approaching the previous peak. With four consecutive annual increases in demand, the price-competitive photovoltaics has trumpeted the arrival of new energy era. Corresponding to the increasing demand is the rapid expansion of production capacity. Statistics show that the announced production capacities of all major links of the photovoltaic industry have exceeded 800GW. Even without new planned capacity, it is already more than enough. At the SNEC photovoltaic conference in May of this year, one founder of a leading enterprise predicted that in the next two to three years, the photovoltaic industry will experience a dramatic industry reshuffle like 2012-2014, when over half of photovoltaic enterprises will disappear from the market.

While domestic "fierce competition" is in full swing, the oversea competition is also building. US and European governments have launched initiatives that support local PV supply chain and reduce demand for Chinese exports by imposing tariff, filing anti-dumping complaints, demanding carbon-emission certifications, and other administrative measures. On the one hand are attractive financial reports, on the other hand is the expectation of excess capacity, with the falling stock tickers pricing in the future concerns. Who then will remain standing after the reshuffle? And how will PV market evolve after this round of severe competition?

The Maze of Excess Capacity

Over the past two decades of rapid development of China's photovoltaic industry, it has experienced two rounds of overcapacity crises.

In 2004, European countries such as Germany, Italy and Spain began subsidizing photovoltaic power generation, thus driving strong installation demand. China's nascent photovoltaic industry thrived as a result, gradually growing into the world's largest photovoltaic manufacturing country. However, behind the rapid expansion of production capacity was the plight of excessive reliance on external markets - upstream raw materials relied on imports, midstream technology and equipment came from overseas, and downstream components were also largely exported overseas to Europe.

The first overcapacity crisis happened when the financial crisis broke out in 2008. As European sovereign debt crisis began to spread across the European continent, various countries cut or even terminated photovoltaic subsidies, causing installation demand to plummet. In 2012, the prices of multicrystalline silicon, silicon wafers, battery slices and components fell by 50.8%, 28.3%, 27.7% and 31.6% respectively year-on-year. Making matters worse, the US and Europe launched anti-dumping investigations into China's photovoltaic battery products. With insufficient domestic demand and a sharp drop in foreign demand, China's photovoltaic industry entered a sharp downturn. By end of 2012, 80% of Chinese multicrystalline silicon enterprises shut down, and a number of enterprises such as Sunvim and Ningxia Sunpower went bankrupt in succession. In 2013, Wuxi Suntech Power, the world's largest photovoltaic component manufacturer at the time, also announced bankruptcy. It was during this time that the Chinese government began to increase support for photovoltaic power generation by clearly defining benchmark on-grid electricity prices for photovoltaic power stations, and subsidizing the portion exceeding the on-grid electricity price benchmark of local coal-fired units. For distributed photovoltaic power generation, a policy of full amount subsidy was implemented, with an electricity subsidy standard of RMB0.42 per kilowatt-hour.

Since then, the domestic market has taken over the baton of demand from overseas markets and quickly grown into the world's largest photovoltaic installation country. By 2018, China's photovoltaic industry had shaken off the constraints of overreliance on external markets, with domestic material and equipment self-sufficiency rates reaching over 60% and 80% respectively. Chinese PV technology reached global leadership, with global component production and sales shares of over 80%.

As the industry grows, the subsidy cost is also widening. The "531 New Deal" was introduced on May 31st 2018, declaring the beginning of subsidy withdrawal and bringing a second major test for the industry. On June 3, 11 photovoltaic entrepreneurs co-signed an open letter to the regulators, earnestly stating the industry's current situation and difficulties, saying, "For photovoltaic industry to truly achieve parity grid parity will still require 3-5 years, and the industry still needs support." In response to this call, policies were adjusted somewhat but without changing the strategic direction of annual subsidy withdrawal.

After the new policies, many small and medium-sized enterprises began to owe back-wages, shut down production or even declare bankrupt. Even some leading enterprises began to reduce production and selectively sell off subsidiaries and power stations. Orders plunged sharply and prices across sectors also slid by 30-55%.

Unlike the previous round, this time market share began to consolidate among leading enterprises. The polysilicon sector had 4 major players, and dedicated battery manufacturers began to emerge, with the top 10 component enterprises accounting for around 60% of the market. With subsidy withdrawal, real competition was unfolding. Without achieving costs lower than thermal power, the market will vote with its feet. On the other hand, a truly competitive PV offering will open a blue-ocean opportunity in trillions of dollars. Fortunately, driven by technological progress and scale expansion, photovoltaic power costs began to be comparable to and even lower than thermal power costs in 2019, ushering in the "grid parity era".

Over the past three years, the photovoltaic industry has grown like wildfire. Any shortage in a single link of the industrial chain would lead to price spikes. The prices of films, glass and polysilicon increased by up to 3, 1 and 5 times respectively over the three years. To strengthen industrial chain defenses, leading enterprises expanded production capacity toward greater integration to shore up weaknesses. Smaller players continued expanding capacity in pursuit of attractive profits. Even non-industry players jumped in to seek a slice of the PV pie. Since 2020, over 200 enterprises from industries such as real estate, landscaping, aquaculture, toys, and automobiles have diversified into photovoltaics, enlarging the ranks of the "new photovoltaic forces".

Aside from domestic competition, external pressures also exist. These include imposing trade barriers, tariff policies, low-carbon certification qualifications, and new measures like "forced labor" accusations and intellectual property barriers. US government support is also given to domestic firms, such as incentives in the US Inflation Reduction Act benefitting the supply and demand sides of photovoltaics to encourage domestic production. The EU's Critical Raw Materials Act aims to locally produce at least 10% of critical raw materials, 40% of key components, and recycling 15% of key raw material by 2030. In addition, strategic raw material imports by single country must not be more than 65% of EU consumption.

The photovoltaic industry now faces major challenges once again. How to balance short-term interests with long-term development, how to maintain an advantageous position amid savage competition, and how to deal with both internal and external pressures - these are issues facing all participants.

Those Who Understand Survive, Those Who Control Win

Looking back at the growth path of the photovoltaic industry, it is full of tire tracks left by the wheels of the PV cycle. Expansion investment → overcapacity → reducing costs and increasing efficiency → growing demand, this repetitive cyclic rule governs the participants and also drives the industry progress. **In essence, the ultimate goal of the photovoltaic industry is to reduce electricity costs, and**

technological progress is the driving force for reducing costs and increasing efficiency, thus the core competitiveness of enterprises is also rooted in this.

In the early stages of the industry, multicrystalline modules dominated the market position by relying on price advantages. Since 2016, monocrystalline products began to show an upward trend, with the global market share increasing annually from 19% in 2016 to 46% in 2018, and becoming the dominant technology in 2019. Behind the change in market share is the iterations of technology. First, the introduction of wire saw cutting doubled the cutting speed and significantly reduced silicon waste. Second, the breakthrough of PERC battery technology significantly improved the efficiency of monocrystalline cells and opened up a power gap vis-à-vis multicrystalline modules. After adding standardized production, the cost of monocrystalline further lowered, so replacing multicrystalline has become the trend.

Such technological innovations have occurred in various links of the industrial chain, constantly enhancing China's competitiveness in photovoltaics. In just over a decade, module power output has increased from 200W to 700W, while prices have dropped by over 90%. Currently, major technological innovations come from the battery cell sector. As P-type cells approach the theoretical efficiency ceiling, the industry is turning to higher efficiency N-type cells. In the first half of this year, N-type accounted for around 90% of new photovoltaic products released. The mainstream N-type cell pathways include TOPCon, HJT and BC. Among them, the TOPCon technology has a lower threshold and higher compatibility with P-type production lines, and is currently the main direction for capacity expansion. The HJT process is simpler, but the production cost is higher. BC, as a quasi-platform technology, can be stacked with existing cell technology, such as creating TBC cells by stacking with TOPCon, and creating HBC cells by stacking with HJT. This generates significant efficiency gains, but the technological difficulty and cost are also very high. In addition to the "big three" N-type technologies, perovskite solar cells represent a dark horse with ultra-high conversion efficiencies and relatively low costs, but the technology challenges are extremely high and short-term mass production will be difficult. Most major manufacturers favor TOPCon, while a few see particular promise in BC.

Before a significant difference in cost-effectiveness is opened up, various technological pathways may coexist for some time. **Once a new technology establishes a dominant position, the industry landscape will be rewritten.** In the past, breakthroughs in wire saw cutting technology and the replacement of multicrystalline by monocrystalline cemented the leading position of flagship enterprises; and when PERC replaced BSF, new players began to emerge.

Comparison of Various Photovoltaic Technologies

	PERC	TOPCon	HJT	BC	钙钛矿
理论极限效率	24.50%	28.70%	28.50%	29.15%	超30%
优势	性价比高	性价比高	工序少 电池参数好	效率高	效率高
技术难度	容易	难度中	难度中偏高	难度高	难度非常高
工序	少	多	较少	非常多	最少
投资设备	低	中	高	较高	低
产线投资成本/GW	1.2-1.5亿元	1.6-2亿元	3.5-4亿元	4-5亿元	/
与P型电池产线兼容	现有产能	可由P型产线升级	不兼容	不兼容	不兼容
量产情况	非常成熟	增长快	已开始量产	量产有难度更适合分布式场景	发展初期，量产难度大
面临问题	逼近极限效率	钝化技术路线不统一	非硅成本高	难度较大成本偏高	不稳定

Source: Haitong International

Compared to the short-term expansion of production capacity, technological innovation requires long-term, large-scale R&D investment. In the second half of the economic cycle, enterprises with earlier blind expansion of production and high debt burdens are easily facing a shortage of funds. Their survival is already challenging, never mind the technological innovation which is even more difficult. Adding to the tightened financing policies, a cruel supply-side structural reform is underway. "Now, balance sheets are more important than profit statements," said an industry expert.

If the problem of product competitiveness can be solved through technological progress, then another issue is challenging not just technology but also operational wisdom. Under the grand goal of carbon neutrality, the world needs more photovoltaics, but they may not want it to all come from China. Today, eight out of every ten photovoltaic modules globally are produced in China. China accounts for around 80% of the production capacity and output in each link of silicon materials, silicon wafers, batteries, and modules, with the market share of silicon wafers even reaching a stunning 97%. Photovoltaics have become a new business card for "Chinese advanced manufacturing", along with electric vehicles and lithium batteries to form Chinese exports' "new top three".

From the perspective of importing countries, the demand for photovoltaics may exceed their own domestic manufacturing capabilities. While North American and European countries have some module manufacturing capabilities, they still largely rely on imports of solar panels from China and Southeast Asia.

Over the past five years, Europe's photovoltaic imports spending has basically quadrupled. It was 50 billion euros in 2018 and has exceeded 200 billion euros in 2022, of which payments to Chinese photovoltaic products totaled 185 billion euros, accounting for 90% of the total. The European Solar Industry Association warned that a large amount of low-priced Chinese imports has pushed some European manufacturers to the brink of bankruptcy.

The photovoltaic industry is not only related to achieving carbon neutrality targets, but also involves national energy security. It represents competition between companies as well as between countries. Restricting imports and supporting domestic enterprises may become a long-term trend, but in the short term, the global industrial and supply chains cannot be decoupled.

Facing the twin challenges of overseas trade barriers and the rise of domestic manufacturing, leading Chinese companies have already taken countermeasures. In addition to intensifying R&D of advanced production capacity and expanding diversified overseas markets, they are taking the lead in laying out production capacity overseas, transforming from "Made in China, sold globally" to "Made globally, sold globally."

Final Thoughts

In 2022, photovoltaics accounted for 65% of the newly installed global power generation capacity. Looking at the global power structure, photovoltaic power generation accounts for only 4.5% of global power generation, leaving huge potential for replacement of existing capacity.

Currently, tightened financing and technological upgrading are jointly promoting supply-side reforms in photovoltaics and thus driving industry progress. Under the leadership of aspirational entrepreneurs, industry share and profitability will once again concentrate on companies that have the correct values and sustainable innovation capabilities.

The photovoltaic index (884045.WI) has fallen nearly 40% from its peak a year ago, with the valuations of leading companies at 10 times or even near 5 times, which put them at the bottom level in nearly ten years, fully incorporating pessimistic expectations. Excess capacity next year is highly likely to become a fait accompli, while expectations for the supply and demand situation and competitive landscape in 2025 are changing. In the past year alone, more than 20 photovoltaic companies have announced share buybacks.

Rather than gamble on the bottom of the index, it is better to explore the inflection points of the industry and companies for the breakthrough. We shall discern the ending from the beginning, act calmly and make decisive moves.

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