TAIYANGNEWS
ALL ABOUT SOLAR POWER

TOP SOLAR MODULES H1 2024

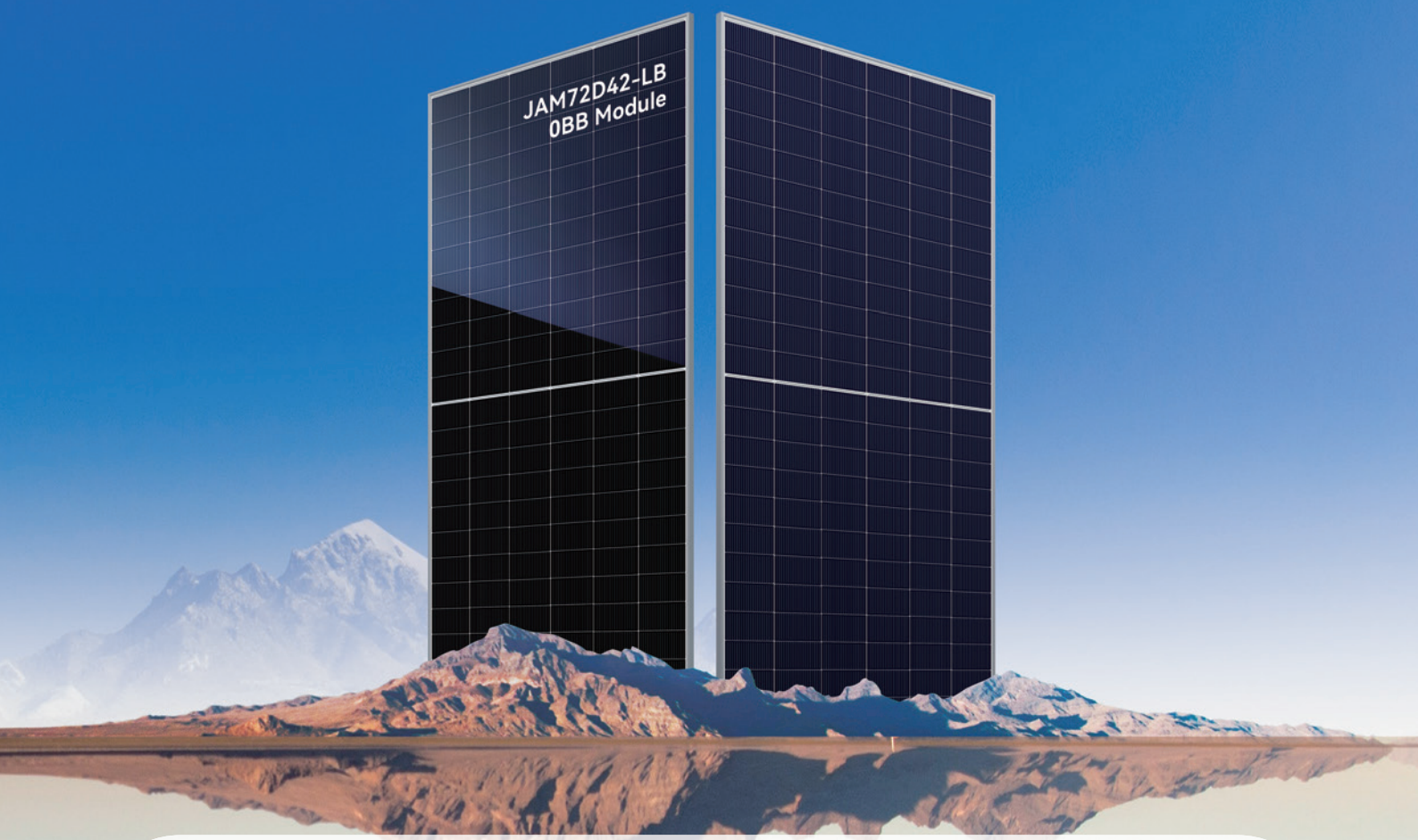
Overview & Analysis of Highest Efficient Commercial Solar Panels

Authors: Shravan K. Chunduri, Michael Schmela

JA SOLAR | DEEP BLUE 4.0 Pro

645W
HIGH POWER

23.1%
HIGH EFFICIENCY



- High Efficiency
- High Energy Yield
- High Reliability
- Low Carbon Manufacture
- Aesthetics

Executive Summary

This TaiyangNews TOP SOLAR MODULES H1-2024 report analyzing solar panels that are commercially available from integrated module manufacturers. A 4th of its kind, this report summarizes the key findings from 30 editions of our monthly ranking of top solar panels published on our website published between early 2022 and June 2024.

As with the previous reports, this publication also fundamentally analyzes efficiency and power data – 2 critical features of solar modules. We assess improvements across various categories, including efficiency ranges, cell technology, and company performance. Over the last 2.5 years, both the number of participating companies and the number of products have significantly increased, from 19 in our first edition to 57 today (see Chapter 3.1).

Efficiency is the parameter to differentiate the potential of a solar module – and that's why it is the key criterion for our module ranking, even though the ultimate performance obviously depends on more characteristics. While the top efficiency increased only by 0.1% absolute from 22.7% to 22.8% throughout 2022, the following year witnessed a more significant change of 1.2% absolute, followed by another 0.2 percentage point increase in the first half of 2024. All this amounts to an impressive cumulative improvement of 1.5% absolute efficiency over the last 30 months. China's cell and module manufacturer Aiko has spearheaded these substantial efficiency leaps since it joined our ranking in early 2023 (see Chapter 3.2).

We also investigated the progress of top efficiencies within each of the 4 major commercially available cell technologies: IBC, HJT, TOPCon, and PERC (see Chapter 3.3). IBC has always excelled among these with its top efficiency improving from 22.7% to 24.2%. The second highest efficiency improvement was from HJT-based modules at over 0.8% absolute, improving from 22.2% to 23.02%, which is where it has remained since September 2023. TOPCon followed, but its best products only experienced a slight uplift from 22.53% to 22.65% by end of 2023, and to 22.8 in February 2024. Similarly, PERC has hardly seen any efficiency changes in the last 2.5 years, as today's top level of 21.7% was already reached in the second month of our coverage, in February 2022, slightly up from 21.6% in January 2022.

For easier analysis, as we dig deeper into efficiency, we have split them into 4 bands: above 22.5%, 22% to 22.5%, 21.7% to 22%, and 21.5% to 21.7% (see Chapter 4). The analysis includes how the count of products listed in each of these bands developed over the last 2.5 years. We also illustrate how each of the listed companies increased efficiencies for their top products in these 4 efficiency categories.

We further analyzed the efficiency progress with respect to each cell technology, showing how the products of the listed companies sorted according to cell technology have progressed in the last 30 months (see Chapter 5).

Power is the other key metric of analysis in this report. For ease of analysis and also to reflect the categorization of products according to applications, we have divided the products into 3 power classes – less than 500 W, 500 to 600 W, and above 600 W. Similar to efficiency, we present the top power ratings in the last 30 months and the top power of each cell technology. Overall, HJT is the power leader with Huasun and Tongwei being the companies offering the most powerful commercial modules – reaching 715 W.

The report also includes summary tables elaborating on the efficiency and power advancements achieved by each company over the time of their listing (see Chapter 7).

As a further development of our TOP SOLAR MODULES Listing, we have created an annual EFFICIENCY LEADERS list. Those module manufacturers featured in the top 10 of the TOP SOLAR MODULES list for at least 6 months of a calendar year are qualified to apply for a badge of excellence (see box on page 7).

Enjoy reading our report on TOP MODULES H1 2024

Shravan K. Chunduri
Head of Technology, TaiyangNews
shravan.chunduri@taiyangnews.info
+91 996 327 0005
Hyderabad, India

Michael Schmela
Managing Director, TaiyangNews
michael.schmela@taiyangnews.info
+49 173 15 70 999
Duesseldorf, Germany

LONGi

Hi-MO X6 Max

Break Boundaries, Embrace Greatness

Explorer | Scientist | Guardian Anti-Dust | Guardian Anti Humidity & Heat | Artist

TaiRay Inside | M11 | HPBC

www.longi.com

Contents

Advertisers:

TAIYANGNEWS
ALL ABOUT SOLAR POWER

TOP SOLAR MODULES H1 2024
ISBN 978-3-949046-24-7

Publisher:
TaiyangNews UG (haftungsbeschraenkt)
An der Golzheimer Heide 23
40468 Duesseldorf, Germany
www.taiyangnews.info

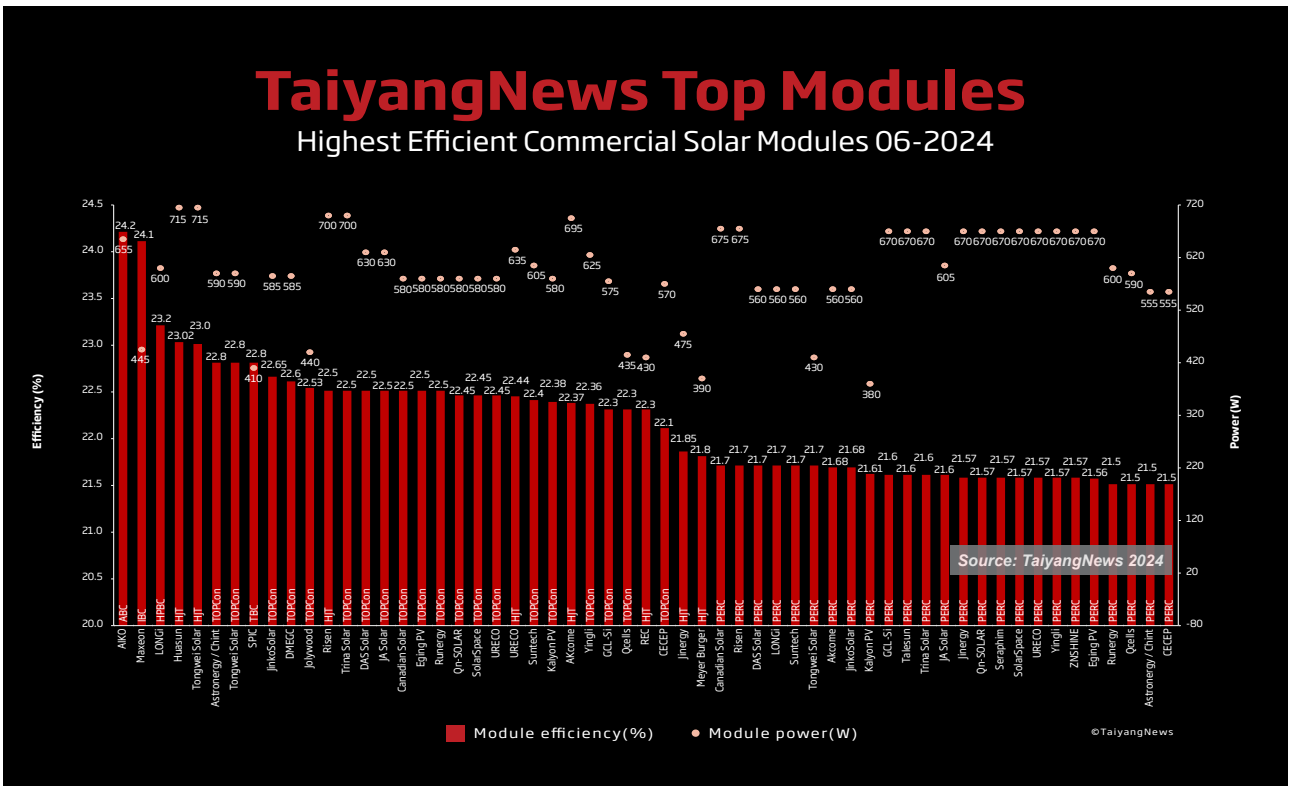
1. Introduction

With 2 of the world's largest solar trade fairs—SNEC and Intersolar—scheduled for June, prepare for a showcase of the latest module products boasting ever-higher efficiencies. Unlike in the past, efficiency is no longer the sole parameter signifying the performance of a PV module. Even when module prices are at their lowest, efficiency retains significant relevance. If you attend any webinars or talks from leading PV manufacturers, you'll frequently hear about how efficiency plays a role in reducing overall system costs, and most importantly, the LCOE. Motivated by this, module makers are announcing products with increasingly higher efficiencies.

However, there is a caveat. Not all announcements or exhibits necessarily translate into reality. While some records are achieved in laboratory settings and can be seen as indicative of future possibilities, other products are merely beta versions, representing the future roadmaps of the companies. This raises questions about the potential commercial reality.

The TaiyangNews TOP SOLAR MODULES Listing aims to bridge this gap. Since 2017, TaiyangNews has been covering the efficiency progress of solar modules through its annual reports on Advanced Module Technologies, alongside several annual online conferences. With the rapid evolution of the solar sector, TaiyangNews began publishing a regular feature article on the most efficient commercial solar panels at the beginning of 2022 to keep our readers regularly updated about the efficiency progress.

This feature article presents a list of commercially available high-efficiency module products that meet a set of predefined criteria. The motivation behind this effort was to create a simple overview of the technically most advanced module products.



30th edition: This graph, summarizing the research for June 2024, marks the 30th edition of TaiyangNews monthly TOP SOLAR MODULES ranking, which lists 57 top efficiency products of 33 PV manufacturers from different cell technology streams.

Badge of excellence

As a further development of TOP MODULES, TaiyangNews has now started an excellence badge scheme.

Those module manufacturers featured in the top 10 of the Top Solar Modules list for at least 6 months of a calendar year are qualified to apply for a badge of excellence, which has been granted to Aiko Solar, Huasun, JA Solar, JinkoSolar, LONGi Solar, Risen Energy, Tongwei Solar, Trina Solar so far.

TOP SOLAR MODULES 2023 TOP 10

Top Solar Modules 2023 Badge of Excellence

Since January 2022, we have been updating this list monthly and publishing it on our website in a dedicated section called TOP SOLAR MODULES. Each monthly feature consists of a graph, a table, and an article covering the important changes from the previous edition. This is our 30th edition; and as an extension of that project, TaiyangNews has now started an excellence badge scheme. Module manufacturers featured in the top 10 of the TOP SOLAR MODULES list for at least 6 months of a calendar year are eligible to claim this badge.

Viewing each edition of TOP SOLAR MODULES provides only the ranking of each product. However, analyzing them collectively over a longer period reveals many interesting trends and developments, which are also summarized in summary reports. So far, TaiyangNews has published reports—TOP SOLAR MODULES 2022, TOP SOLAR MODULES H1 2023, and TOP SOLAR MODULES 2023—that present the analysis of data collected during the respective periods. Continuing this effort, this latest report summarizes the trends observed over 30 editions of the TOP SOLAR MODULES.

**All TaiyangNews Reports and Market Surveys are available for free download at* www.taiyangnews.info

TOP SOLAR MODULES 2023 Monthly TOP 10 Companies

Rank	January	February	March	April	May	June
1	LONGi	LONGi	AIKO	AIKO	AIKO	AIKO
	Maxeon	Maxeon				
2			LONGi	LONGi	LONGi	LONGi
			Maxeon	Maxeon		
3	JinkoSolar	JinkoSolar			Maxeon	Maxeon
4	HUASUN	HUASUN	JinkoSolar	JinkoSolar	JinkoSolar	JinkoSolar
	Jolywood	Jolywood				
5			HUASUN	HUASUN	HUASUN	HUASUN
			Jolywood	Jolywood	Jolywood	Jolywood
6	Canadian Solar	Canadian Solar				
7	JA SOLAR	JA SOLAR		JA SOLAR	JA SOLAR	JA SOLAR
				TW SOLAR	TW SOLAR	TW SOLAR
			Canadian Solar	Canadian Solar	Canadian Solar	Canadian Solar
						risen
					Astronergy	Astronergy
						Trinasolar
						Canadian Solar
8	SPIC	SPIC	Astronergy			
	REC	REC	JA SOLAR			
9						
10	Akcome	Akcome		Astronergy		
			TW SOLAR			

Continued From Page 8

July	August	September	October	November	December
AIKO	AIKO	AIKO	AIKO	AIKO	AIKO
LONGi	LONGi	LONGi	LONGi	LONGi	LONGi
Maxeon	Maxeon	HUASUN	HUASUN	HUASUN	HUASUN
JinKO Solar	JinKO Solar				TW SOLAR
		Maxeon	Maxeon	Maxeon	Maxeon
HUASUN	HUASUN	SPIC	SPIC	SPIC	
Jolywood	Jolywood				
		JinKO Solar	JinKO Solar	JinKO Solar	SPIC
JA SOLAR	JA SOLAR				
TW SOLAR	TW SOLAR				JinKO Solar
Canadian Solar	Canadian Solarr				
risen	risen				
DAS Solar	DAS Solarr				
Astronergy	Astronergy	Astronergy	Astronergy	Astronergy	Astronergy
Trinasolar	Trinasolar				
Canadian Solar	Canadian Solar				
		Jolywood	Jolywood	Jolywood	
		risen	risen	risen	Jolywood
		Trinasolar	Trinasolar	Trinasolar	
		DAS Solar	DAS Solar	DAS Solar	
		JA SOLAR	JA SOLAR	JA SOLAR	
		Canadian Solar	Canadian Solar	Canadian Solar	
		TW SOLAR	TW SOLAR	TW SOLAR	
		Canadian Solar	Canadian Solar	Canadian Solar	
					risen
					Trinasolar
					DAS Solar
					JA SOLAR
					Canadian Solar
					Runergy
					TW SOLAR
				Source: TaiyangNews 2024	Canadian Solar

TOP SOLAR MODULES H1 2024 Monthly TOP 10 Companies

Rank	January	February	March	April	May	June
1	AIKO	AIKO	AIKO	AIKO	AIKO	AIKO
2	LONGi	LONGi	LONGi	LONGi		
					Maxeon	Maxeon
3	HUASUN	HUASUN	HUASUN	HUASUN	LONGi	LONGi
4	TW SOLAR	TW SOLAR	TW SOLAR	TW SOLAR	HUASUN	HUASUN
	Maxeon	Maxeon	Maxeon	Maxeon		
5					TW SOLAR	TW SOLAR
6	SPIC	SPIC	SPIC	SPIC	SPIC	SPIC
		TW SOLAR	TW SOLAR	TW SOLAR	TW SOLAR	TW SOLAR
			Astronergy	Astronergy	Astronergy	Astronergy
7	Astronergy					
	JinKO Solar					
8		JinKO Solar				
		Astronergy				
9			JinKO Solar	JinKO Solar	JinKO Solar	JinKO Solar
	Jolywood					
10	risen	Jolywood	Jolywood	DMEGC	DMEGC	DMEGC
	Trinasolar					
	TW SOLAR					
	DMEGC					
	Canadian Solar					
	Canadian Solar					
	Runergy					
	JA SOLAR					
	DAS Solar					

Source: TaiyangNews 2024

Trinasolar

Powering Sustainability with Smart Solar & Energy Storage

2. Methodology

Before going into details, here is some background on the methodology and selection criteria:
since module efficiencies have been improving considerably in recent years, we set the minimum efficiency for inclusion in the list at 21.5%, so as to make it rewarding for technically advanced products. We have listed only the commercially-available TOP SOLAR MODULES from each cell technology stream of one module maker. For example, if a company is offering 2 different product streams based on PERC technology that have more than 21.5% efficiency, then only the product with the higher efficiency is considered for this list. But if a module maker is offering, for example, products based on PERC and TOPCon that have efficiencies of 21.5% or above, then both products are listed. Efficiency is the only criterion for ranking in the list. However, as we see multiple products with the same efficiency, power determines the order in such cases. And when both efficiency and power are the same, we list the manufacturers in an alphabetical order.

We consider a module as commercially available when the complete data sheet for the product is listed on the manufacturer's website. The efficiency and power data listed here are taken from the data sheets available on the respective company's website. This also means that any new product announcements without final technical data published are not included in the list, as their module specs often differ considerably from the products that are finally available for purchase, and some products presented at trade fairs do not even make it to the market.

Finally, as the cell is the key also to module efficiency, we only list modules that are based on cells produced in-house, which means modules using externally-sourced cells are not featured in this TOP SOLAR MODULES list. If module specs listed on websites seem to have 'conspicuously' high efficiencies, we ask for certificates from third-party test institutes and proof of commercialization including the production, shipment and project details in which the products are used before we include a product in the list.

Aesthetic & Functional: The IBC modules, such as the ones offered by AIKO, with an all-black appearance, not only seamlessly integrate into the roof but also deliver high efficiency, combining pleasing aesthetics with performance. AIKO's latest module has the highest commercial efficiency of 24.2% today.

3. Toppers of TOP SOLAR MODULES

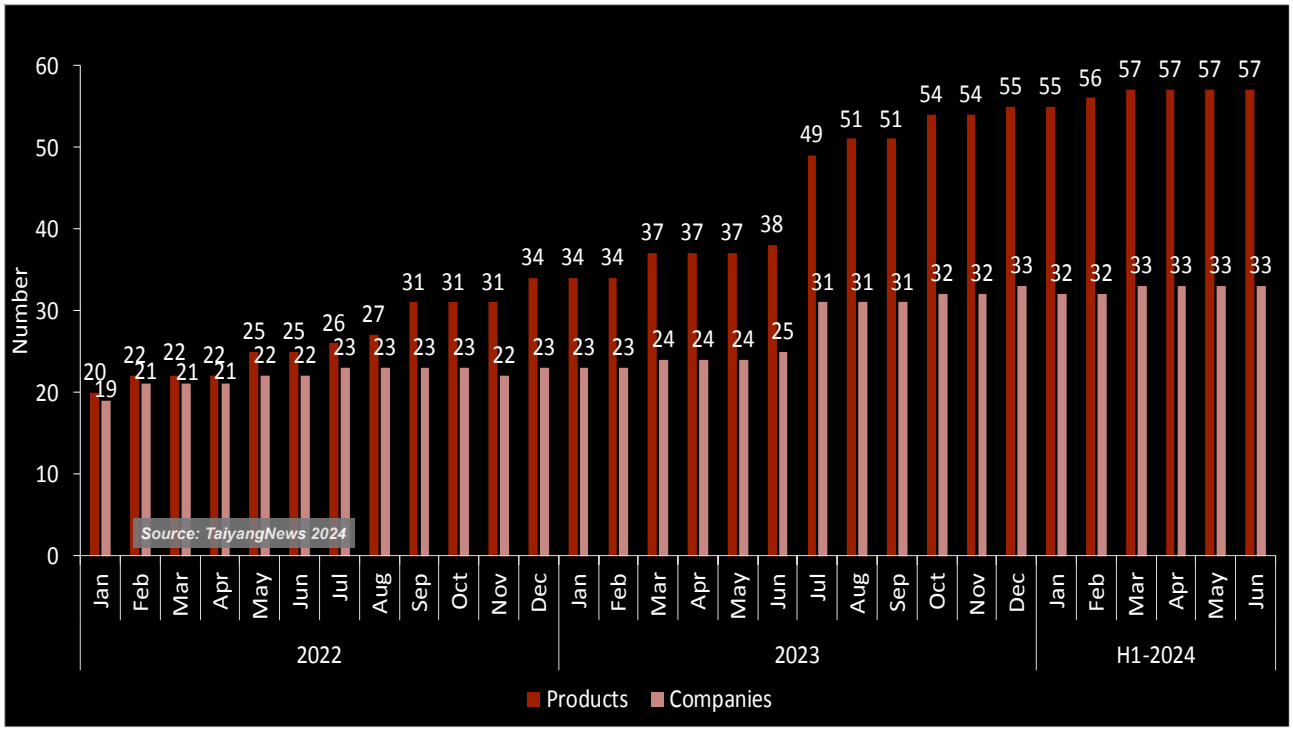
We have added an analysis of the H1 2024 TOP SOLAR MODULES listing data to the previous 2023 and 2022 results. Note that in cases where the data is too dense to be represented by a single graph, we have omitted the data for 2022. However, 2022 data for these graphs is available in our previous reports, which can be accessed for free.

As with the previous edition, the core section of this report is the analysis of data with respect to efficiency and power, which are 2 critical attributes of solar modules, as well as companies' progress in these areas. Here, we look at how power and efficiency have improved in various categories, including efficiency bands and cell technology, as well as how different companies have advanced in terms of efficiency and power in different efficiency bands and also with respect to different cell technologies.

3.1 Count of companies & products

There has been increased emphasis on efficiency in general, as is evident from the number of commercially available products listed in the TOP SOLAR MODULES section that meet the minimum efficiency criterion of 21.5%. From 20 in January 2022, this number increased consistently to 34 by December 2022. In 2023, the number of products continued to rise within the first half, to 38 in June and 55 by December. In the first half of 2024, the count has increased to 57. The number of companies offering such products also increased from 19 to 23 through 2022, then to 33 by the end of 2023, and remains steady at 33 as of H1 2024. This increase in the count of companies, however, is not quite in step with the rise in the number of products. This indicates that more and more cell/module manufacturers are focusing on multiple technologies that ultimately result in module efficiencies above 21.5%. For example, the number of companies offering 2 product platforms based on different technologies was 11 in December 2022, which increased to 20 by the end of 2023 and remained so in the first half of 2024, while there are also 2

TOP SOLAR MODULES 2022 - H1 2024 Products & Companies Count



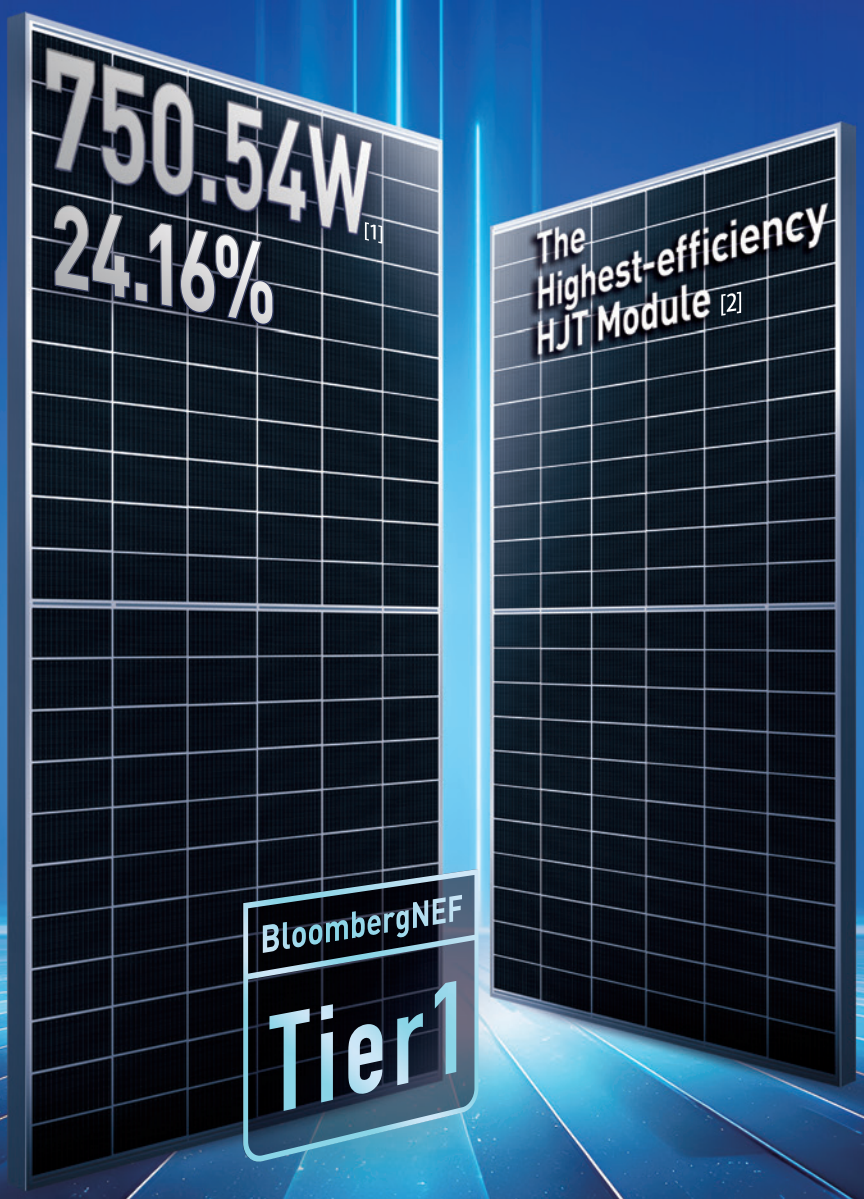
Symbol of technology diversification: The number of products in our TOP SOLAR MODULES list is rising, while the supplier count has not increased proportionately, indicating that companies are increasingly focusing on more than one cell technology.

HUASUN

No.1 in Heterojunction

Capacity
20GW+

Shipment
6GW+

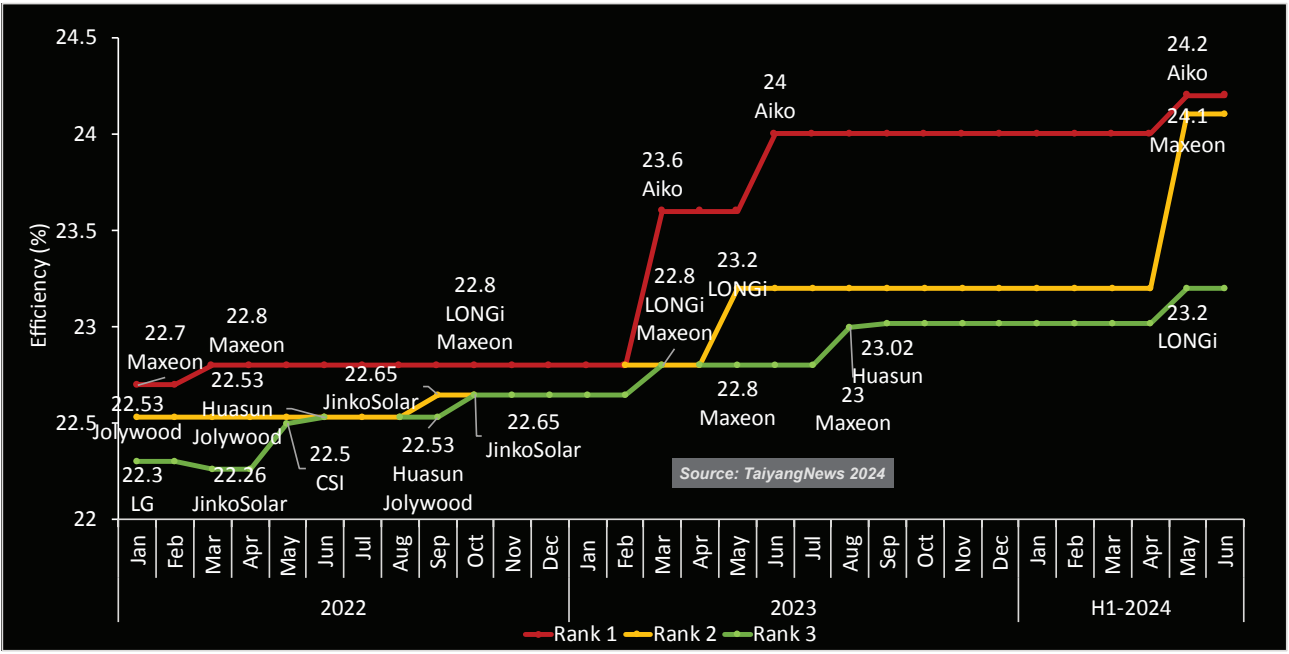


[1] Certified by TÜV SÜD

[2] Source: TaiyangNews Top Modules

www.huasunsolar.com sales@huasunsolar.com Follow us on

Top 3 Commercial Module Efficiencies 2022 - H1 2024



An IBC fortress, again: With the inclusion of the 24.2% module from AIKO and Maxeon's 24.1% product in the May listing, the top 3 ranks on the TaiyangNews TOP SOLAR MODULES list became exclusive to IBC, similar to the March to July 2023 period.

companies that currently offer products in 3 different cell technology categories.

3.2 Top 3 efficiencies in 2024 H1

In terms of efficiency, it is interesting to note that the highest module efficiency reported in our listing has only increased by 0.1% absolute – from 22.7% to 22.8% – over the course of the first full year of rankings. However, developments in H1 2023 were phenomenal. China's prime cell maker AIKO announced its arrival on the module scene by introducing its ABC module series based on the back-contact cell architecture in March, which was also the highest efficiency commercially available module for the month with an efficiency of 23.6%. AIKO not only held on to its top rank for the next 2 consecutive months, but it beat its own record in June by delivering another efficiency record in mid-May, again with an ABC series module with 24% efficiency. Maintaining the efficiency at the same level throughout 2023, AIKO retained its top position. Nearly a year after making history by achieving a landmark efficiency of 24% for commercial modules, the Chinese company broke its own record in H1 2024 by commercializing a new module with an even higher efficiency of 24.2%. In the same month, Maxeon Solar, a pioneer in back-contact technology, commercialized a module with an efficiency of 24.1%. With the addition of these 2 modules, we now have 2 commercially available modules surpassing the 24% efficiency benchmark.

We further analyzed how the top 3 ranks in the listing have changed over the last 2.5 years, as depicted in the above graph. At the beginning of 2024, the top 3 ranks were held by AIKO at the top with 24% efficiency, LONGi at 2nd with 23.2%, and Huasun at 3rd with 23.02%. While the first 2 are IBC modules, Huasun's HJT module made a mark by finding a place in the top 3. These ranks remained unchanged until AIKO's latest entry in May, with an IBC product featuring an efficiency of 24.2%. The same list also included Maxeon's 24.1% efficiency module claiming the 2nd position. This pushed LONGi's 23.2% efficiency module to 3rd but also made the top 3 ranks exclusive to IBC as was for the March-July 2023 period.

The year 2023 started with IBC modules from LONGi and Maxeon sharing the top spot with the same efficiency figure of 22.8%, and JinkoSolar's TOPCon module with an efficiency of 22.65% at 3rd. These ranks remained the same till February. With Aiko'S ABC module entering the list in March, the top 3

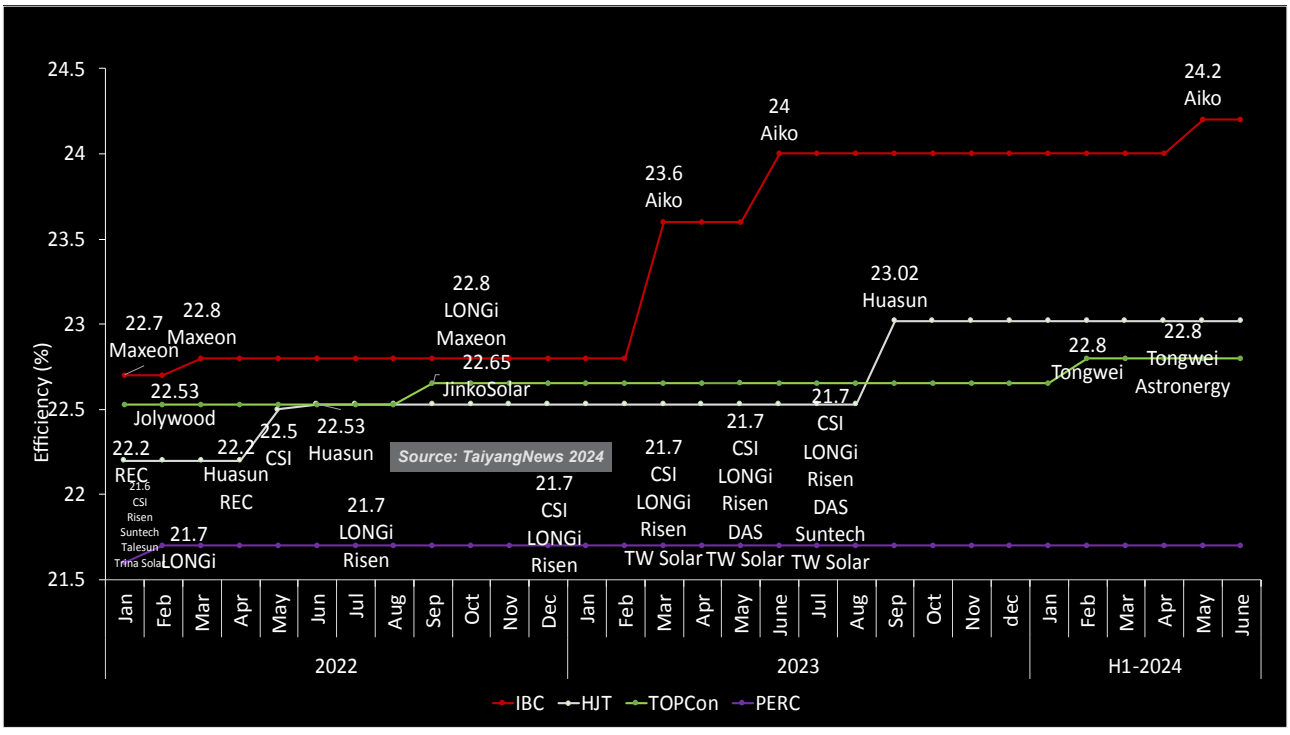
ranks became exclusive to IBC modules. While Aiko maintained its lead, March and April saw LONGi and Maxeon share the 2nd position. However, the rankings changed in May as LONGi upgraded the efficiency of its Hi-MO 6 module series to 23.2%, making the 2nd position its own. June marked another significant development as AIKO further elevated its product efficiency to 24%, widening the gap with its peers. The next change in the top 3 ranks took place in September, when Huasun breached the IBC fortress with its HJT module with an efficiency of 23.02%, ranking 3rd on the list. The top 3 ranks remained so till the end of the year 2023.

When we started the TOP SOLAR MODULES listing in 2022, Maxeon, Jolywood, and LG held the top spots for the first 2 months with respective efficiencies of 22.7%, 22.53%, and 22.3%. While products from Maxeon and LG were based on IBC, Jolywood's module was based on TOPCon. There were a couple of developments in the March 2022 listing: Maxeon increased the efficiency of its module by 0.1% absolute to 22.8%, and LG exited the solar module supply business. As a result, JinkoSolar's TOPCon module with 22.6% efficiency climbed up to the 3rd position. While there was no change in April, Canadian Solar commercialized its HJT module with 22.5% efficiency, replacing JinkoSolar's product. However, the following month, Huasun launched its HJT module with 22.53% efficiency, the same as Jolywood's product, resulting in both products sharing the 2nd rank that remained unchanged until August. In September 2022, JinkoSolar launched its next-generation TOPCon product with a rated efficiency of 22.65%, which qualified for the 2nd position, pushing products from Jolywood and Huasun down by a rank. The next month, LONGi introduced its Hi-MO 6 module series based on its proprietary HPBC back contact technology, which directly claimed the top spot, sharing it with Maxeon and pushing JinkoSolar's product to 3rd. This ranking was maintained until the end of 2022.

3.3 Top efficiency of each cell technology

It is evident that module efficiency is mainly driven by the cell technology, and companies often rely on advanced cell architectures such as IBC, TOPCon, and HJT. The graph on Page ## summarizes the top efficiency product in all commercial cell structures.

Top Efficiencies For Different Cell Technologies - 2022 to H1 2024



IBC leads the way: Over the past 30 months, the top module efficiencies based on different cell technologies have progressed, with IBC gaining the most at a 1.5% absolute increase, followed by HJT, TOPCon, and PERC.

Historically, IBC has always been considered the efficiency leader among the commercially offered modules; which is also reflected in our list from the beginning. Over the last 2.5 years, the commercial module efficiency has increased by 1.5% absolute. At the beginning of 2024, AIKO represented the highest efficiency of 24%, which it retained until it broke its own record in the month of May. Its latest Comet series product features an efficiency of 24.2%, putting it directly at the top. As for 2023, the top IBC efficiency position was held by both LONGi and Maxeon with both their modules featuring 22.8% efficiency. In March, Aiko'S module with 23.6% efficiency took the lead and it strengthened its position further with a 24% product in June 2023, staying on top through December 2023. Looking back to 2022, Maxeon represented the highest efficiency module product with an efficiency of 22.7% in the IBC category until March 2022. It again increased the efficiency of its module to 22.8%, continuing its leadership position until September. In October 2022, LONGi introduced its Hi-MO 6 product with an efficiency of 22.8%, sharing the top spot with Maxeon till February 2023.

The top commercial module efficiency among TOPCon products has increased by only 0.27% absolute. The top efficiency increased once in the first half of 2024 from 22.65% at the beginning of the year represented by JinkoSolar, which was first superseded by Tongwei with a 22.8% product in February. The very next month in March, Astronergy also commercialized a product with the same efficiency. The duo held the top efficiency position for TOPCon until the end of the monitoring period for this report - H1 2024. During 2023, JinkoSolar was the TOPCon efficiency leader for the entire year with a 22.65% efficiency product, a place it claimed from Jolywood in September 2022. In fact, Jolywood was the top seed with an efficiency of 22.53% in the TOPCon segment from the beginning of 2022, maintaining it until August 2023, when JinkoSolar surpassed it with the 22.65% product, which has not changed since.

In the case of **HJT**, the top efficiency has been represented by Huasun, the pioneer of this technology, for about 2 years out of the 2.5-year evaluation period. The top HJT efficiency has remained unchanged during the first half of 2024 since September 2023, which was when Huasun hit an efficiency of 23.02%, the highest for any HJT module. Reaching this number also earned it a spot among the top 3 ranks of all modules. The top HJT module until August 2023 was Huasun's 22.53% efficiency module, which entered our listing in June 2022. Looking further back, it was initially REC that had an HJT module with the highest efficiency of 22.2% at the start of our TOP MODULES ranking in 2022. In April 2022, Huasun also started offering HJT modules with the same efficiency. Canadian Solar began promoting its HJT module with an efficiency of 22.5% in May 2022, which was replaced the next month by the abovementioned 22.53% module from Huasun. The top efficiency for HJT has increased by 0.82% absolute in the last 2.5 years, making it 2nd among the technology streams, after **IBC**.

For **PERC**, the top efficiency has remained at 21.7% for most of this report's monitoring period except for the month of January 2022, when the top PERC efficiency of 21.6% was shared by 5 companies – Canadian Solar (CSI), Risen, Suntech, Talesun and Trina Solar. The following month, LONGi increased it to 21.7% and held the top spot until June 2022. In July, however, Risen also introduced a product with similar efficiency, thereby sharing PERC's top position until November 2022. In December, while the top efficiency remained at 21.7%, CSI joined the club. The status quo was maintained for the next 2 months, after which Tongwei, a leading cell and silicon supplier, also started offering a PERC module with 21.7%. In April 2023, DAS Solar joined the list, which remained unchanged for the next 2 months. In July, Suntech moved in, and the 6 companies (CSI, LONGi, Risen, Tongwei, DAS Solar, and Suntech) continued with the same efficiency to the end of 2023 and also through the first half of 2024.

TW SOLAR

FORTUNE GLOBAL 500 | TIER1 Bloomberg | Kiwa PVEL TOP PERFORMER

Tongwei Gene Repower

Tongwei Gene

Tongwei Solar

en.tongwei.com.cn

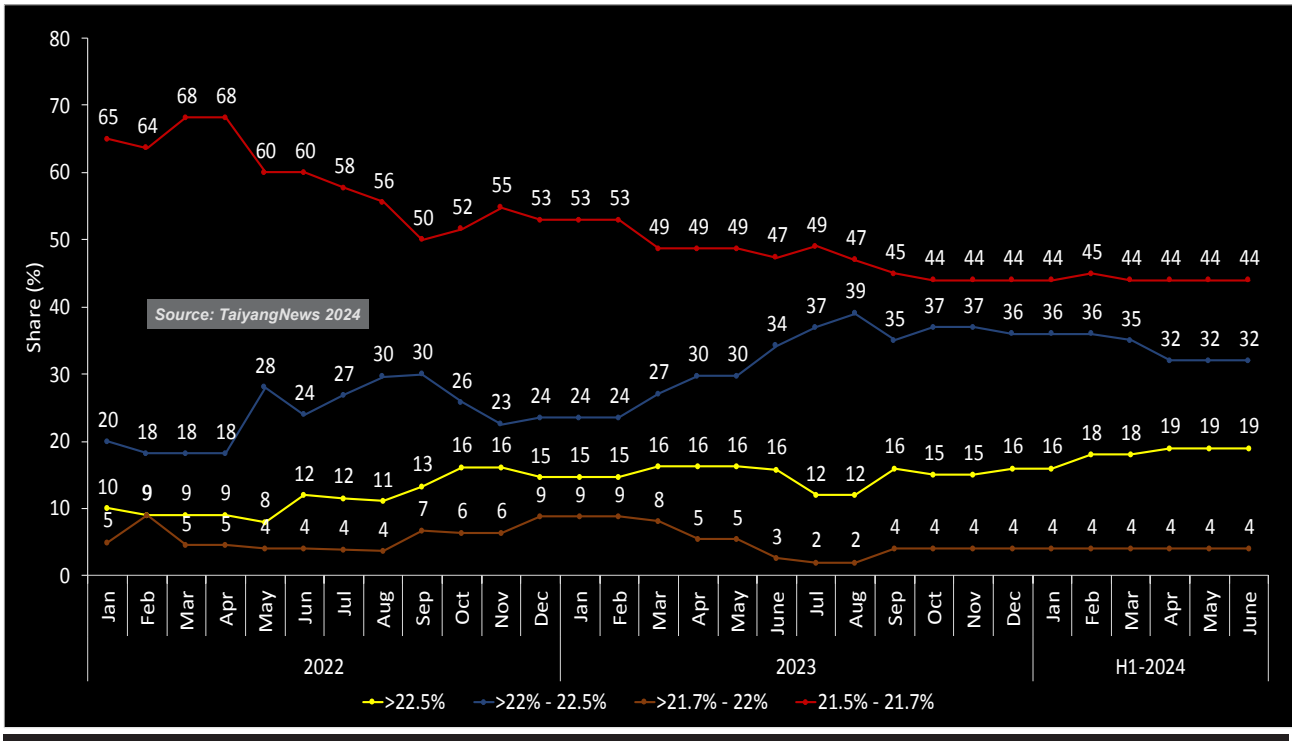
4. Module Efficiency Developments

For easier analysis, as we dig deeper into efficiency, we have split them into 4 bands: >22.5%, >22% to 22.5%, >21.7% to 22%, and 21.5% to 21.7%. In terms of the number of products in each band, for the highest efficiency band of greater than 22.5%, the number of products increased from 2 to 11 during the last 30 months with its share nearly doubling from 10% to 19% in terms of the total product count. During H1 2024, the product count increased just by 1, from 10 to 11, corresponding to a share of 16% in January to 19% in June 2024. In 2023, the product count rose from 5 to 9 with the relative share up by 1 percentage point to 16%. In 2022, the count increased from 2 to 5, and the share from 10% of the total product count in January 2022 to 15% by the end of the year.

The number of products in the next band – >22% to 22.5% – nearly quadrupled from 2022 to 19 by the end of H1 2024. However, the relative gain in total products has increased from 20% to 32% during this period. The count and share are actually down during the first 6 months of 2024, from 20 and 36% in January to 19 and 32% in June, respectively. However, this efficiency band increased its share from 24% to 36% in 2023 and 20% to 24% in 2022.

The third band – >21.7% to 22% –, had the lowest representation, with only 1 product in January 2022 and 2 products in June 2024. During the first 6 months of this year, the number of products with efficiencies between 21.7% and 22% remained the same at 2. In 2023, the product count was 3 for the first quarter and 2 for another 2 months after that, then back to being represented by a single product. Starting from September 2023, 2 products with efficiencies falling within this efficiency band have been included in the list. Accordingly, the share of this efficiency also started low at 5% but increased to 9% after 12 months. In 2023, this share fluctuated between 9% and 4%. In 2022, the product count increased from 1 in January to 3 in December, corresponding to a relative share of 5% to 9%, the latter being the all-time high that lasted for 2 months.

Product Shares Of Different Efficiency Bands 2022 - H1 2024



High efficiency in focus: The increasing share of products in higher efficiency bands, coupled with the declining share of low-efficiency products, indicates that manufacturers are increasingly focusing on high-efficiency products.

The 21.5% to 21.7% range is mostly represented by PERC, while only 1 HJT module falls under this bracket, and the band also represents the bulk of the listing. The product count increased from 13 to 25 during the evaluation period, but its share in the total products decreased from 65% in January 2022 to 44% in June 2024. However, during H1 2024, the product count increased from 24 in January to 25 in June, while the relative share remained at 44%. This was before the share fell from 53% in January 2023 to 43% as of the end of 2023. In the year prior, while the product count jumped from 13 to 25, its share of total products decreased from 65% in January to 53% in December 2022. This indicates that more and more companies are commercializing products based on advanced cell architectures. Although this summary chart may appear complex, analyzing each efficiency band separately provides a clearer picture.

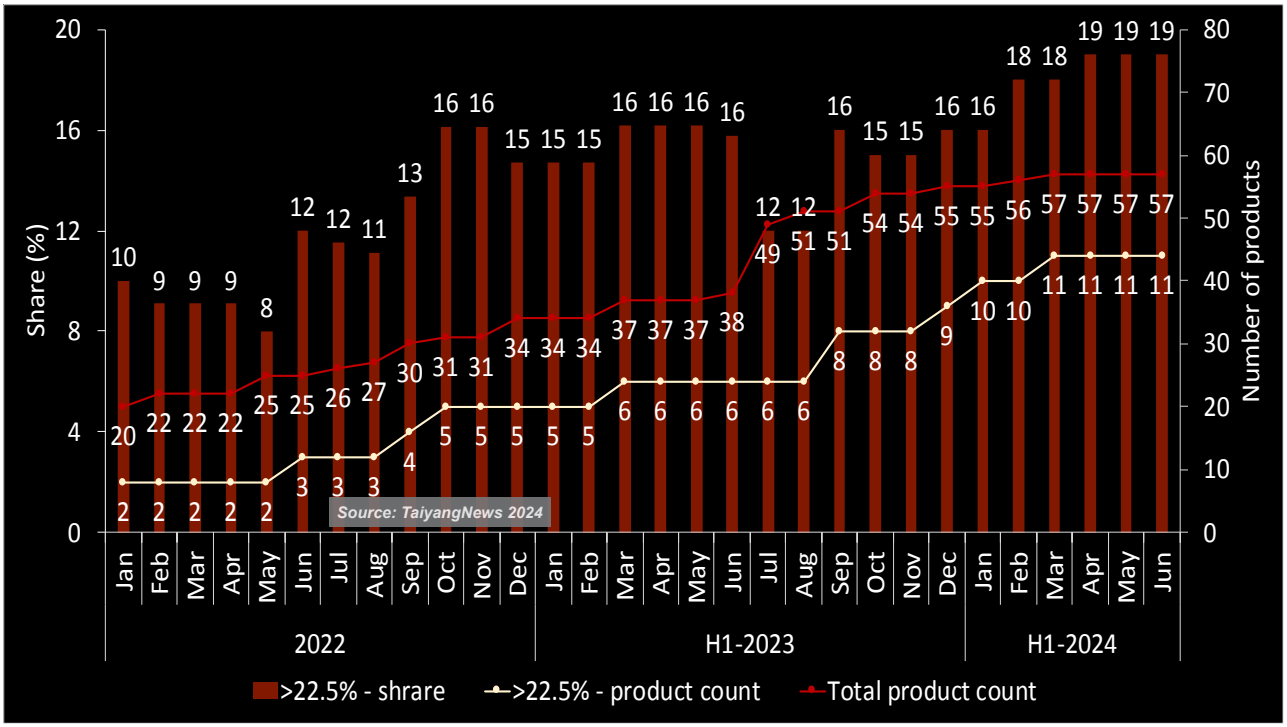
4.1 Efficiencies >22.5%

Continuing with the same chronology of high-efficiency products first in the highest efficiency band above 22.5%, in 2024, the first change occurred in February when Tongwei increased the efficiency of its TOPCon product from 22.5% to 22.8%. This marked Tongwei's first appearance in this efficiency band, sharing the space with SPIC's IBC module, which had been listed at this level since September 2023. The very next month in March, Astronergy also joined the 22.8% efficiency club, increasing the number of companies listed at this efficiency level to 3. In April, DMEGC entered this efficiency band with a TOPCon module achieving 22.6% efficiency.

However, May 2024 saw the most significant advancements. Not only did AIKO introduce a product with an even higher efficiency of 24.2%, but another IBC expert, Maxeon, also commercialized a 24.1% module. This marked the first time that 2 commercially available modules surpassed 24% efficiency. With this, the number of products in this efficiency band increased to 11.

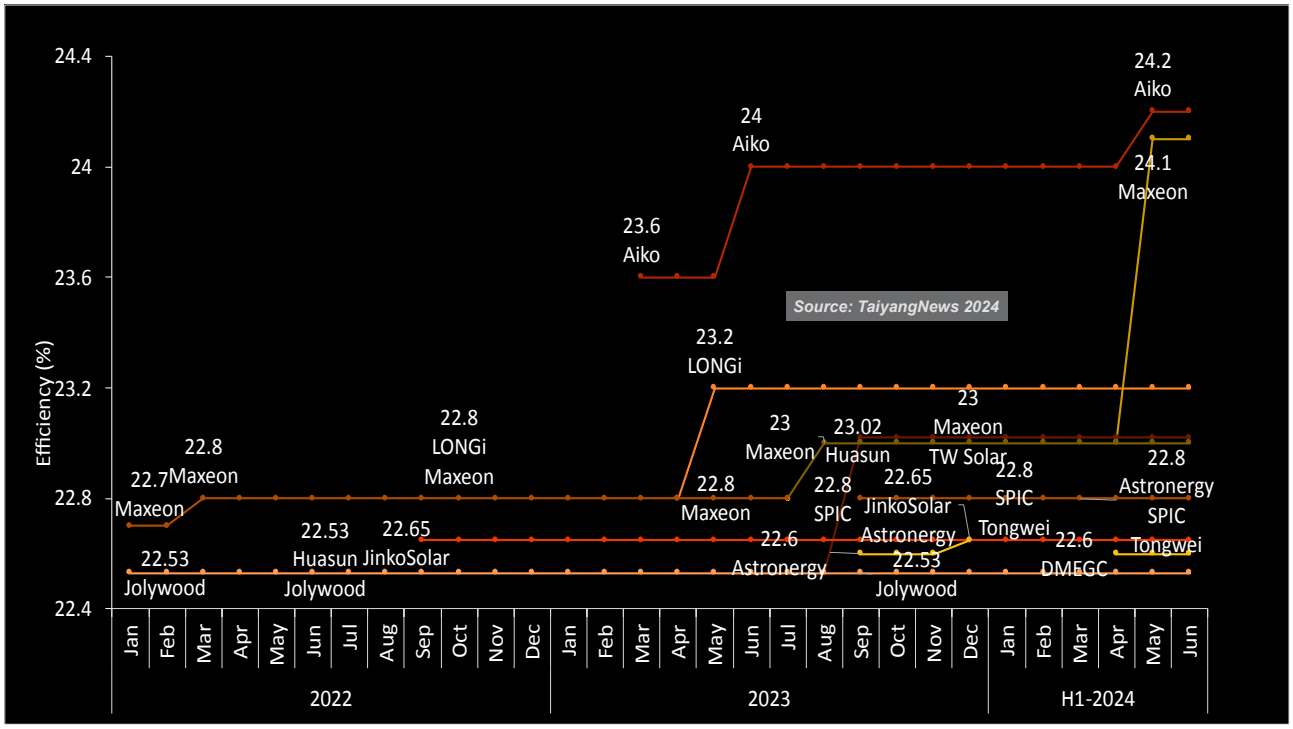
AIKO made a remarkable entry in March 2023, directly taking the top spot with its 23.6% efficient ABC module series, and subsequently raising the bar again with a 24% product in June. After Maxeon updated its product offerings with the inclusion of

Module Count & Shares >22.5% Efficiency Band



The growth band: In the highest efficiency band of greater than 22.5%, the number of products increased from 2 to 11 over the last 30 months, with its relative share nearly doubling from 10% to 19%.

Products With Efficiencies >22.5%



In the last 6 months, not only did 2 companies announce the highest commercial module efficiencies, but 2 other companies also moved into the >22.5% efficiency band from a lower level.

a 23% IBC module, as many as 3 new products were added to this efficiency band in September 2023: Huasun's top HJT module efficiency was 23.02%, the TOPCon-based IBC module from SPIC came with an efficiency of 22.8%, and Astronergy's TOPCon product showed a top efficiency of 22.6%.

The next change took place in the last month of 2023, when not only Astronergy improved its TOPCon product range with an efficiency reaching 22.65%, the same as JinkoSolar's TOPCon products, Tongwei's HJT module also created ripples with 23% efficiency. Thus, by the end of 2023, a total of 9 products/companies reached the above-22.5% efficiency band.

Only 2 companies, Maxeon and Jolywood, offered such products until June 2022. SunPower spin-off Maxeon had an efficiency of 22.7% at the launch of our listing, which was later improved to 22.8% in April 2022, while Jolywood offered a module at 22.53%. In July 2022, Huasun joined the club with its 22.53% HJT module. In October, JinkoSolar entered the league with its TOPCon product, achieving 22.65% and taking the 2nd place. Then in November 2022, LONGi surprised the industry with its HPBC technology, realizing 22.8% efficiency, which was on par with Maxeon's module that had been No.1 for several years before we started this feature.

4.2 Efficiencies >22 to 22.5%

The efficiency range of >22% to 22.5% seems like the gateway efficiency band, especially for TOPCon and HJT technology, more so for the latter. It is also the band that saw the highest growth in 2023, when more and more companies started commercial activities with TOPCon. While product representation in this efficiency range increased from 20% to 24% in 2022, it reached 36% by the end of 2023. When it comes to actual numbers, from 4 products in 2022, the number of products doubled to 8 in December 2022, then shot up to 20 by the end of 2023. However, this also explains the eventual fall in the number of products as well as their relative share, as witnessed in H1 2024, falling from 20 and 36% in January to 19 and 32% in June. While it is the entry level, some technically advanced companies are going beyond 25% with their TOPCon products.

Regarding changes in this efficiency band during the first half of 2024, in January 2024, DMEGC's latest TOPCon product reached the top efficiency of this

risen

www.risenenergy.com

HJT

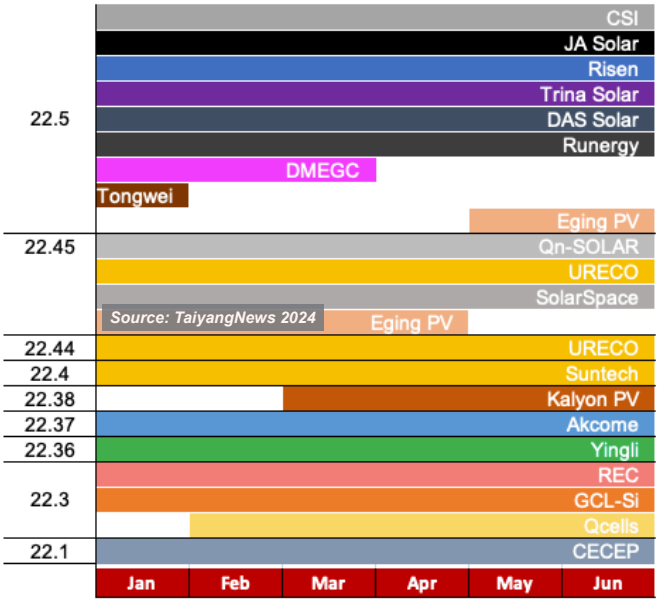
CHOOSE RISEN ENERGY

Higher Return, Lower Carbon Emission

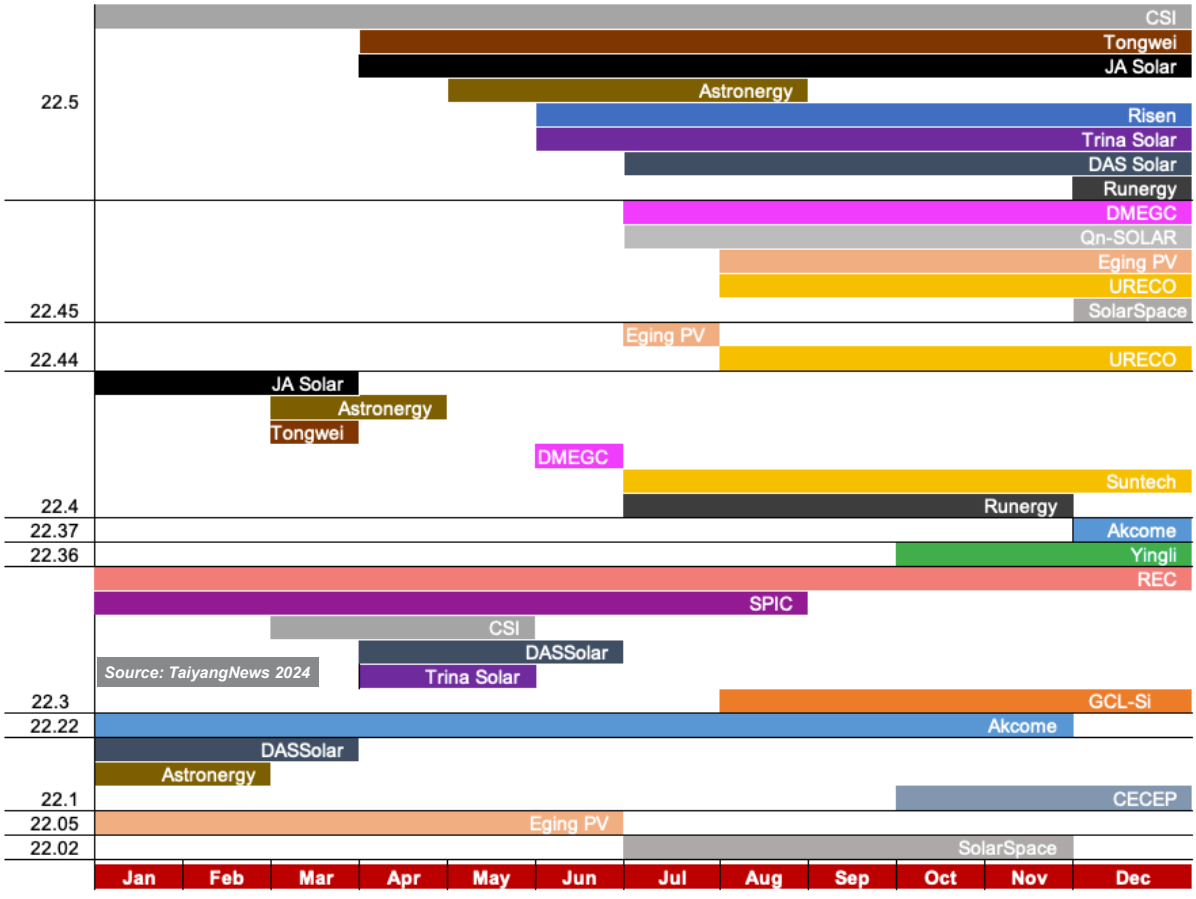
CFP < **376.5kg eq CO_2/kWc**

CONTACT US

Module Products With Efficiencies >22% To 22.5% - H1 2024

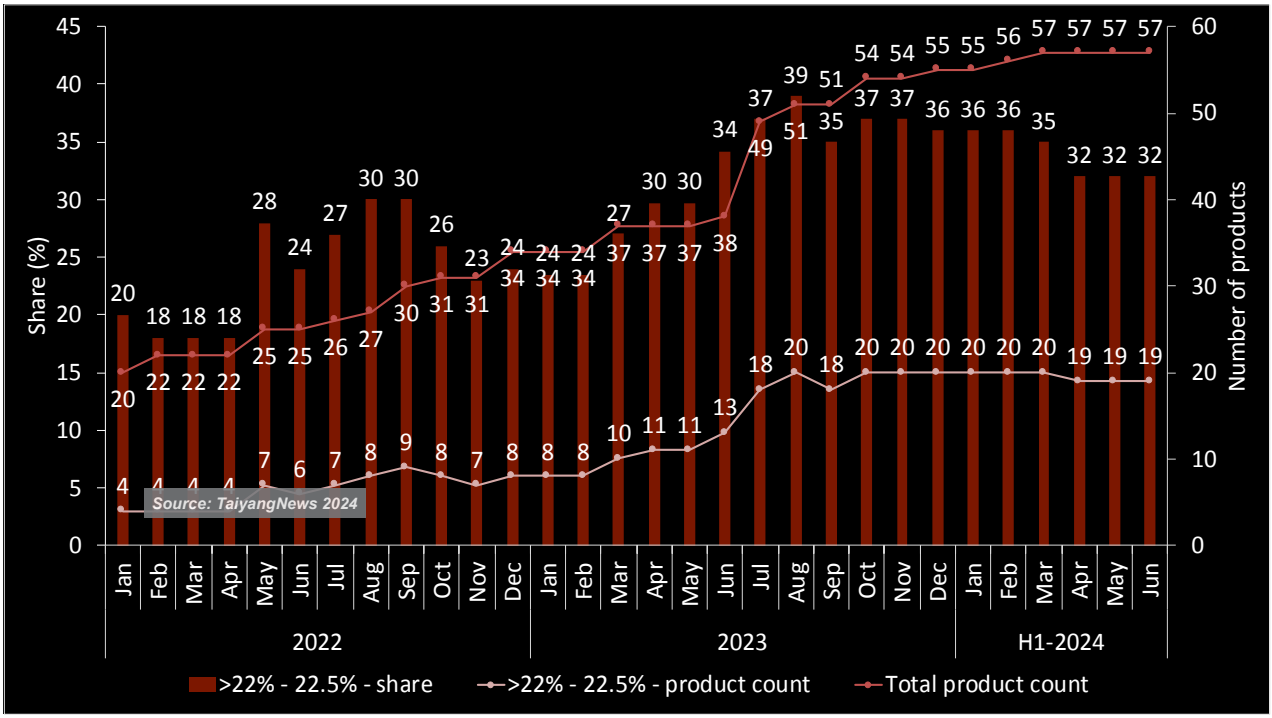


Module Products With Efficiencies >22% to 22.5% - 2023



Crowded excellence: With more and more companies pushing efficiency levels, the top 2 efficiency points in the >22% to 22.5% efficiency range—22.5% and 22.45%—were represented by 8 and 4 companies, respectively, at the beginning of 2024.

Module Count & Shares >22 to 22.5% Efficiency Band



Entry but not the ultimate: The efficiency band of >22 to 22.5%, serving as the entry level for TOPCon and HJT, saw the highest growth during 2023, a period marked by significant commercial activity in these technologies. However, efforts by companies to exceed 22.5% efficiency are also reflected in declining product numbers in this efficiency band in recent months.

band at 22.5%. In February, Tongwei increased the efficiency of its TOPCon module, moving beyond this efficiency level. In the same month, Qcells joined our listing with an efficiency of 22.3%, which remained at this level until June. In March, Turkey's Kalyon was included in our list for the first time with a TOPCon module of 22.38% efficiency. In April, DMEGC once again improved the efficiency of its TOPCon product beyond 22.5%, leaving this group. In May, EGing PV improved its TOPCon product efficiency from 22.45% to 22.5%, maintaining its position in this group.

While there was no change in January and February 2023, there were a few in the following months. In March, Tongwei started offering its TOPCon modules in the commercial space with an efficiency of 22.4%, the same as that of JA Solar's product. Astronergy also increased the efficiency of its product from 22.1% to 22.4%. Canadian Solar joined the TOPCon group as well, with a 22.3%efficiency module, the same as the HJT and IBC modules from REC and SPIC, respectively. April again saw some changes: JA Solar and Tongwei increased the efficiency of their TOPCon products from 22.4% to 22.5%; DAS Solar also increased the efficiency of its TOPCon module from 22.1% to 22.3%. Trina Solar started offering a 22.3% TOPCon module; however, its predecessor had an efficiency of 21.9%, thus absent from this efficiency band, giving the impression that the product is new. As to the changes in June 2023, Risen commercialized a TOPCon module with 22.5% and Trina once again increased the efficiency of its TOPCon product to 22.5%, increasing the count of companies offering products with this efficiency to 6.

22.5% seems to be the sweet spot, as by December this efficiency level was shared by as many as 8 products. In June 2023, DMEGC entered our listing for the first time with a 22.45% efficiency module. A major change happened in July 2023 with 6 new companies entering the TOP SOLAR MODULES list, of which products from 4 companies fall in this efficiency band. These are from Qn-SOLAR with 22.45%, Runergy and Suntech with 22.4%, and SolarSpace with 22.02% modules. In the same month, DAS Solar improved its TOPCon module efficiency from 22.3% to 22.5%. EGing PV, which was at 22.05% since August 2022, commercialized

a 22.44% product that was also reflected in the July 2023 edition.

The following month, 2 more companies – URECO and GCL-Si – joined in with 2 products from the former and 1 from the latter. Both featuring for the first time, URECO's products have the higher efficiencies among these. Its TOPCon product is rated with 22.45%, while the HJT module falls short by just 0.01% with a labeled efficiency of 22.44%. GCL-Si's TOPCon module entered our list with 22.3% efficiency and remained at that level until the end of 2023. SPIC, however, made a big leap into the highest efficiency class with an IBC product of 25.8% efficiency.

In October, Yingli and CECEP joined the group with their TOPCon products featuring respective efficiencies of 22.36% and 22.1%. While there were no changes in the month of November, December 2023 saw a couple of improvements: Runergy – from 22.4% up to 22.5%; SolarSpace – from 22.02% up to 22.45%; and Akcome – from 22.22% up to 22.37%.

LG's IBC module topped the list at the beginning of 2022 with an efficiency of 22.3%, followed by JinkoSolar's TOPCon product with 22.26% efficiency. HJT products from Huasun and REC were also part of this efficiency group with 22.2% and 22.1% efficiency, respectively. The list remained the same until February 2022, whereas in March, LG was delisted due to its exit from the PV market. The product count, though, remained the same with SPIC improving its TOPCon module efficiency from 22% to 22.1% to foray into this band for the first time. The only change in April was Huasun increasing its HJT module efficiency by 0.1% absolute to 22.2%.

Several changes took place in May 2022: Canadian Solar introduced a 22.5% efficiency HJT module, Qcells and Astronergy commercialized TOPCon modules with 22.3% and 22.1% efficiency, respectively, and REC upgraded its HJT module series to reach 22.3%. The only change in June was that Huasun further improved its HJT module efficiency to 22.53%, beyond the scope of this band and thus exiting the range altogether.

In July, Akcome commercialized an HJT module with 22.5% efficiency, the same as another HJT product from Canadian Solar. The upgrade to SPIC's IBC product was reflected in our June research – the company improved its IBC module efficiency to 22.3%, which is the same as the products from REC and Qcells. EGing's TOPCon module was added to the list in August, with an efficiency of 22.05%.

In September, JinkoSolar increased the efficiency of its TOPCon module beyond 22.5%, earning it an exit in the form of a promotion to the big leagues, while 2 new products were added to the list. JA Solar introduced its TOPCon module with 22.4% efficiency, and DAS Solar's product, also based on TOPCon, had a slightly lower efficiency of 22.1%. In October, the products from Akcome and Qcells were not listed on their respective websites and thus were delisted, while the rest remained the same. No changes were noticed in November, but Akcome started promoting an HJT module with a lower efficiency of 22.22% in December 2022.

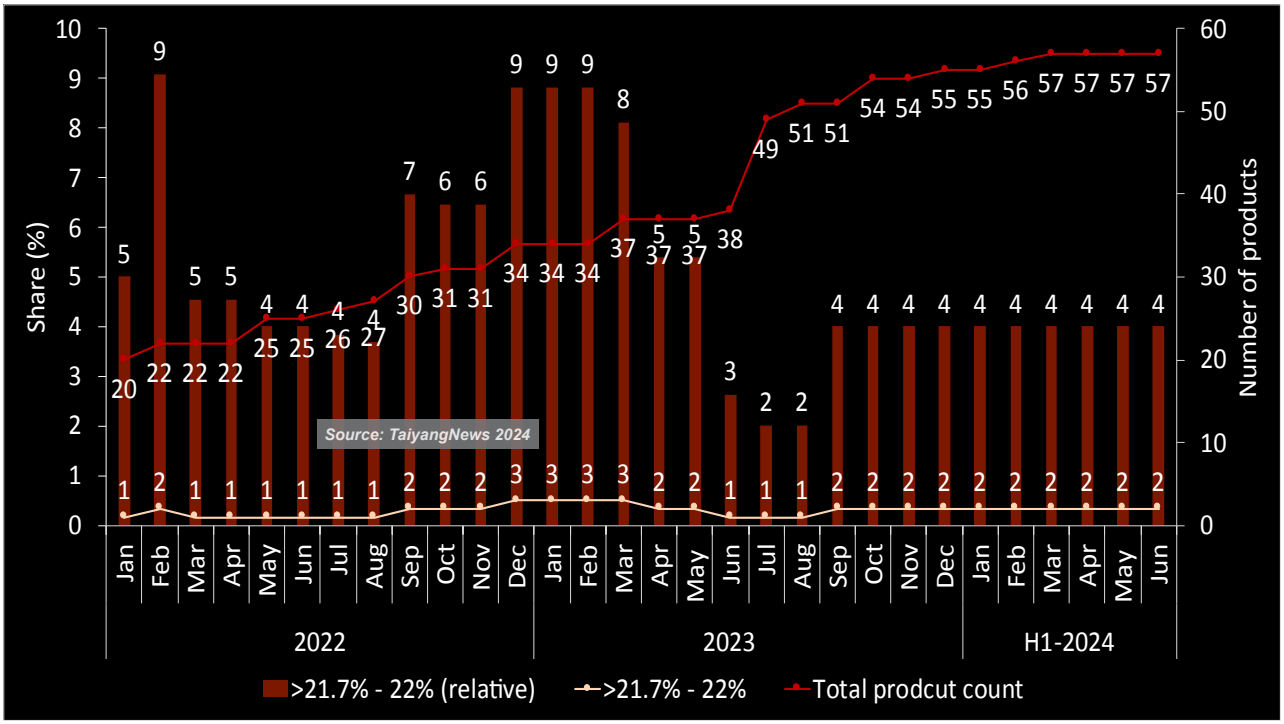
4.3 Efficiencies >21.7 to 22%

This efficiency band has the least representation. In January 2022, the only product present in this efficiency range was the HJT module from Meyer Burger. Then, in February, SPIC's IBC module was also added to our listing, with 22% efficiency. However, the very next month, the company improved its efficiency to 22.1%, thus jumping to the next class and leaving Meyer Burger all alone in this efficiency range.

It continued until September 2022, when Trina Solar launched a TOPCon module with 21.9% efficiency, which remained the same until December 2022. In the same month, Qcells' TOPCon module reappeared with a lower efficiency of 22%, increasing the product count in the month to 3. However, the TOPCon products from Trina and Qcells improved their efficiency in the months of March and April 2023, respectively, again leaving Meyer Burger as the lone contender in this efficiency class. This continued until August.

In September, Jinergy, as a result of improving the highest module efficiency of its HJT products from 21.68% to 21.85%, entered the list, increasing the count to 2. The number of products in this band remained at 2 through the end of 2023 and also during the first half of 2024.

Module Count & Shares >21.7% to 22% Efficiency Band



Scarce territory: The efficiency range of >21.7% to 22% has the fewest module products in our ranking, peaking at only 3 products in early 2023, and now 'stable' at 2.

4.4 Efficiencies 21.5% to 21.7%

The efficiency range of 21.5% to 21.7%, the narrowest and lowest band in our rankings, has the highest number of products and is mostly represented by PERC technology. The only exception being an HJT module from Jinergy that consistently featured in this range throughout the year 2022 until August 2023 with an efficiency of 21.68%. As mentioned above, Jinergy improved its HJT module efficiency in September, qualifying it for the band above.

During 2022, the product count increased from 13 to 18, and then to 24 by the end of 2023. However, in January 2022, products within this efficiency band had a 65% market share, which peaked at 68% in March and April 2022 before gradually decreasing to 53%. By the end of 2023, it had dropped further to 44%. This reiterates the trend that an increasing number of companies are bringing products to the market based on advanced cell architectures. On the other hand, companies have also improved their PERC product efficiencies.

The only change in this band has during the first 6 months of 2024 was that Kalyon's PERC product was included in the TOP SOLAR MODULES list at 21.61% efficiency in March. None of the 25 products listed in this group have seen any considerable efficiency change.

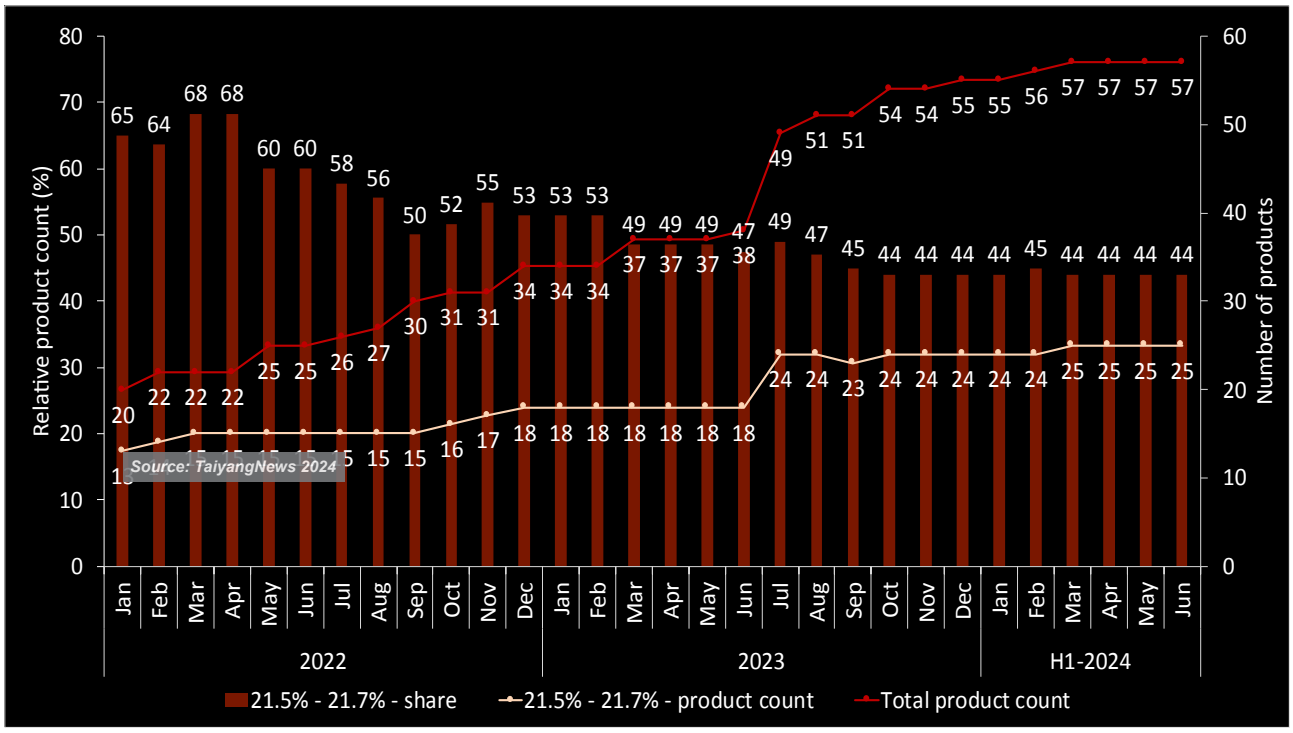
In 2023, the product count remained steady at 18 for the first 6 months, increasing to 24 in July. However, efficiencies improved within this range, as shown in the table on p.25. Initially, Canadian Solar, Risen, and LONGi had products with 21.7% efficiency in January. By June, Tongwei and DAS Solar joined in, with Suntech following in July. This lineup persisted until December. At 21.68% efficiency, Akcome, JinkoSolar, and Jinergy maintained consistency until August. Jinergy moved to a higher band in September.

The number of products at 21.6% efficiency initially increased from 4 to 5 in March, remaining so for the next 3 months. JA Solar, Talesun, Suntech and Trina Solar were among them in January, with Astronergy

joining in March. Suntech left in July, and GCL-Si joined in August. In September, Astronergy moved back to 21.5% efficiency, while GCL, JA, Talesun, and Trina continued until December. The trio of Jinergy, Seraphim, and Yingli remained unchanged throughout H1 and persisted until the end of 2023. However, the list of companies offering 21.57% efficiency increased to 7 by the end of 2023, with Qn-SOLAR, SolarSpace, and URECO joining in July, and ZNSHINE joining in October. EGing PV remained the sole supplier of a 21.56% product for the entire period. Interestingly, the number of products at 21.5% efficiency decreased to 1 from 4 in the first 6 months of 2023. Initially offered by DAS Solar, Astronergy, Qcells, and Tongwei, the list shrunk to DAS Solar and Qcells by March and only Qcells in April. Starting from July, several new products from CECEP, GCL, and Runergy joined the list, with GCL moving to 21.6% in August, and Astronergy joining with reduced efficiency in September.

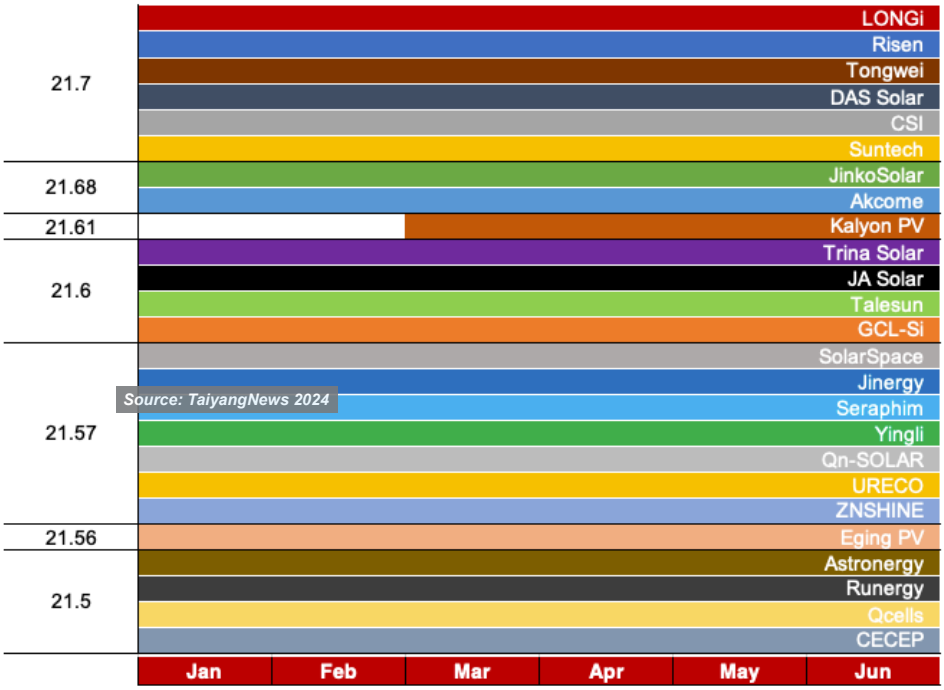
In January 2022, a total of 13 products were listed within this efficiency range, with Jinergy's module being the most efficient at 21.68%. 5 other modules from Risen, CSI, Suntech, Talesun and Trina Solar were listed at 21.6%, with only one module from EGing at 21.57%. The remaining 6 modules from LONGi Solar, JA Solar, Jinergy, Astronergy, Qcells, and Tongwei were at the lower limit of 21.5%.
By the end of 2022, the total number of products listed within this efficiency range had increased to 18. While none of the products reached 21.7% in January 2022, 3 did so by December 2022. Modules with 21.68% efficiency were offered by 3 companies in December, while the number was only 1 in January. Products listed at 21.6% increased from 5 in January to 6 in February, and remained so until November, before decreasing to 4 in December. The missing ones were replaced by products with higher efficiencies. There was only 1 product with 21.57% efficiency, which gradually increased to 4 by year-end. In contrast, the count of products with 21.5% efficiency reduced from 6 to 4.

Module Count & Shares >21.5% to 21.7% Efficiency Band

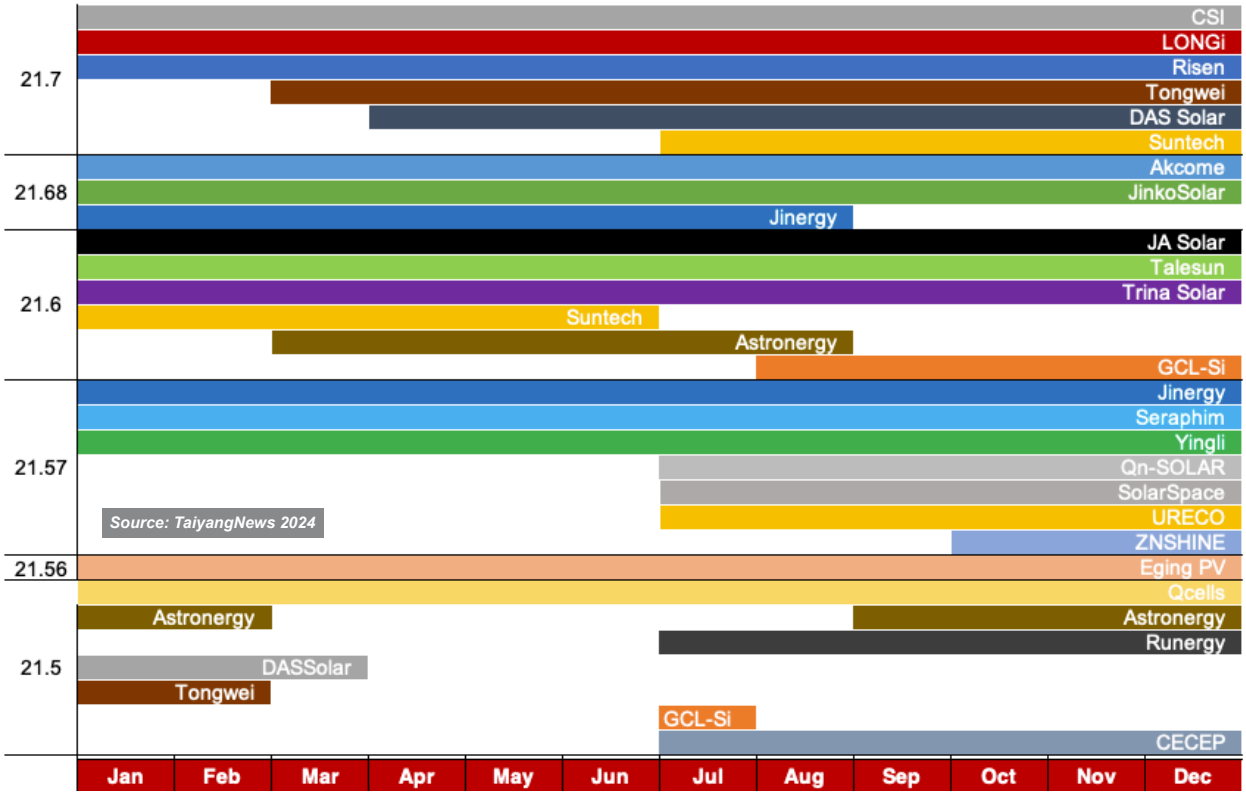


Old guards: The efficiency band of 21.5 to 21.7% is almost solely represented by PERC and has the highest number of products in absolute terms, but its relative share is shrinking with hardly any new companies entering this stream.

Module Products With Efficiencies >21.5% to 21.7% - H1 2024



Module Products With Efficiencies >21.5% to 21.7% - 2023



Getting obsolete: With more focus on new n-type technologies, this efficiency band mostly represented by PERC is failing to attract attention, which is also reflected in the H1 2024 listing.

ASTRONERGY

For A Greener World

Pioneer in n-type TOPCon PV Modules

Tier 1
BloombergNEF

TOP PERFORMER 2024
kiwa PVEL
PV MODULE RELIABILITY SCORECARD

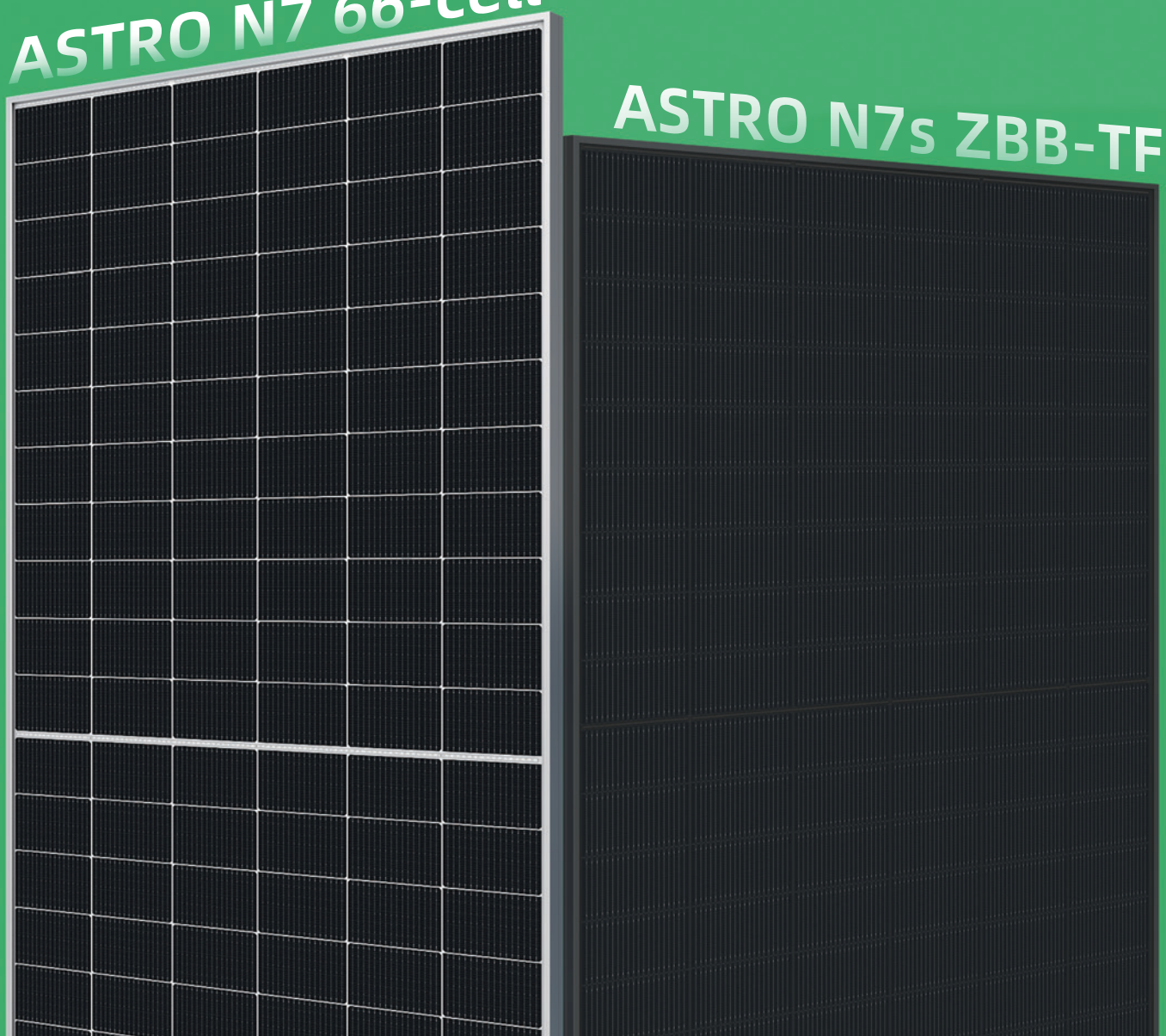
PV MODULE INDEX REPORT 2023
HIGHEST ACHIEVER
RETC

EUPD RESEARCH
TOP BRAND PV
MODULES
GERMANY
2023

ZERO BY 2050
Carbon Neutrality

ASTRO N7 66-cell

ASTRO N7s ZBB-TF



5. Module Efficiency Developments for Different Cell Technologies

While the previous chapter provides an overview of the efficiency distribution among the listed modules over 2.5 years, we have further analyzed the efficiency progress in each of the cell technologies. While it does show the larger picture as every cell technology has a typical efficiency band, there are always exceptions. However, in this chapter, we aim to provide an analysis of each cell technology used in commercial module production.

5.1 Share of technologies

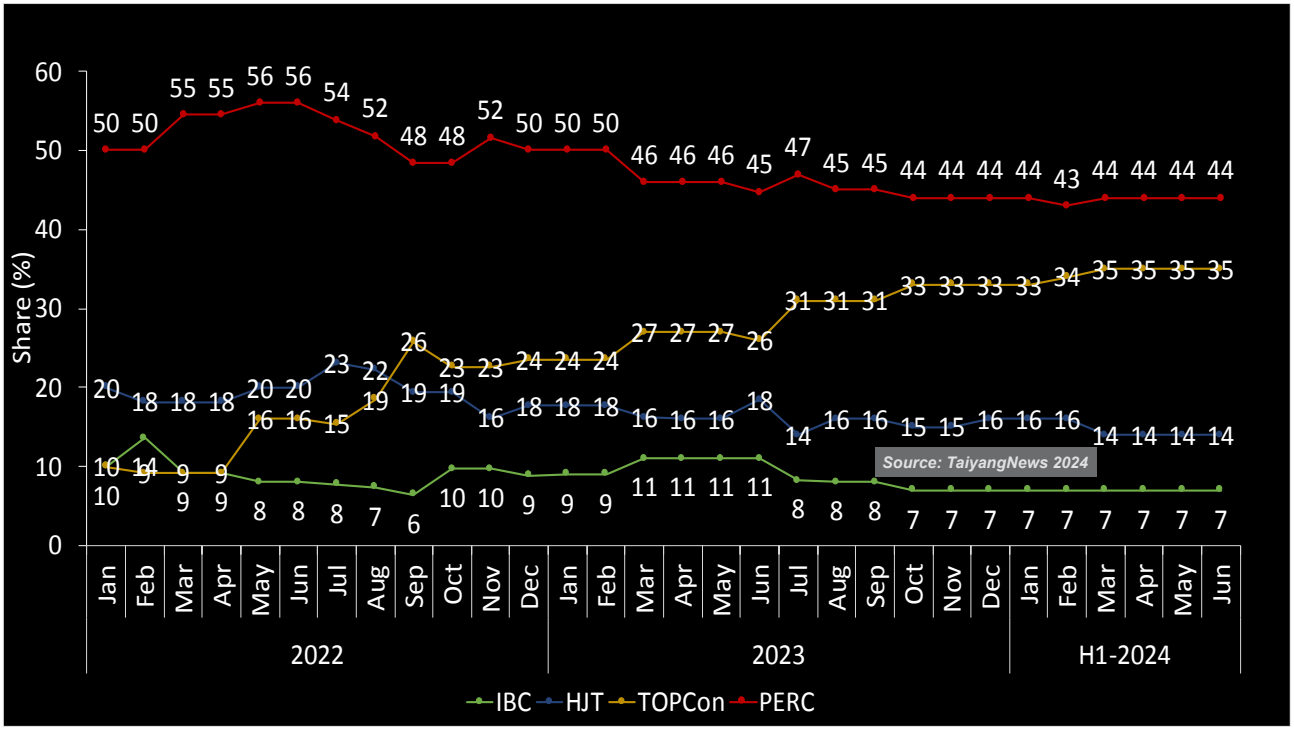
Starting with the statistics, the chart below summarizes the cell technology distribution among the top module products listed each month. Except for TOPCon, all the technologies have lost their share over the course of 24 months, while the absolute product count did increase for all technologies except for PERC. With all the technologies put together, the graph may appear somewhat complex. However, it becomes clearer when each cell technology is evaluated separately.

5.1.1 IBC

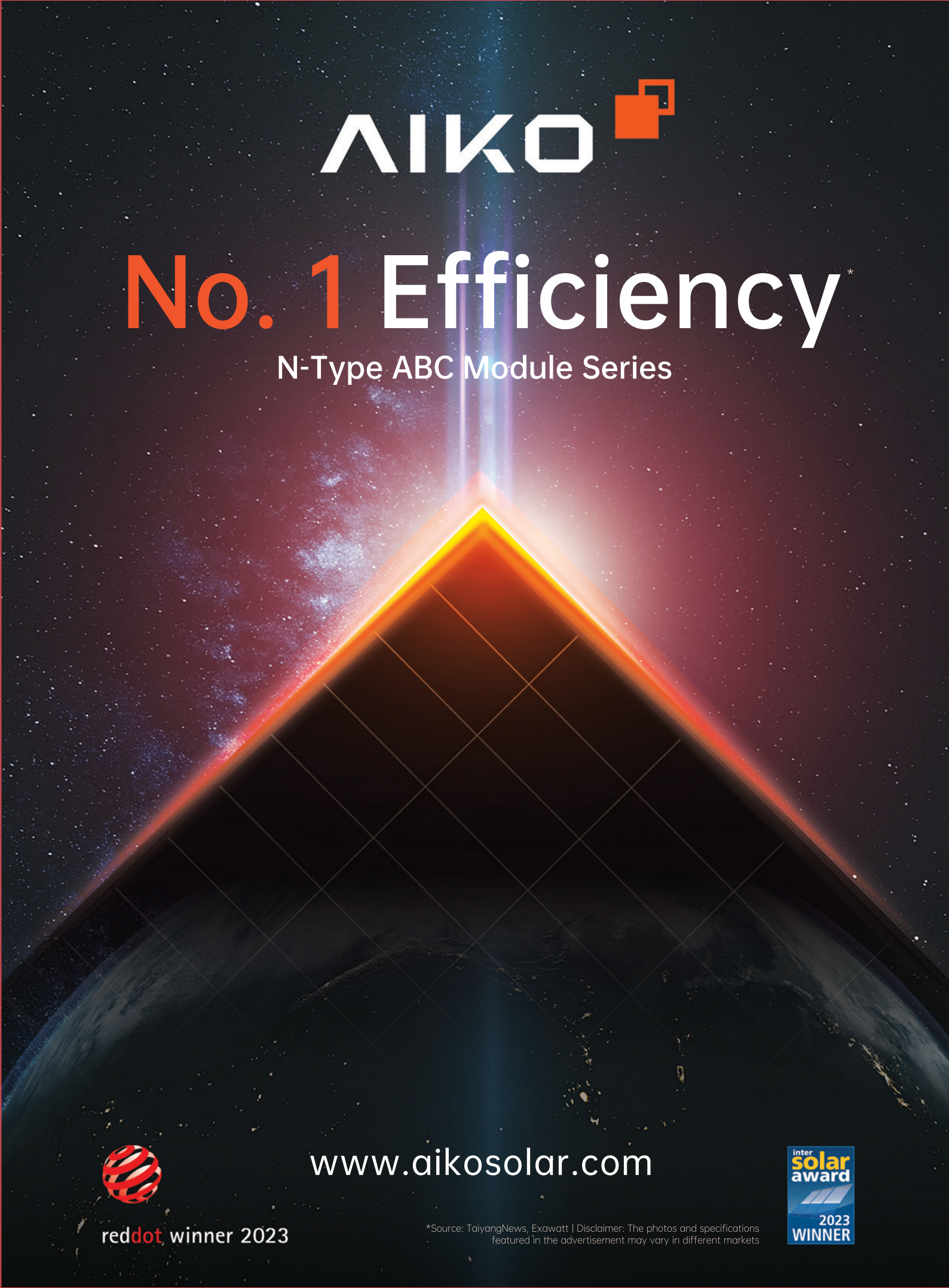
Starting with IBC, providing the highest efficiency, it had the lowest product count with 2 in January 2022 and 3 in December 2022. Even with the addition of one product during 2023, the product count only increases to 4. With hardly any growth in the number of products, the technology's share decreased from 10% to 9% in 2022 and to 7% in 2023. This is an indication that only a few companies have been able to master IBC as a commercial technology.

Initially, it was mainly 2 companies in January 2022, LG and Maxeon, with LG exiting the solar industry in April 2022. In March 2022, SPIC's IBC product based on ISC Konstanz's Zebra technology also entered the market. This left Maxeon and SPIC as the sole suppliers of commercial IBC modules at the time. However, in November 2022, LONGi launched its HPBC, also built on the IBC platform, thus increasing the number of products to 3. In March 2023, Aiko also joined this elite club, increasing the count to 4 and its share to 11%. While the product

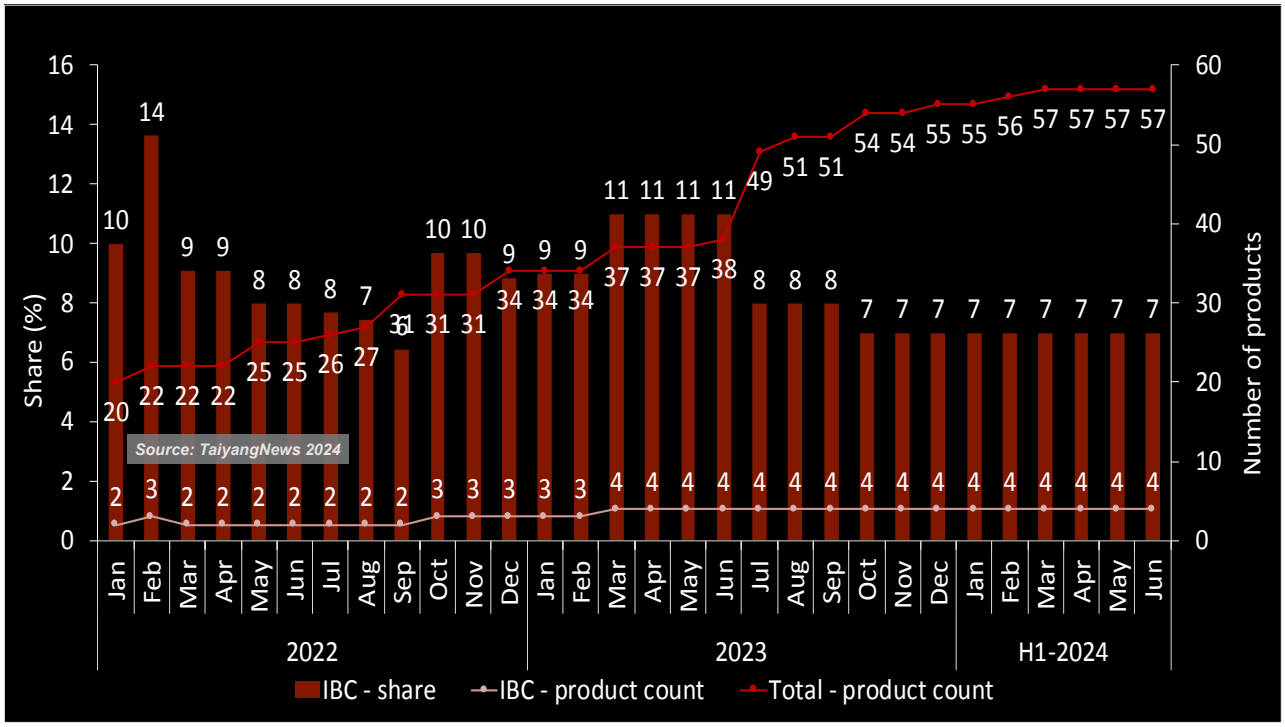
Product Shares Of Different Technologies



TOPCon on the rise: While the total number of products based on various cell technologies has increased over the past month, their relative market shares have declined, with the exception of TOPCon, which remains the sole beneficiary of this fall.

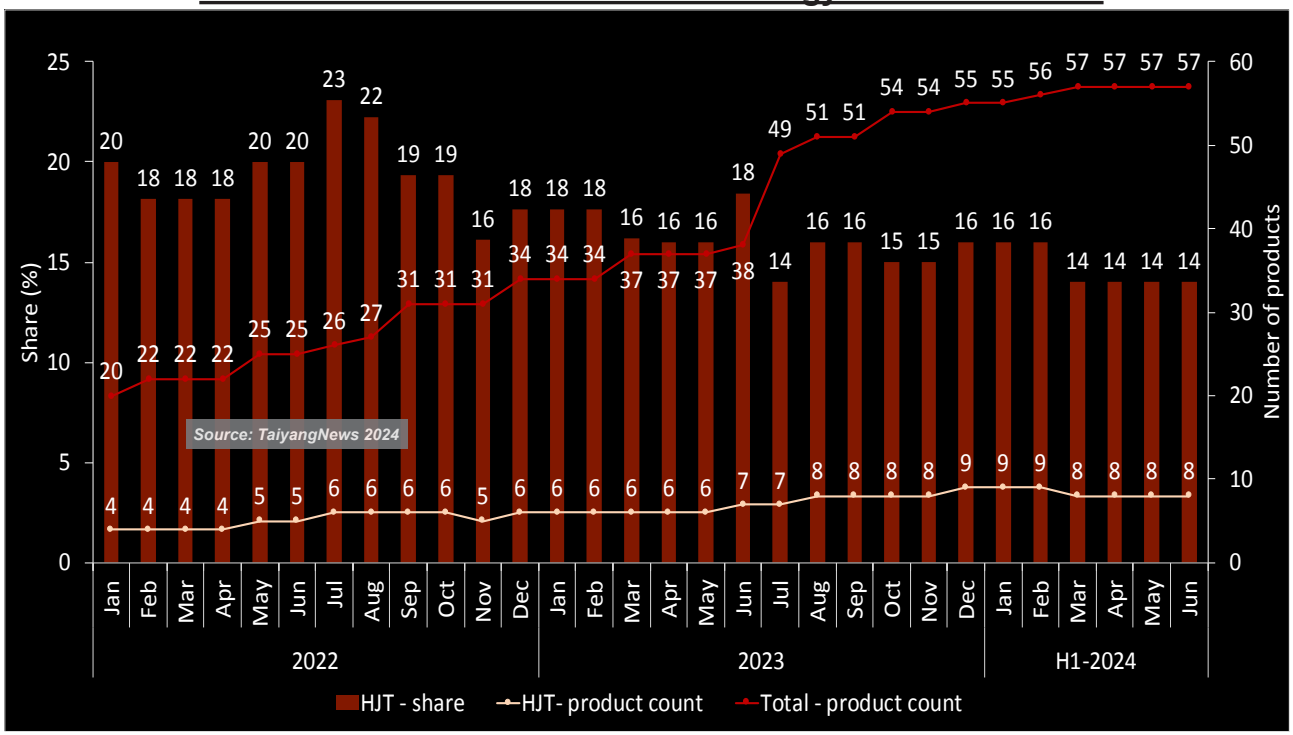

AIKO
No. 1 Efficiency*
N-Type ABC Module Series
www.aikosolar.com
reddot winner 2023
*Source: TaiyangNews, Exawatt | Disclaimer: The photos and specifications featured in the advertisement may vary in different markets
inter solar award 2023 WINNER

Product Share Of IBC Module Technology 2022 To H1 2024



Exclusive expertise: Only 4 companies have mastered the complex IBC technology, a minimal increase from 2 over the past 2.5 years.

Product Share Of HJT Module Technology 2022 To H1 2024



Few followers: Although the number of HJT technology adopters has doubled from 4 to 8 in the past 2.5 years, the overall market share of products based on this technology in the TOP SOLAR MODULES listing has declined.

count remained the same, IBC's share declined to 7% from September onwards into H1 2024.

5.1.2 HJT

Moving on to HJT, represented by 4 products at the beginning of 2022, the number increased to 6 over the course of 2022. However, the relative share of HJT products decreased from 20% to 18% during this period. 4 companies – REC, Meyer Burger, Huasun, and Jinergy – were the initial players offering HJT modules commercially. In May 2022, Canadian Solar entered the market with its HJT product, followed by Akcome in July 2022. Although these companies continued to offer their products, the graph shows a dip in the product count to 5 in November, which was due to Akcome's website being inaccessible during the time of our research. It reappeared in December 2022, taking the count back up to 6.

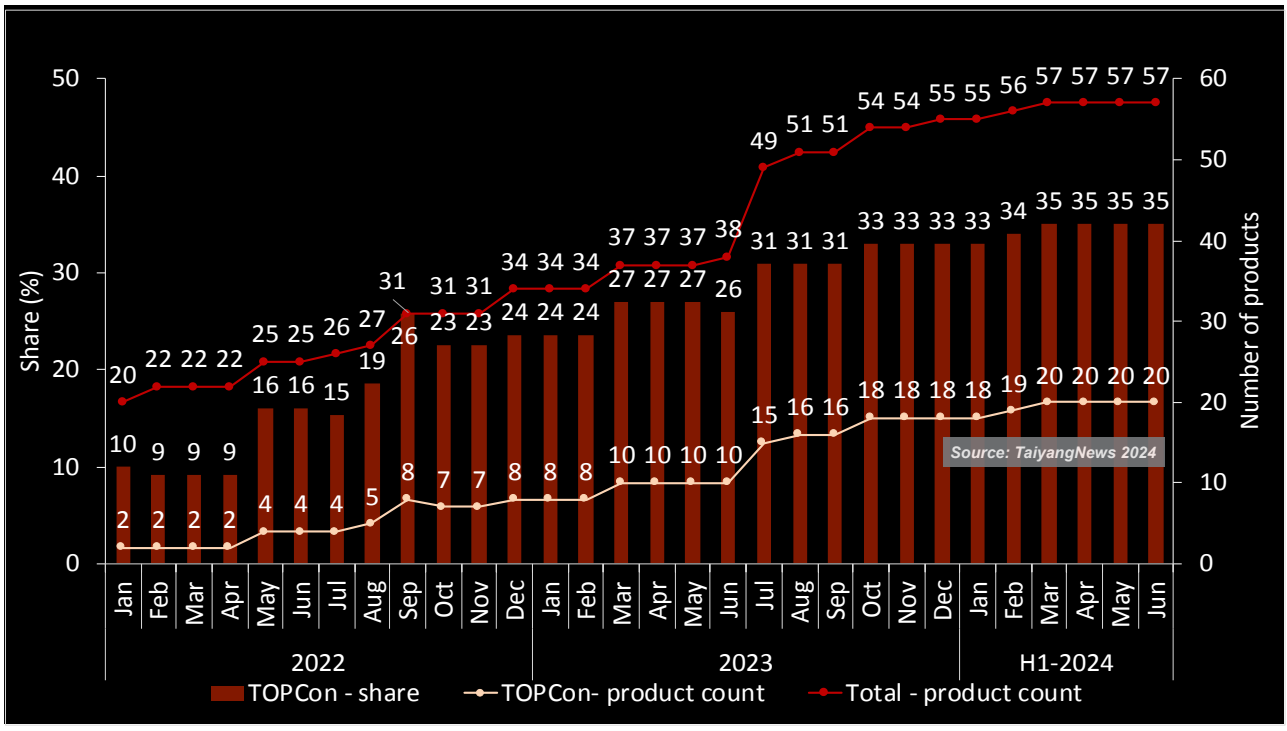
The module count and participating companies remained constant until May 2023. In June, Risen commercialized its HJT module, elevating the count to 7 and increasing HJT's share to 18%. In August 2023, URECO entered the list, further expanding the count to 8. Then in December, the product number increased to 9 with Tongwei; however, the share of HJT products fell 2 percentage points to 16% by the end of 2023. While there was no change in the first 2 months of 2024, the count reduced to 8 due to the delisting of CSI's HJT module, due to the data sheet being unavailable on the company's website.

5.1.3 TOPCon

On the other hand, TOPCon – represented by only 2 products in January 2022 – quickly entered the commercial space and had 8 products on offer by December of that year. As a result, it increased its share from 10% to 24%. By the end of 2023, TOPCon had 18 products listed, translating into a share of 33%. It's the only cell technology stream that has increased its product share over the 2.5-year period.

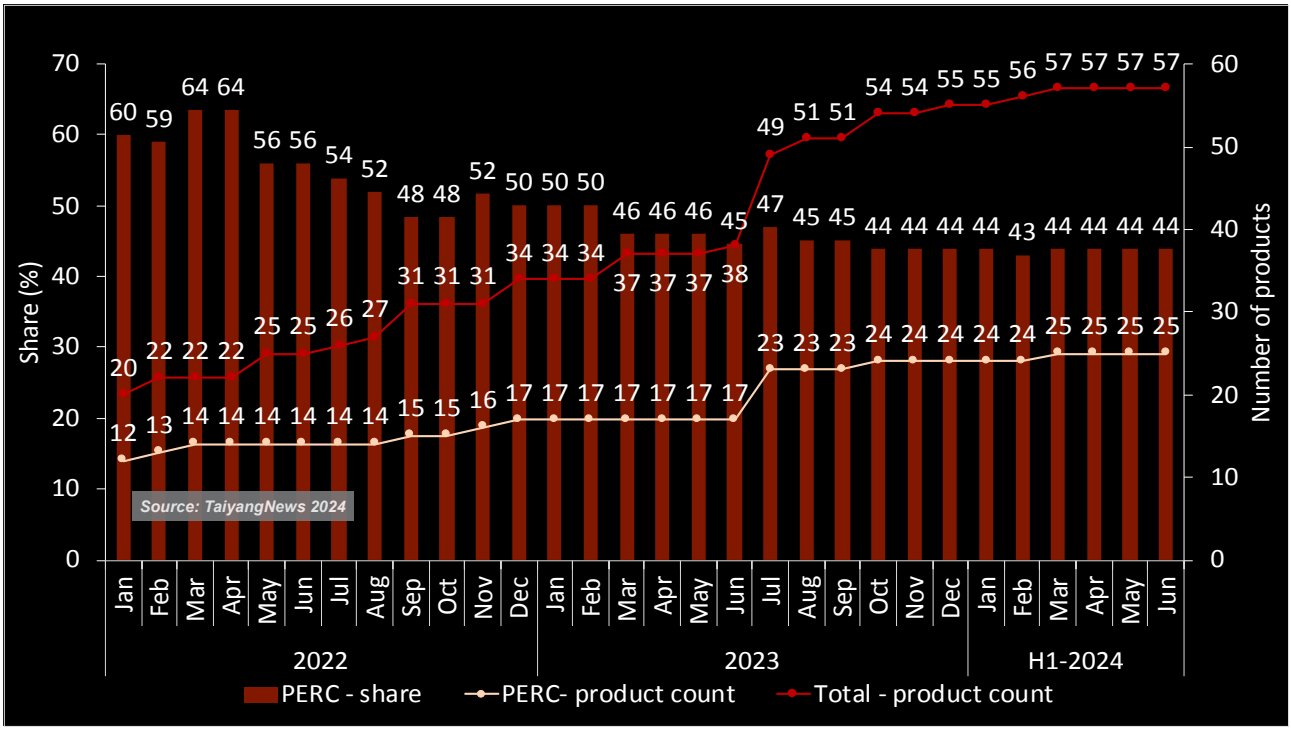
In January 2022, we first listed products from JinkoSolar and Jolywood, which remained the only pair of TOPCon module makers that could offer higher efficiency products. Later, in May 2022, Qcells and Astronergy started selling such products. In August, EGing joined the stream, followed by JA Solar, DAS Solar and Trina, as reflected in the September listing. However, in the subsequent 2

Product Share Of TOPCon Module Technology 2022 To H1 2024



Increasing prevalence: As TOPCon becomes the new industry standard, an increasing number of companies are adopting this technology. The number of products based on TOPCon has surged from 2 to 20, with its market share growing from 10% to 35% over the past 30-month period.

Product Share Of PERC Module Technology 2022 To H1 2024



Steady Presence: Although PERC technology is now considered prior art and no longer attracts new entrants, companies continue to include it in their portfolios. Over the past year, only 2 new companies were added to the list, bringing the current total to 25 and their share to 44%.

months, Qcells' product lost its place in the list as its data was not accessible and only became available again in December 2022.

The next change happened in March 2023 when 2 more companies – Tongwei and Canadian Solar – started offering TOPCon modules commercially. With these additions taking the listed products to 10, the technology's share increased to 27%. However, in June 2023 again, Qcells' product was removed from the company's website, and consequently also from our listing. However, the product count remained at 10 with DMEGC's product entering our listing for the first time the same month.

In July, 5 modules were included from companies using their own TOPCon cells for their manufacture – Qn-SOLAR, Suntech, GCL-Si, Runergy, and SolarSpace. Then URECO joined the stream in August, followed by Yingli and CECEP in October. The total product count increased to 18 through these additions and remained unchanged till the end of 2023, as did TOPCon's share of 33%.
While there was no change in January 2024, the number of products increased to 19 in February and 20 in March, increasing the share to 56% and 57%, respectively. However, the technology stream has gone through many other changes in the next 3 months.

5.1.4 PERC

The share of PERC products has been decreasing over the past 2.5 years. With a total of 12 products in January 2022, the technology accounted for 60% of the listed modules. It peaked at 64% in March and April that year, before falling to 48% in September and October with 15 products. Although there was a marginal increase in share from November to February, the share of products has been generally shrinking, down to 44% by the end of 2023.

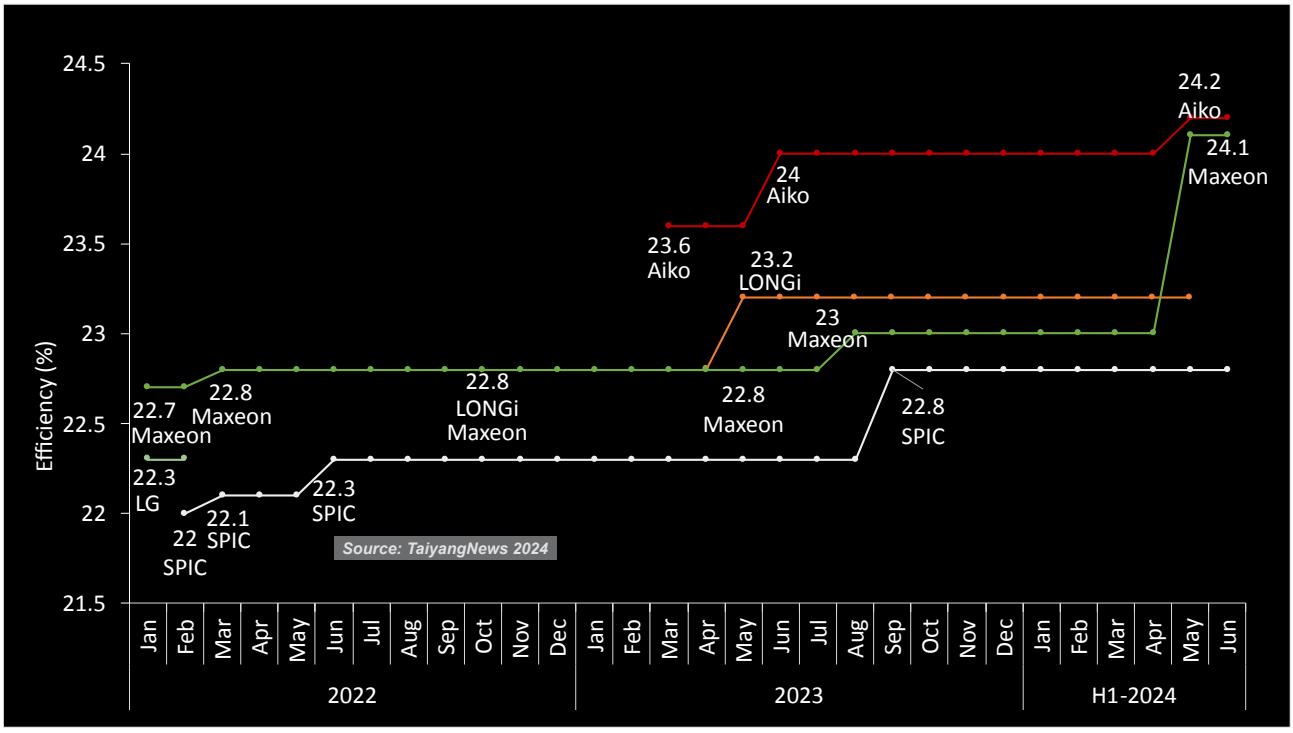
The companies offering PERC modules commercially at the start of our TOP SOLAR MODULES coverage were CSI, Risen, Suntech, Talesun, Trina Solar, EGing, Astronergy, JA Solar, Jinergy, LONGi, Qcells, and Tongwei. In February 2022, Yingli was added to the list followed by Seraphim in March. The list remained unchanged till September when JinkoSolar

GCL SI
CONNECT, TRACE, SUSTAIN
OUR DIGITAL PROMISE

IBC Module Efficiency Range - 2022 To H1 2024

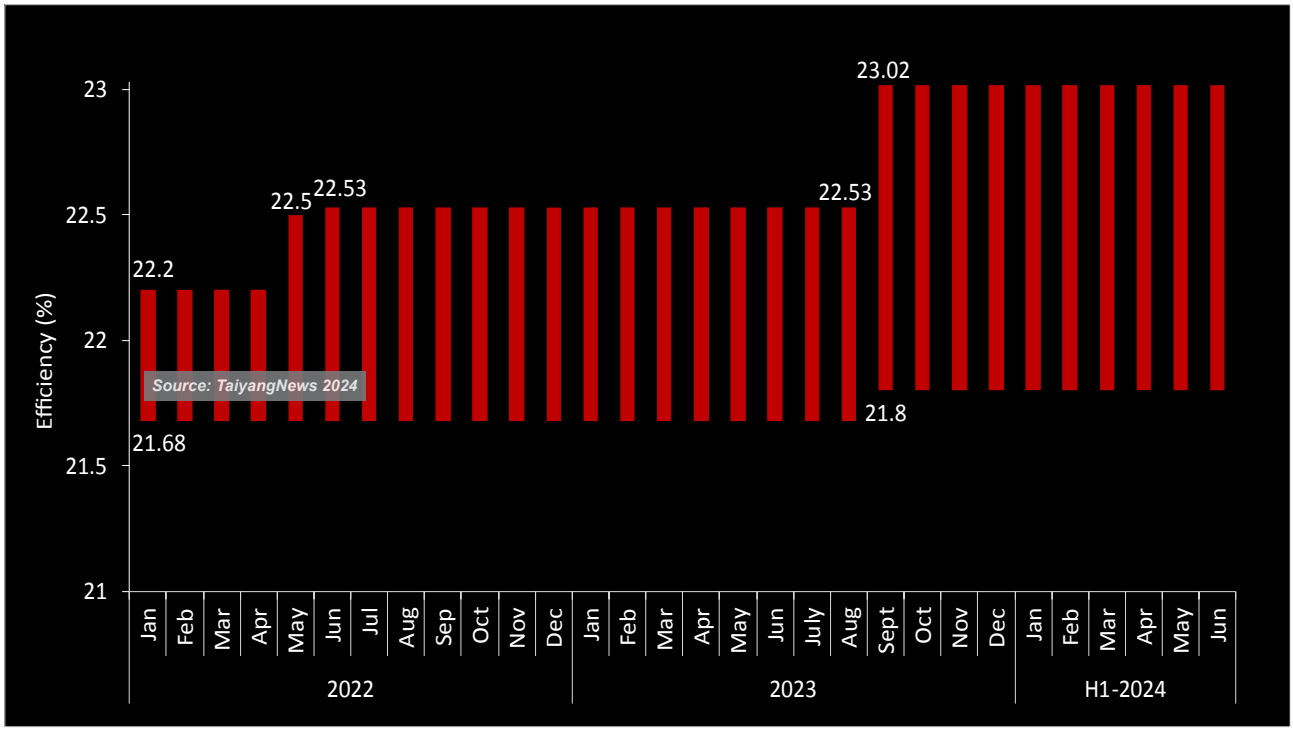
Higher and higher: IBC-based module products have seen both lower and upper limits elevated over the last 2.5 years; about 0.5% absolute for the lower limit and up to 1.5% absolute for the upper limit.

Module Efficiency Progress For IBC Cell Technology 2022 To H1 2024



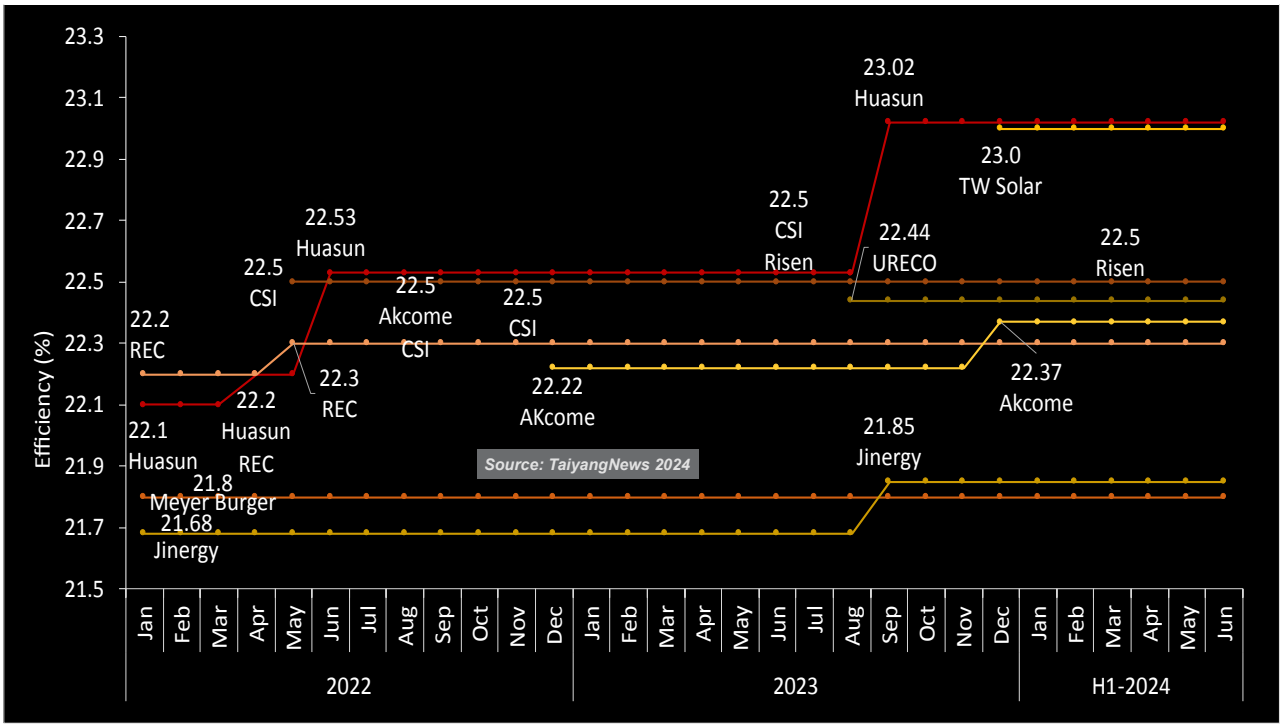
Go-getter: Since entering the module production business, AIKO has not only taken a leading position but has also retained that position ever since.

HJT Module Efficiency Range - 2022 To H1 2024



Second gainer: The top efficiency for HJT modules listed in TOP SOLAR MODULES increased from 22.2% in January 2022 to 23.02% by the end of H1 2024, gaining 0.82% absolute, the second highest among all technologies.

Module Efficiency Progress For HJT Cell Technology 2022 To H1 2024



A 2-year leader: Huasun has represented the top HJT efficiency level from June 2022 till June 2024, increasing efficiency twice – to 22.53% and 23.02%.

DAH Solar

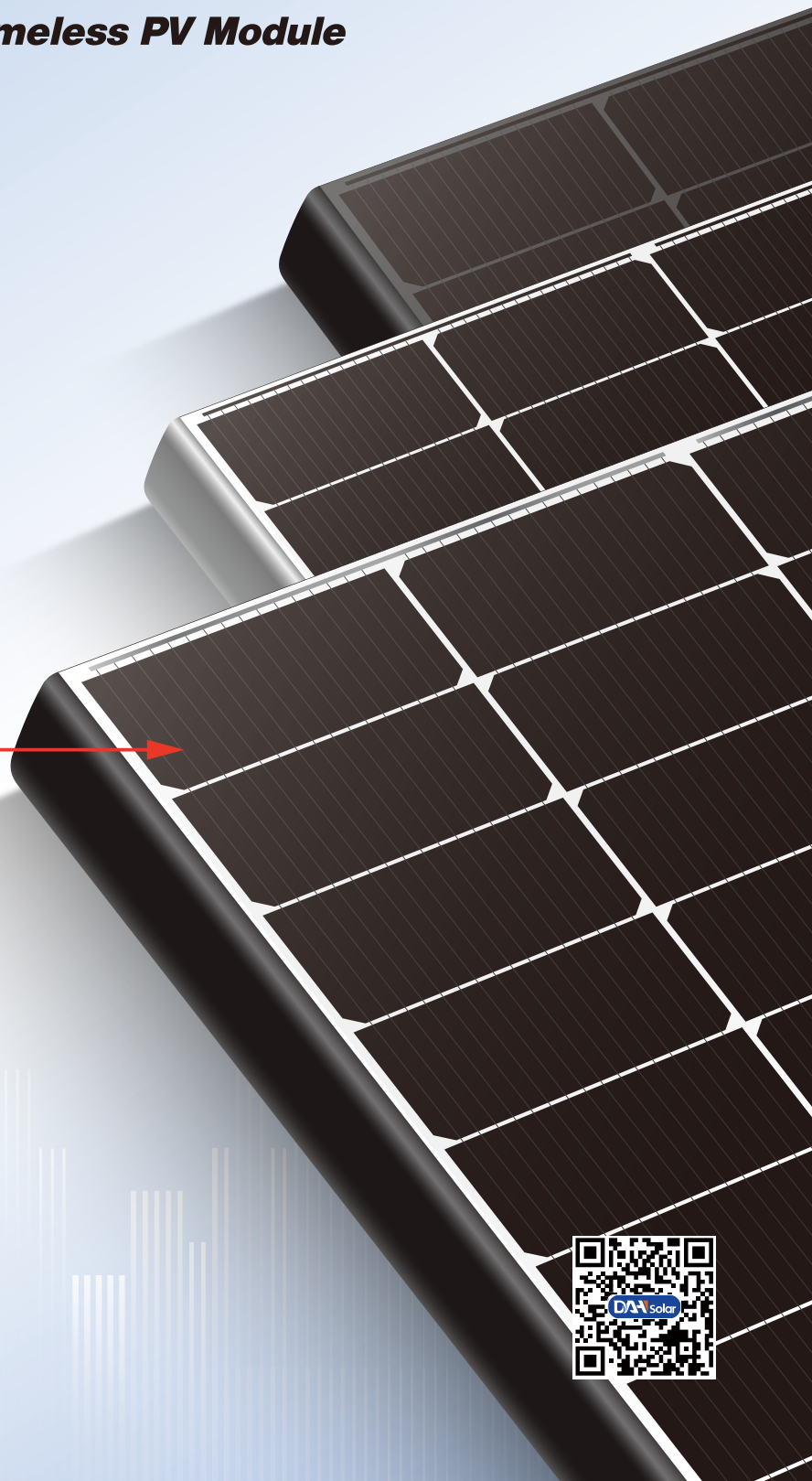
TIER 1
BloombergNEF

「Full Screen PV Module」

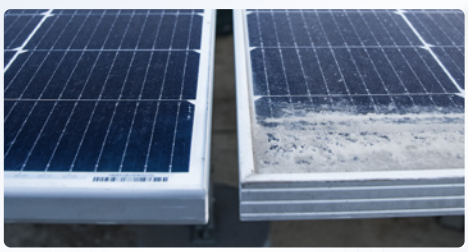
The Founder & Master of Frameless PV Module

6-15%

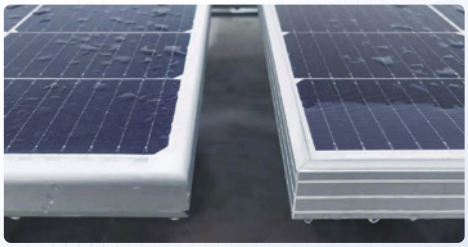
Full-Screen PV Module
Power Generation Increase



Front A-Side Frameless



Dust Comparison



Water Comparison

began offering PERC modules above 21.5% efficiency. In November, Jinergy started offering such modules, while Akcome followed in December 2022, taking the count to 17 products and their share to 34%. The list essentially remained the same even during H1 2023, while the efficiency ratings of the products changed from time to time.

In July, we included 6 companies – Qn-SOLAR, SolarSpace, URECO, CECEP, GCL-Si, and Runergy – offering commercial PERC module products with or above 21.5% efficiency. By September, PERC started losing share just due to the overall increase in the number of products getting listed. ZNSHINE joined in October, and the segment remained unchanged until the end of December and remained so until February 2024, with 24 products and a share of 44%. In March, one product from Kalyon was added to the list, taking the relative share from 43% back up to 44% as at the beginning of the year.

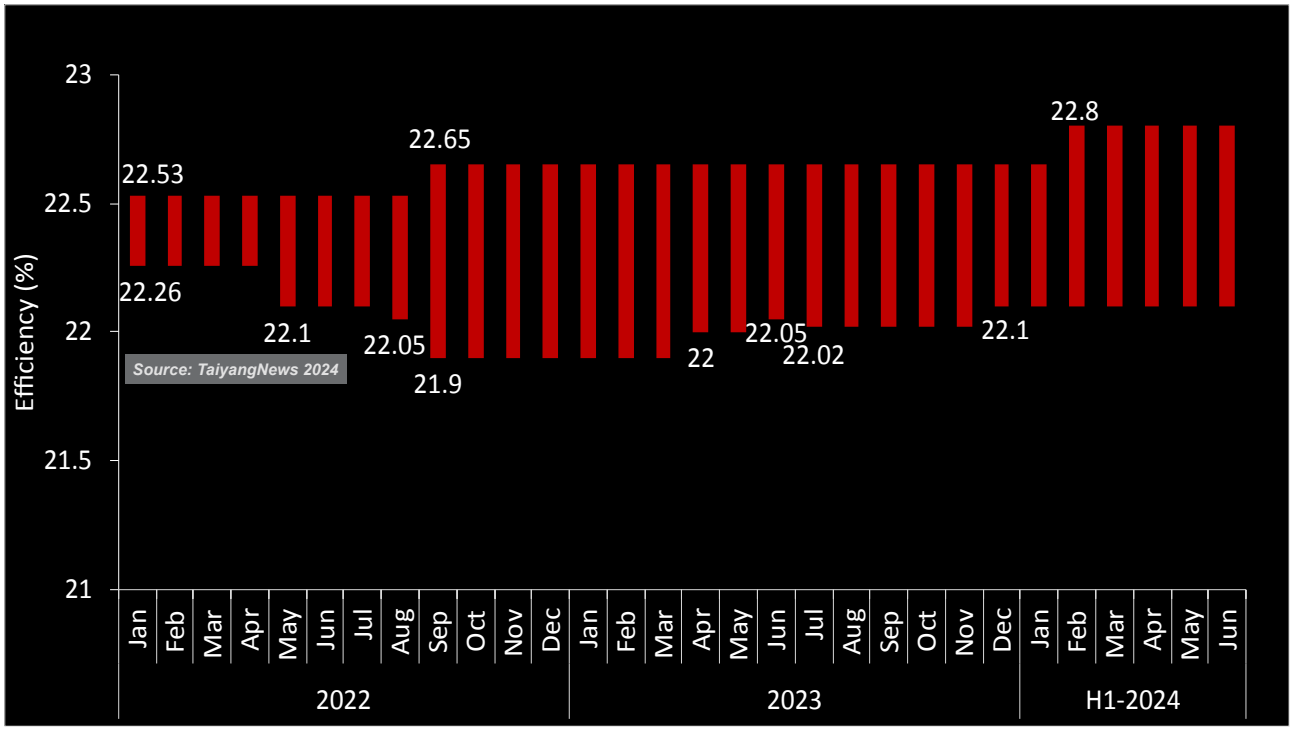
5.2 Module efficiency developments for different technologies

In this chapter, we delve into the efficiency distribution and progress of each cell technology.

5.2.1 IBC

In January 2022, the efficiency range for IBC was between 22.3% and 22.7%, with the lower limit extending to 22% in February. The efficiency band for IBC shifted by 0.1% at both the lower and upper limits to 22.1% and 22.8%, respectively, in March and remained unchanged until May. In June 2022, the minimum efficiency increased again to 22.3% with no change in the maximum value, which continued until February 2023. The upper limit increased to 23.6% in March 2023, and to 24% in June 2023. While it remained so until the end of the year, the range narrowed by increasing the lower limit to 22.8% from September onwards till April 2024. As reiterated several times above, AIKO once

TOPCon Module Efficiency Range - 2022 To H1 2024



The band gets bigger: In 2022, the efficiency band for TOPCon modules, ranging between 22.26% and 22.53%, expanded to 22.1% and 22.8%, accommodating 20 products within this 0.7% range.

again raised the bar to 24.2% in May 2024.

Moving on to the companies and their respective efficiencies, Maxeon and LG had the highest efficiencies in the first month of 2022, at 22.7% and 22.3%, respectively. In February, SPIC entered with a somewhat lower-level efficiency of 22%. In March, while LG was delisted due to its exit from the solar business, both Maxeon and SPIC increased their efficiency by 0.1%, and then SPIC alone increased it to 22.3% in June. While these efficiency levels remained the same, LONGi entered the IBC game in October with its brand new HPBC technology, realizing 22.8%, on par with Maxeon's module.

5.2.2 HJT

For HJT, the lower limit of 21.68% was maintained throughout 2022 and a major part of 2023, before it changed once – increasing to 21.8% in August. The January 2022 upper limit of 21.9% was bettered in February to reach 22.2%, which remained the case till April. It then increased to 22.5% in May, and again marginally to 22.53% in July 2022. It exceeded the 23% level in September 2023, when 23.02% was reached, and remained so until the end of the coverage period for this report – H1 2024.

As for the companies, REC held the top spot at 22.2% until March 2022. Then in April, Huasun, the HJT segment pioneer that had been promoting a 22.1% HJT module, commercialized an HJT product with 22.2% efficiency, sharing the top space with REC. In May 2022, Canadian Solar entered the list with a 22.5% product, pushing REC down to 2nd place with its 22.3% efficiency HJT module, which itself had increased from 22.2%. The very next month, Huasun commercialized its new HJT module with 22.53%, which remained the top efficiency until August 2023. In September, Huasun bettered itself by commercializing a module with 23.02% efficiency, which not only took HJT beyond the 23% level but also earned it a place among the top 3 ranks in our list. Huasun continued its lead till the coverage period of this report – H1 2024.

REC and CSI also maintained the efficiencies of their HJT products at the same level during the period, at 22.3% and 22.5%. In June 2022, Akcome entered our listing as an HJT maker with a 22.5% efficient module, but the product specs became inaccessible in November. While the company released a new HJT module in December 2022, it was with a lower efficiency of 22.22%. Exactly after 1 year, in December 2023, the company improved it to 22.37%. Longtime HJT proponent Risen's HJT module featured for the first time in our list in April 2023 with an efficiency of 22.5%, the same as CSI's product. URECO joined the list with 22.44% efficiency in August 2023, and all 3 products remained unaltered till the end of the year. Our December 2023 edition included the HJT module from Tongwei for the first time with an impressive 23% efficiency.

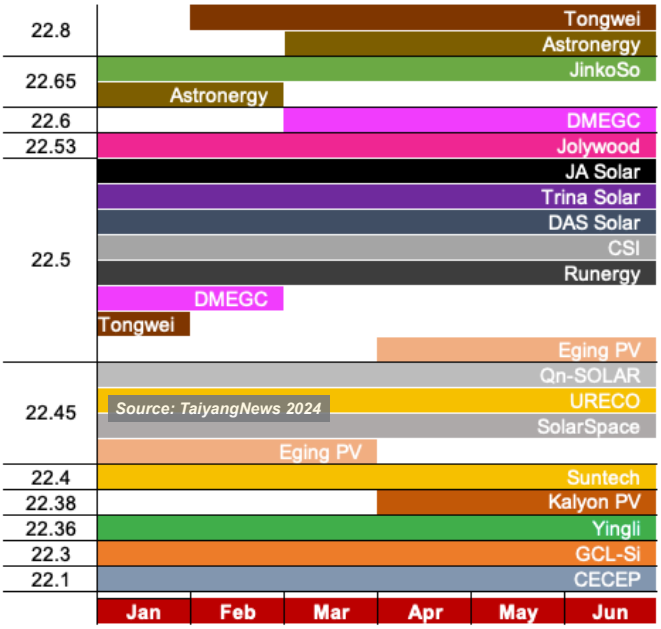
Meyer Burger, a Germany-based HJT manufacturer using its own proprietary cell and module production equipment, maintained the same module efficiency of 21.8% throughout our TOP SOLAR MODULES coverage. Jinergy's HJT module represented the lower limit of HJT modules at 21.68% from the beginning of 2022 until August 2023. In September, the company commercialized a module with an improved efficiency of 21.85%, pushing Meyer Burger's product to the lowest level in this segment. These 8 companies maintained their respective efficiency levels throughout the first 6 months of the 2024 as well.

5.2.3 TOPCon

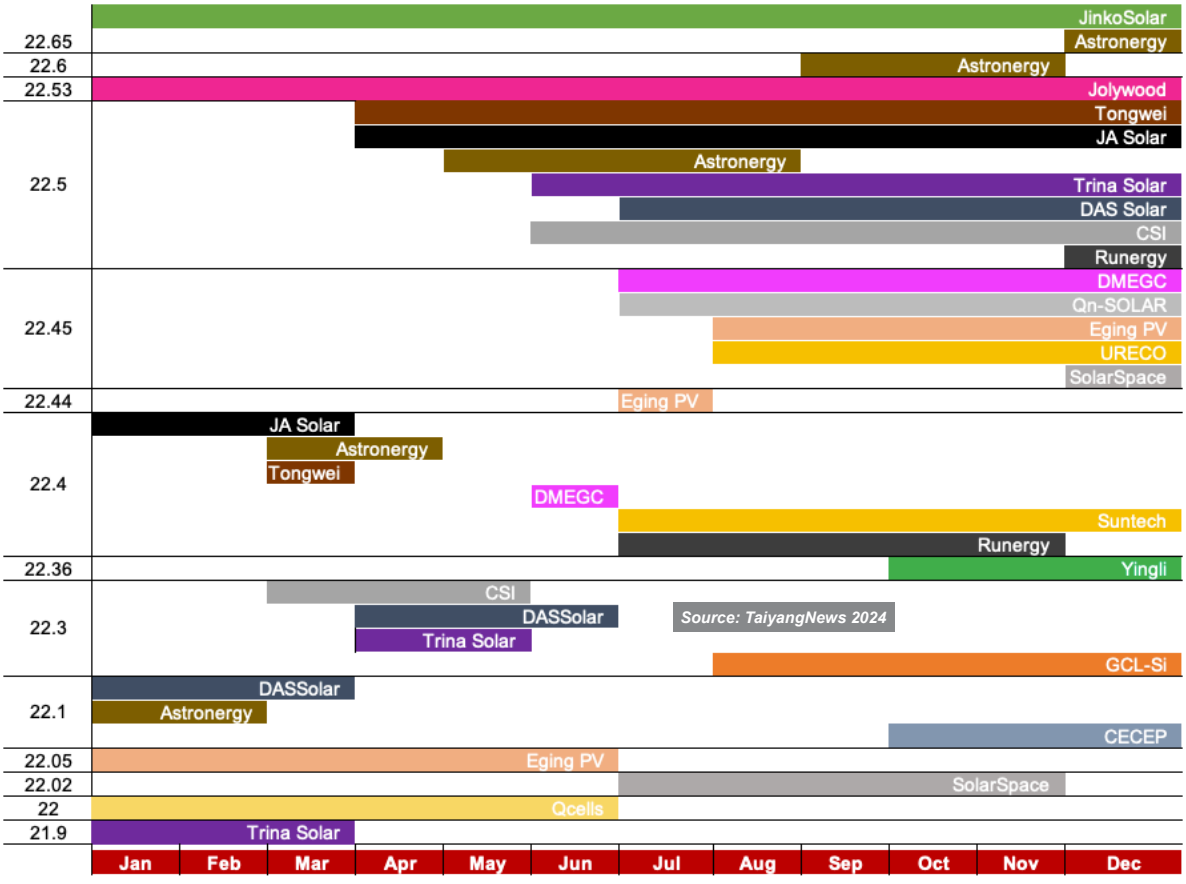
In the TOPCon segment, the efficiency range initially began at 22.26% and ended at 22.53%, with 2 products representing the lower and higher ends. The first change occurred in May 2022, when the lower limit was changed to 22.1%, again to 22.05% in August, and then to 22.19% in September 2022. It changed twice in 2023 – to 22% in April and 22.05% in June. However, in the second half of 2023, it changed twice again – going down to 22.02% in July to remain there until November, and then moving up to 22.1% in December. However, the best efficiency for TOPCon was improved only once in September to 22.65%. While the lower limit remained the same even during the first half of 2024, the upper limit increased to 22.8% in February, which remained the same over the next 4 months.

In terms of product-level details, Jolywood retained its leadership until September 2022 with its 22.53% TOPCon module, which it continues to offer. However, in September, JinkoSolar, which had been offering a TOPCon module with an efficiency of 22.26% until then, launched a 22.65% efficiency product that remained at the top of the TOPCon

Module Efficiency Progress For TOPCon Cell Technology In H1 2024



Module Efficiency Progress For TOPCon Cell Technology In 2023



Touching new heights: Tongwei raised the bar by achieving 22.8% efficiency and surpassing the 22.65% efficiency mark set by JinkoSolar 1.5 years ago. Astronergy followed suit by matching Tongwei's figure the next month.

modules listing till the end of 2023.

As the adoption of TOPCon spread wider, several companies started commercializing their products based on this cell technology. Following the chronological order, Qcells entered our listing in May 2022 with a 22.3% TOPCon module, which remained unchanged until September 2022. However, the product was not available on the company's website for the next 2 months, and the company introduced a slightly lower efficiency product in December, at 22%. It remained at this level till May 2023, while its specs were again inaccessible for the June edition. Astronergy entered our list at the same time as Qcells, with a 22.1% TOPCon module that maintained the same efficiency until February 2023. Its efficiency improved to 22.4% in March 2023, to 22.5% in May, followed by the next level of improvement to 22.6% in September and finally sharing the top level of 22.65% with JinkoSolar in December 2023.

DAS Solar also started offering a TOPCon module with the same 22.1% efficiency from August 2022 onwards, and the listed specifications remained unchanged until March 2023. The company's TOPCon module featured a higher efficiency of 22.3% in April 2023, then increased to 22.5% in July and listed as-is from then onwards. EGing PV's 22.05% efficiency product saw no changes since it entered our listing in August 2022 until June 2023, while in July the company commercialized a 22.44% product and increased it marginally to 22.45% the following month.

In September 2022, Trina Solar commercialized its TOPCon module with 21.9% efficiency, which did not undergo any changes till March 2023. However, the company's top TOPCon product featured 2 upgrades in the next 3 months – 22.3% in April and 22.5% in June, which continued till the end of the year. JA Solar was the last entrant to our TOPCon listing during 2022 with a module of 22.4% efficiency, which was reflected in our October listing and remained so until March 2023, and featured with a slightly higher efficiency of 22.5% from April 2023 onwards.

In 2023, DMEGC was the first new company to enter the TOPCon segment in June with 22.45%. In July, 5 companies were added with their TOPCon products, all featuring above 22% efficiency. Qn-SOLAR, Suntech, and GCL-Si maintained their efficiencies of 22.45%, 22.4%, and 22.3%, respectively, without changes until December. Runergy, entering with 22.4%, improved to 22.5% in December, while SolarSpace, initially at 22.02%, upgraded to 22.45% in the same timeline.

URECO joined in August with 22.45% efficiency, which remained the same until the end of the year. In October, Yingli and CECEP joined with 22.36% and 22.1%, respectively, and their efficiencies remained unchanged for the next 2 months.

DMEGC joined in at the 22.5% level in January 2024, where a bulk of 6 TOPCon products were already listed in December 2023, increasing the count to 7. DMEGC has increased its best TOPCon module's efficiency by 0.05% from the December level of 22.45%. In February, Tongwei raised the bar for TOPCon module efficiency to 22.8%, breaking the 22.65% level that JinkoSolar attained for the first time in September 2022. In March, Astronergy's top TOPCon module also reached the same level, but jumping from the previous highest 22.65% level. DMEGC also improved its product's best efficiency to 22.6% from 22.5%. In May, there were 2 changes in the TOPCon section for TOP SOLAR MODULES: EGing improved the efficiency from 22.45% to 22.5% and Kalyon's TOPCon module entered our list with an efficiency of 22.38%.

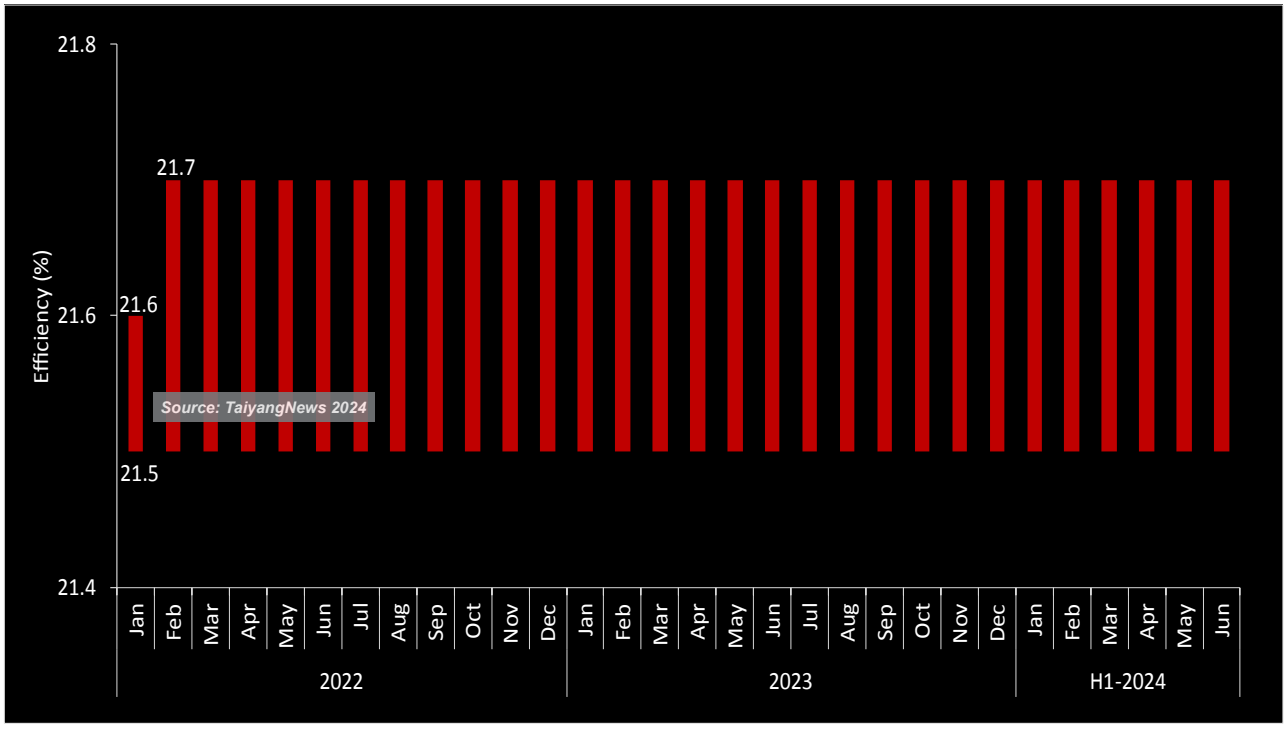
5.2.4 PERC

In January, the PERC efficiency range was 21.5% to 21.6%, which quickly increased to 21.7% the following month and remained so from then on. While a few companies did announce PERC modules above 21.7%, we did not find proof for commercialization, so we haven't included them in our TOP SOLAR MODULES list.

Initially, there were 12 products listed in the PERC category in January 2022: 5 modules from Risen, CSI, Suntech, Talesun and Trina Solar were listed at 21.6%, while only 1 module from EGing was reaching 21.57%. In addition, 6 modules from LONGi Solar, JA Solar, Jinergy, Astronergy, Qcells, and Tongwei were at the lowest threshold of 21.5%.

In February 2022, LONGi increased the efficiency of its PERC module to 21.7%, JA Solar's product improved to 21.6%, and Yingli entered the list with a

PERC Module Efficiency Range - 2022 To H1 2024



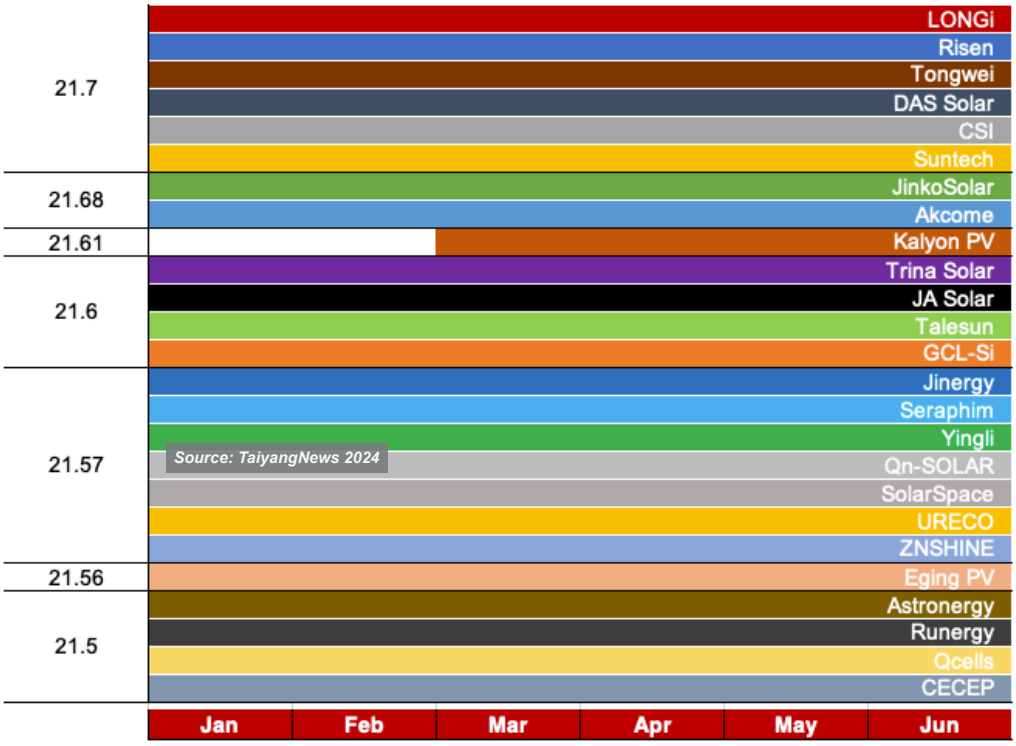
Steady-state: Starting in February 2022, the efficiency spectrum of PERC products remained unwaveringly stable between 21.5% and 21.7%, indicating the maturity of the technology.

21.57% efficiency module. The only change in March was Seraphim entering the list with a 21.5% module. The next change took place only in July 2022, when Risen commercialized an improved product with an efficiency of 21.7%, making it the second product to hit the highest point for PERC in the listing, after LONGi.

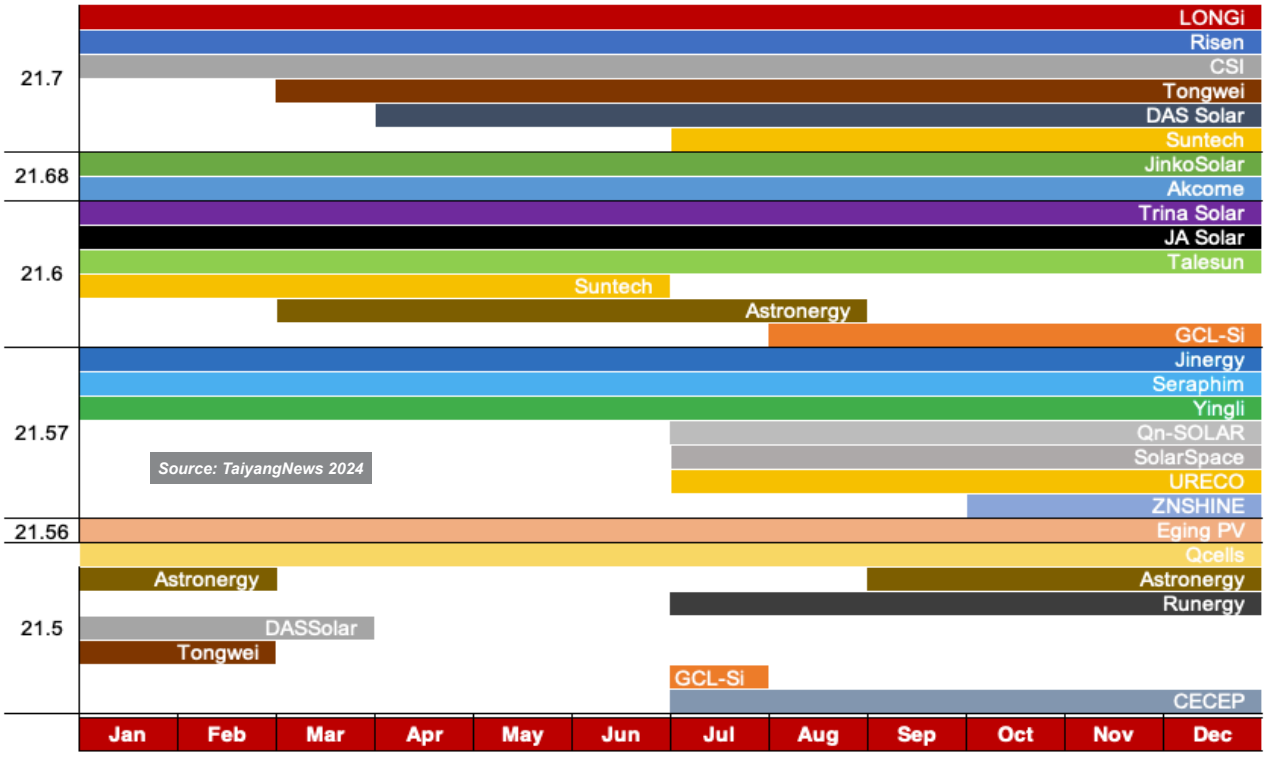
In August, Jinergy's product was listed with an improved efficiency of 21.52%, but the product spec was inaccessible for the next 2 months. In September, DAS Solar entered the list with a 21.5% PERC module. In October, JinkoSolar, with no representation in the segment until then (i.e., the company's commercially available PERC products didn't clear the 21.5% criterion), entered the list with a 21.68% product. Jinergy re-entered our radar with a product featuring improved efficiency of 21.57% in November.

The last 2 changes for 2022 in the PERC category were CSI's new 21.7% efficiency module and Akcome's PERC module entering the list for the first time with an efficiency of 21.68%. While there was no change in the first 2 months of 2023, Tongwei improved the efficiency of its PERC modules in March to 21.7% and Astronergy to 21.6%. Then in April 2023, DAS Solar increased its product efficiency to 21.7%, while there were no further changes to the PERC listing till the end of H1 2023. From July, Suntech joined the list with an efficiency of 21.7%, an improvement from its previous 21.6%. In the same month, Qn-SOLAR, SolarSpace, and URECO joined at the 21.57% efficiency point, while CECEP, GCL-Si, and Runergy entered with 21.5% efficiency. In August, GCL-Si improved the top efficiency of its PERC product to 21.6%. The only change to take place in September was Astronergy reducing the best efficiency of its PERC offerings to 21.5%, back to the February level. In October, ZNSHINE joined in with an efficiency of 21.5%, and these products maintained their efficiency levels until the end of December 2023. None of these products have undergone any changes throughout the first half of 2024. However, the segment as a whole saw only one change: Kalyon's PERC product with 21.61% efficiency was included in the March list, which has remained unchanged since then.

Module Efficiency Progress For PERC Cell Technology - H1 2024



Module Efficiency Progress For PERC Cell Technology 2023



Lost momentum: While the PERC segment experienced some activity in 2023 with a few companies entering the list and others improving efficiency levels, the only noticeable change during H1 2024 was Kalyon's product being added to the list, indicating the technology may have gone out of focus for major PV makers.

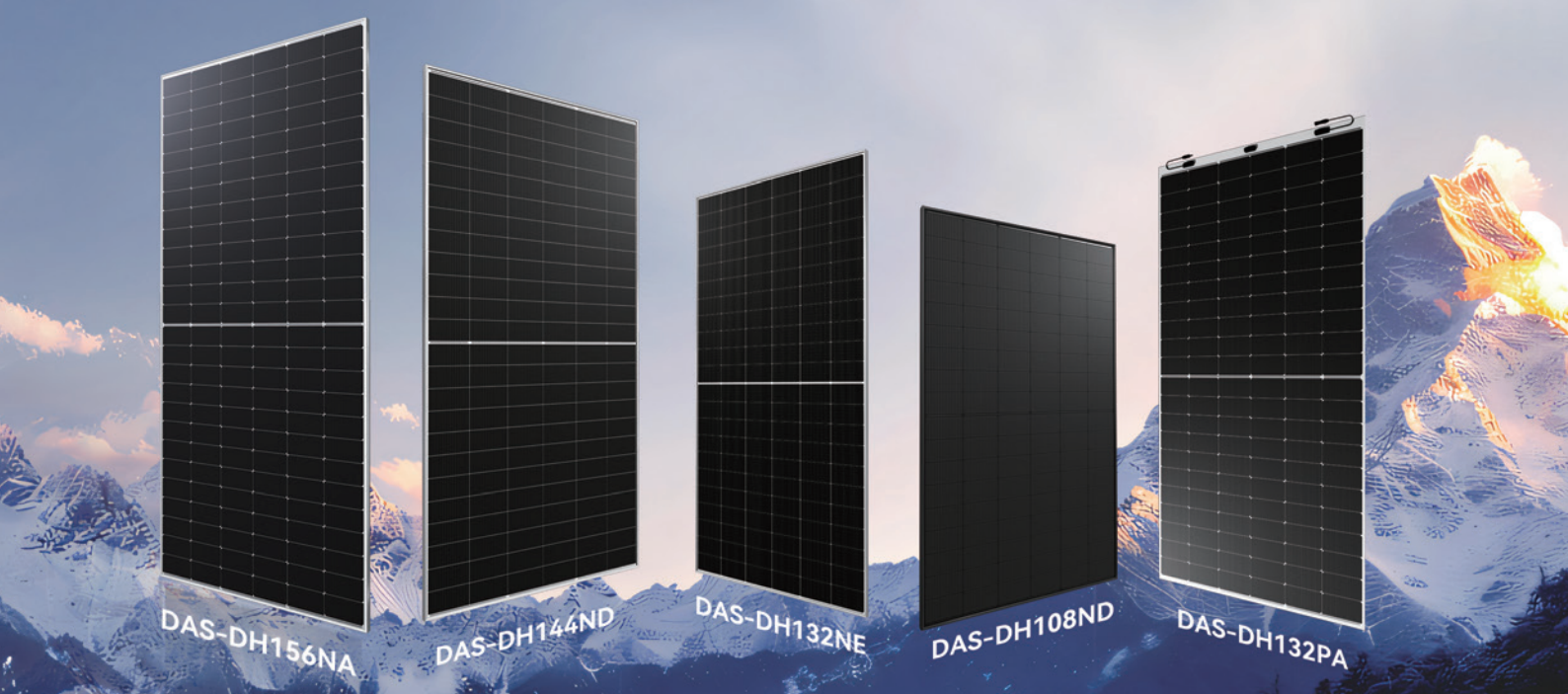
DASOLAR

A Leader in N-type PV Technology

TOP3
N-type
Module Shipment

50GW
Planning Cell/Module
Production Cpacity for 2024

Top 10
Global Module Shipment
(as of 2023)



Instagram LinkedIn YouTube Facebook

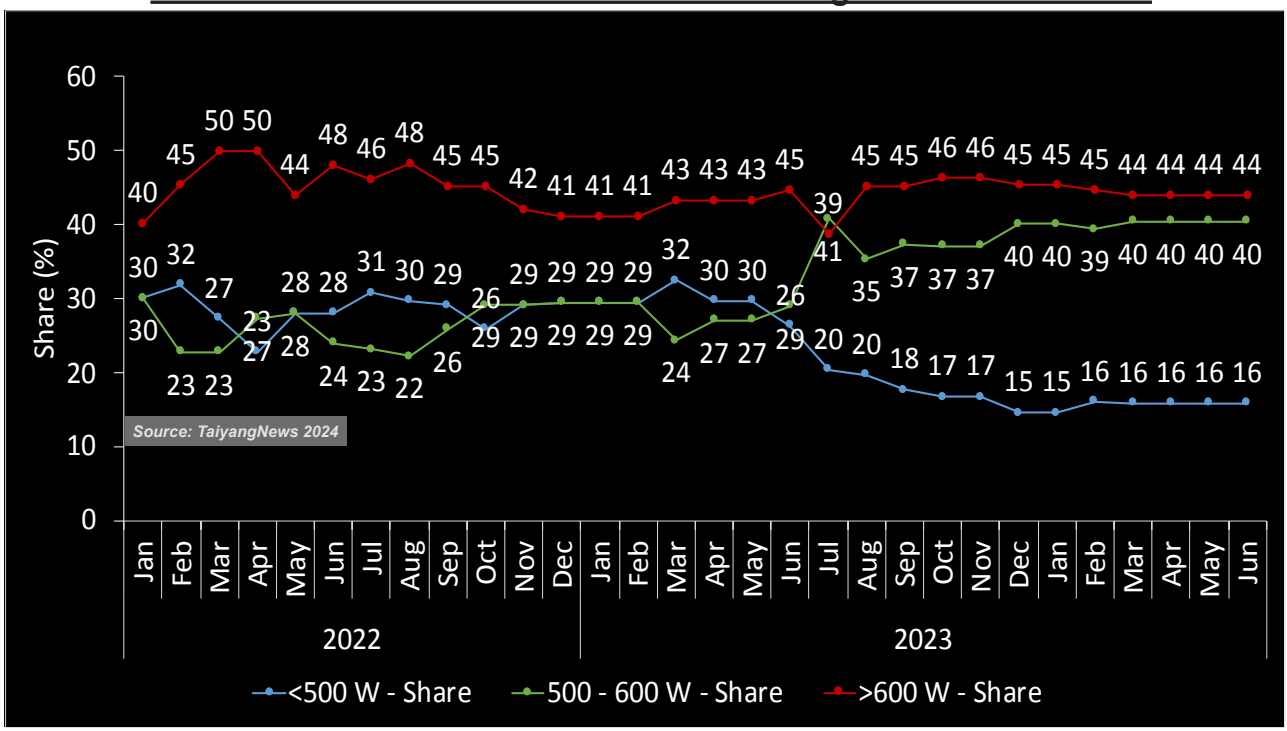
info@das-solar.com www.das-solar.com

6. Power

Power is the most important characteristic of a module, next to efficiency, given it also serves as the primary sales metric for a PV panel. Furthermore, power indirectly determines the module's application since it generally relates to size. Although there is no hard and fast rule, solar modules are typically categorized into different applications based on their power rating. Usually, modules with a power rating of less than 500 W are preferred for residential applications, 500 to 600 W for commercial and industrial (C&I) applications, and above 600 W for utility installations. We have also followed the same analogy for power analysis.

When we look at the product count of modules bifurcated into these 3 power classes, the TOP MODULES listing is clearly dominated by high-power modules with a rating of greater than 600 W. The number of products increased steadily from 6 to 14 by the end of 2022, and then to 25 by the end of 2023, and staying steady through H1 2024. However, its share has been the most consistent overall, varying mostly from 40% to 45%. This trend also continued throughout H1 2024. The other classes have been fluctuating much more. The count of products in the 500 W to 600 W power output range increased from 5 to 10 by the end of 2022, and to 22 by the end of 2023. During the first 6 months of 2024, the product count increased by 1 to 23. This power class was in the growth mode at least during H2 2023 and continued to be so in the first half of 2024. Its relative share increased from 30% to 40% over the 2.5 years. The number of small modules increased from 6 to 10 by the end of 2022, while slightly decreasing to 8 by December 2023. This power class also won one more follower - Qcells - during H1 2024. It class lost half its share in the total count of products from the beginning of 2022 to December 2023, from 30% to 15%, rising marginally to 16% during the first 6 months of 2024. Together with the fact that the residential segment is booming, the indications are clear that more and more module makers are promoting modules above 500 W also for this application.

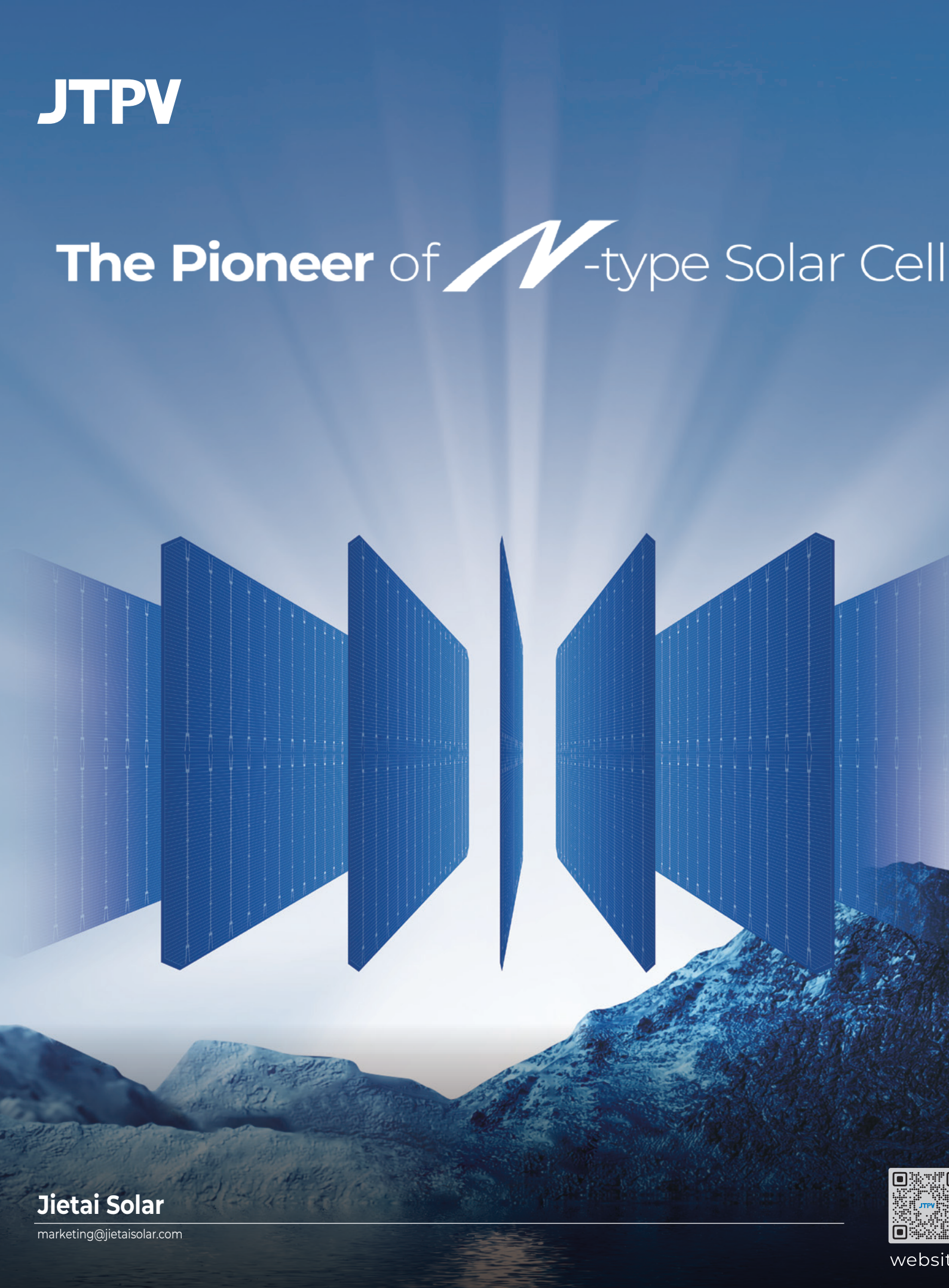
Shares Of Different TOP Module Power Ratings - 2022 To H1 2024



The power order: In our TOP SOLAR MODULES analysis, high-power modules dominate, comprising roughly 40% of the total, followed by mid-level modules, while lower-power modules have the smallest share.

JTPV

The Pioneer of N-type Solar Cell



Jietai Solar

marketing@jietaisolar.com

website

6.1 Top 3 power ratings

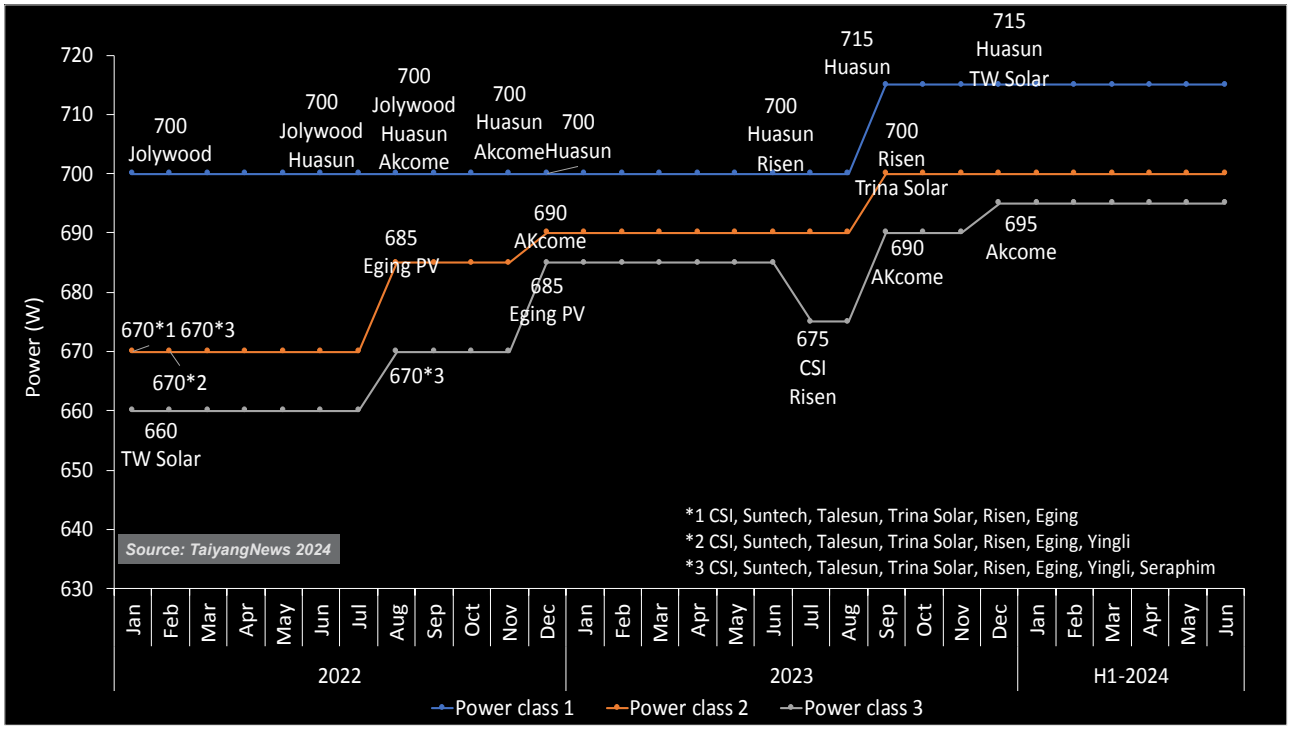
Similar to efficiency, we have also examined the products in the top 3 power levels. Jolywood, with its TOPCon module rated at 700 W, remained at the top until October 2022 and was an exclusive promoter until May 2022. In June 2022, Huasun introduced its HJT product with the same power rating as Jolywood's module, thus sharing the top level with a 700 W power rating. Then in July 2022, Akcome also introduced a higher power HJT module with a 700 W power rating. The trio – Huasun, Jolywood, and Akcome – enjoyed the top position until October 2022.

In November, however, Jolywood's high-power panel was replaced with a rather low power module of 440 W, while maintaining efficiency at the same level, and Akcome reduced the power rating of its product to 690 W. As a result, Huasun had the top position all to itself until May 2023. In June, Risen, another strong advocate of HJT, also commercialized a 700 W module, sharing the top spot with Huasun. This dual leadership continued till August 2023.

In September, Huasun retook the top spot by commercializing yet another HJT module rated at 715 W. However, at the end of 2023, Tongwei also launched a similar HJT module with 715 W. As a result, both Huasun and Tongwei shared the top honors in terms of power ratings until H1 2024.

In the 670 W category, as many as 6 companies, namely Canadian Solar, Suntech, Talesun, Trina Solar, Risen, and EGing, had a product listed at the beginning of 2022. In the following months, 2 more products were added, qualifying for the second highest rank in power rating – Yingli in February and Seraphim in March 2022. However, in addition to the PERC module with 670 W, EGing introduced another high-power TOPCon module with a 685 W rating in August 2022, which took 2nd place, pushing the whole group of 670 W modules to 3rd. This also meant that EGing was listed at both power levels. However, as mentioned above, Akcome lowered the power rating of its HJT module in December 2022 to 690 W. While this cost it the top spot, it did take 2nd

The 3 Highest Power Ratings - 2022 To H1 2024



Powerful performance of HJT: Over the past 2.5 years, HJT has reigned the power domain, holding the top ranks exclusively since November 2022. Huasun has been a consistent representative, currently offering the highest-powered module at 715 W together with TW Solar.

place, a position it held till August 2023. With Huasun upping its power rating, Risen's 700 W product was relegated to the 2nd place. However, it soon found a peer in Trina Solar when it commercialized its high-power TOPCon module with the same 700 W power rating in September 2023, a rank they continue to maintain till now.

As for the next power category, Tongwei's 660 W PERC module held this place till July. In August, EGing's TOPCon module displaced 8 PERC products with 670 W power from the 2nd place, which itself was relegated to 3rd with Akcome's HJT module ranking 2nd in December. However, EGing replaced this high-power module with a high-efficiency one, but with a lower power rating of 580 W. As a result, one PERC module each from Canadian Solar and Risen was elevated to a shared 3rd position, but only for the months of July and August. With the introduction of Huasun's 715 W module, Akcome's 690 W HJT module slipped to the 3rd place, but the company also increased the power ratings for this product range in December 2023 to 695 W.

It is evident from the power analysis that PERC was not able to support power ratings beyond 675 W for standard module sizes, and HJT and TOPCon are the only cell technologies that can lead up to 700 W module power. It looks like HJT is now the preferred choice for going to power levels beyond 700 W, as shown by Huasun and Tongwei.

6.2 Top power of each cell technology

When it comes to top power in each of the cell technologies, TOPCon technology was at the top in the beginning of 2022 with Jolywood offering a power rating of 700 W. In November 2022, the product's power was downgraded to 440 W, while maintaining its efficiency. As a result, EGing's 685 W module topped the November listing and kept its place through the first half of 2023. However, EGing also went the Jolywood way by replacing the module with lower power but with improved efficiency in July. This put the modules from Runergy and Suntech, featuring for the first time, at the top. The very next month, the latest generation TOPCon modules from DAS Solar and JA Solar, with a slightly higher power of 630 W, were the most powerful modules of the segment. Even this was short-lived as Trina Solar commercialized a 700 W module in September that remained the TOPCon module with the highest rated power till now. One reason for TOPCon not achieving high power is that most mainstream TOPCon followers adopted rectangular wafer formats that are smaller than G12, thus delivering relatively lower power.

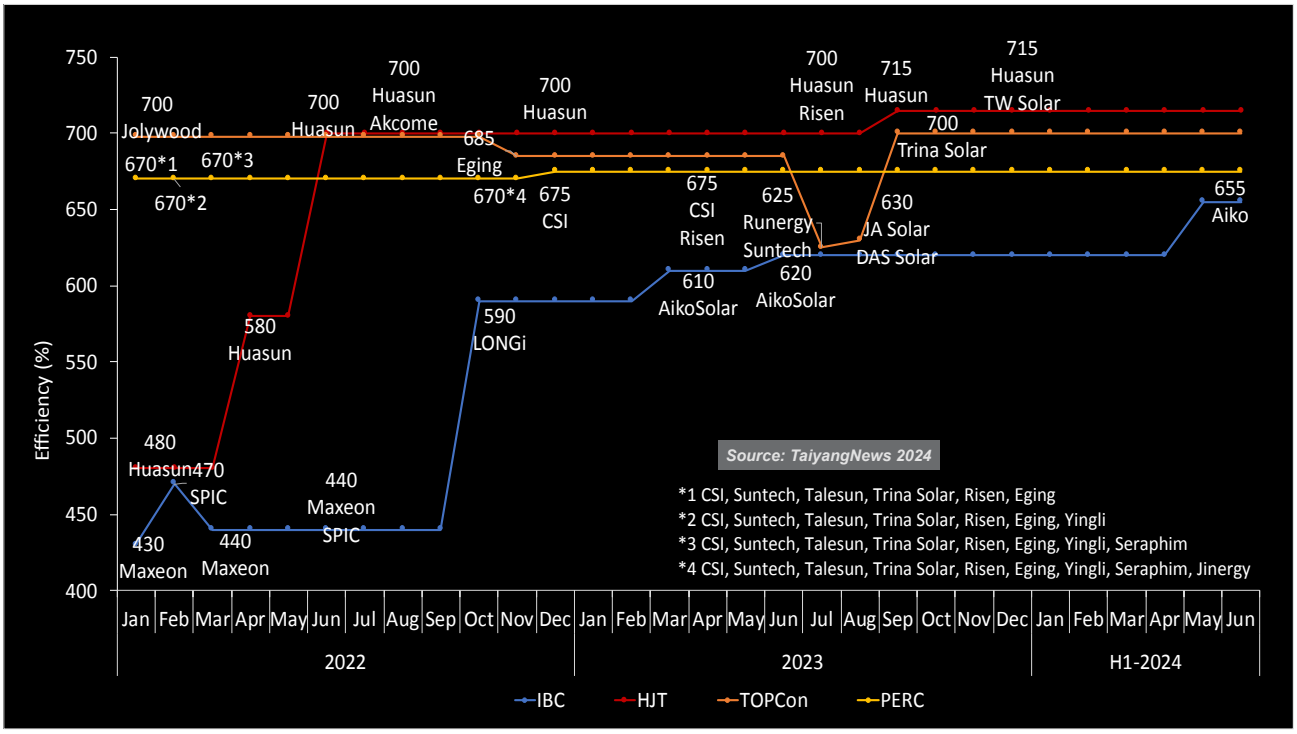
In contrast, the leading HJT makers are focusing heavily on the G12 format. However, the power journey of this technology started at a rather low level, and it was mostly the HJT pioneer Huasun that also led the power segment. The most powerful HJT module had a rated power of 480 W till March 2022, increased to 580 W in April and then again to 700 W in June. Akcome also joined this power class in August; however, the rated power of its product reduced to 690 W only 4 months later in December, leaving the top position to Huasun alone which it enjoyed till June 2023. In July, Risen joined the club with a 700 W HJT module, but then in September Huasun commercialized an even more powerful module of 715 W, as did Tongwei in December 2023. The duo still represents the best power class not just in the HJT segment, but in the entire TOP SOLAR MODULES listing.

PERC technology has the most stable top power ratings, meaning the technology has hit its threshold. Its top power of 670 W was maintained through the end of 2022. However, the companies offering such products changed track with time. A total of 6 PERC products featured in the January 2022 list with a power of 670 W from CSI, EGing, Risen, Suntech, Talesun, and Trina Solar. In February, 1 product was added from Yingli and 1 from Seraphim in March 2022, and the list remained unchanged for the coming months. The next change took place in November when Jinergy also joined the club. However, in December 2022, CSI introduced a 675 W module, which became the only PERC product to reach such a high power rating. While 675 W continued to be the top level, in April 2023, Risen also introduced a 675 W module, sharing the top rank with CSI.

Coming to IBC technology, the most powerful module in January 2022 was a 'residential rooftop size' 430 W module offered by Maxeon. In February, SPIC

promoted a 470 W module, but the product specs were removed from its website, thus a 435 W rated module replaced the previous product in our listing. In the same month, Maxeon improved its module slightly to 440 W, which took the top spot in March and continued its lead until September. In October 2022, LONGi entered the IBC league with a product built with 144 cells based on the M10 wafer format that not only had the top efficiency in the segment but also a larger format and the highest power of 590 W. Then in March 2023, AIKO's ABC module series featured a higher power of 610 W, which was even increased to 620 W in June. This remained the case till the end of the year. As for H1 2024, the highest efficiency IBC module from AIKO, introduced in May, had an accompanying power boost to 655 W, which remained the top IBC module for this time frame.

Top Power Of Each Cell Technology



Prominence of power: High module power seems to be the need of the day; the best power classes offered in every technology stream are 650 W+, including the premium IBC.

BAJsolar

Small Size & Large Energy

for residential rooftop

BM9R-T48HDB

Maximum Power Output:

450W

Maximum Module Efficiency:

22.52%

www.bajsolar.com

7. Company-wise progress

While we have discussed the progress of efficiency and power in the prior chapters, here are the summary tables for each company in our list with respect to efficiency and power. These 2 tables – one for 2023, the other for H1 2024 – show how the 2 characteristics have progressed for each company in every cell technology segment.

TOP SOLAR MODULES Producers' Efficiency Progress For Different Cell Technologies In 2023

Source: TaiyangNews 2024

Company	Techno-logy	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Progress
Aiko Solar	ABC	-	-	23.6	23.6	23.6	24	24	24	24	24	24	24	
Akcome	HJT	22.22	22.22	22.22	22.22	22.22	22.22	22.22	22.22	22.22	22.22	22.22	22.37	
Akcome	PERC	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	
Astronergy	PERC	21.5	21.5	21.6	21.6	21.6	-	21.6	21.6	21.5	21.5	21.5	21.5	
Astronergy	Topcon	22.1	22.1	22.4	22.4	22.5	22.5	22.5	22.5	22.6	22.6	22.6	22.65	
CSI	HJT	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	
CSI	TOPCon	-	-	22.3	22.3	22.3	22.5	22.5	22.5	22.5	22.5	22.5	22.5	
CSI	PERC	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	
CECEP	TOPCon	-	-	-	-	-	-	-	-	-	22.1	22.1	22.1	
CECEP	PERC	-	-	-	-	-	-	21.5	21.5	21.5	21.5	21.5	21.5	
DAS Solar	PERC	21.5	21.5	21.5	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	
DAS Solar	TOPCon	22.1	22.1	22.1	22.3	22.3	22.3	22.5	22.5	22.5	22.5	22.5	22.5	
DMEGC	TOPCon	-	-	-	-	-	22.45	22.45	22.45	22.45	22.45	22.45	22.45	
EGing	PERC	21.56	21.56	21.56	21.56	21.56	21.56	21.56	21.56	21.56	21.56	21.56	21.56	
EGing	TOPCon	22.05	22.05	22.05	22.05	22.05	22.05	22.44	22.45	22.45	22.45	22.45	22.45	
Qcells	PERC	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	21.5	
Qcells	TOPCon	22	22	22	22	22	-	-	-	-	-	-	-	
Qn-SOLAR	PERC	-	-	-	-	-	-	21.57	21.57	21.57	21.57	21.57	21.57	
Qn-SOLAR	TOPCon	-	-	-	-	-	-	22.45	22.45	22.45	22.45	22.45	22.45	
Runergy	PERC	-	-	-	-	-	-	21.5	21.5	21.5	21.5	21.5	21.5	
Runergy	TOPCon	-	-	-	-	-	-	22.4	22.4	22.4	22.4	22.4	22.5	
GCL-Si	PERC	-	-	-	-	-	-	21.5	21.6	21.6	21.6	21.6	21.6	
GCL-Si	TOPCon	-	-	-	-	-	-	22.3	22.3	22.3	22.3	22.3	22.3	
Huasun	HJT	22.53	22.53	22.53	22.53	22.53	22.53	22.53	22.53	23.02	23.02	23.02	23.02	
JA Solar	PERC	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	
JA Solar	TOPCon	22.4	22.4	22.4	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	
Jinergy	HJT	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.85	21.85	21.85	21.85	
Jinergy	PERC	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	
JinkoSolar	PERC	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	21.68	
JinkoSolar	TOPCon	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	22.65	
Jolywood	TOPCon	22.53	22.53	22.53	22.53	22.53	22.53	22.53	22.53	22.53	22.53	22.53	22.53	
LONGi	HPBC	22.8	22.8	22.8	22.8	23.2	23.2	23.2	23.2	23.2	23.2	23.2	23.2	
LONGi	PERC	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	
Maxeon	IBC	22.8	22.8	22.8	22.8	22.8	22.8	22.8	23	23	23	23	23	
Meyer Burger	HJT	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8	

TOP SOLAR MODULES Producers' Efficiency Progress For Different Cell Technologies In 2023

Source: TaiyangNews 2024

Company	Techno-logy	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Progress
REC	HJT	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	
Risen	HJT	-	-	-	-	-	22.5	22.5	22.5	22.5	22.5	22.5	22.5	
Risen	PERC	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	
Seraphim	PERC	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	
SolarSpace	PERC	-	-	-	-	-	-	21.57	21.57	21.57	21.57	21.57	21.57	
SolarSpace	TOPCon	-	-	-	-	-	-	22.02	22.02	22.02	22.02	22.02	22.45	
SPIC	IBC	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.3	22.8	22.8	22.8	22.8	
Suntech	PERC	21.6	21.6	21.6	21.6	21.6	21.6	21.7	21.7	21.7	21.7	21.7	21.7	
Suntech	TOPCon	-	-	-	-	-	-	22.4	22.4	22.4	22.4	22.4	22.4	
Talesun	PERC	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	
Trina Solar	PERC	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	
Trina Solar	TOPCon	21.9	21.9	21.9	22.3	22.3	22.5	22.5	22.5	22.5	22.5	22.5	22.5	
Tongwei	HJT	-	-	-	-	-	-	-	-	-	-	-	23	
Tongwei	PERC	21.5	21.5	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.7	
Tongwei	TOPCon	-	-	22.4	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	
URECO	HJT	-	-	-	-	-	-		22.44	22.44	22.44	22.44	22.44	
URECO	PERC	-	-	-	-	-	-	21.57	21.57	21.57	21.57	21.57	21.57	
URECO	TOPCon	-	-	-	-	-	-		22.45	22.45	22.45	22.45	22.45	
Yingli	PERC	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	21.57	
Yingli	TOPCon	-	-	-	-	-	-	-	-	22.36	22.36	22.36	22.36	
Yingli	PERC	-	-	-	-	-	-	-	-	21.57	21.57	21.57	21.57	
ZNSHINE	PERC	-	-	-	-	-	-	-	-	21.57	21.57	21.57	21.57	

TOP SOLAR MODULES Producers' Efficiency Progress For Different Cell Technologies In H1 2024

Source: TaiyangNews 2024

Company	Technology	Jan	Feb	Mar	Apr	May	Jun	Progress
AikoSolar	ABC	24	24	24	24	24.2	24.2	
Akcome	HJT	22.37	22.37	22.37	22.37	22.37	22.37	
Akcome	PERC	21.68	21.68	21.68	21.68	21.68	21.68	
Astronergy	PERC	21.5	21.5	21.5	21.5	21.5	21.5	
Astronergy	Topcon	22.65	22.65	22.8	22.8	22.8	22.8	
CSI	HJT-	22.5	22.5	-	-	-	-	
CSI	TOPCon	22.5	22.5	22.5	22.5	22.5	22.5	
CSI	PERC	21.7	21.7	21.7	21.7	21.7	21.7	
CECEP	PERC	21.5	21.5	21.5	21.5	21.5	21.5	
CECEP	TOPCon	22.1	22.1	22.1	22.1	22.1	22.1	
DASSolar	PERC	21.7	21.7	21.7	21.7	21.7	21.7	
DASSolar	TOPCon	22.5	22.5	22.5	22.5	22.5	22.5	
DMEGC	TOPCon	22.5	22.5	22.5	22.6	22.6	22.6	
Eging PV	PERC	21.56	21.56	21.56	21.56	21.56	21.56	
Eging PV	TOPCon	22.45	22.45	22.45	22.45	22.5	22.5	
GCL-Si	PERC	21.6	21.6	21.6	21.6	21.6	21.6	
GCL-Si	TOPCon	22.3	22.3	22.3	22.3	22.3	22.3	
Huasun	HJT	23.02	23.02	23.02	23.02	23.02	23.02	
JA Solar	PERC	21.6	21.6	21.6	21.6	21.6	21.6	
JA Solar	TOPCon	22.5	22.5	22.5	22.5	22.5	22.5	
Jinergy	HJT	21.85	21.85	21.85	21.85	21.85	21.85	
Jinergy	PERC	21.57	21.57	21.57	21.57	21.57	21.57	
JinkoSolar	PERC	21.68	21.68	21.68	21.68	21.68	21.68	
JinkoSolar	TOPCon	22.65	22.65	22.65	22.65	22.65	22.65	
Jolywood	TOPCon	22.53	22.53	22.53	22.53	22.53	22.53	
Kalyon PV	PERC	21.61	21.61	21.61	21.61	21.61	21.61	
Kalyon PV	TOPCon	22.38	22.38	22.38	22.38	22.38	22.38	
LONGi	HPBC	23.2	23.2	23.2	23.2	23.2	23.2	
LONGi	PERC	21.7	21.7	21.7	21.7	21.7	21.7	
Maxeon	IBC	23	23	23	23	24.1	24.1	
Meyer Burger	HJT	21.8	21.8	21.8	21.8	21.8	21.8	
QCells	PERC	21.5	21.5	21.5	21.5	21.5	21.5	
QCells	TOPCon	-	22.3	22.3	22.3	22.3	22.3	
Qn-SOLAR	PERC	21.57	21.57	21.57	21.57	21.57	21.57	
Qn-SOLAR	TOPCon	22.45	22.45	22.45	22.45	22.45	22.45	

TOP SOLAR MODULES Producers' Efficiency Progress For Different Cell Technologies In H1 2024

Source: TaiyangNews 2024

Company	Technology	Jan	Feb	Mar	Apr	May	Jun	Progress
REC	HJT	22.3	22.3	22.3	22.3	22.3	22.3	
Risen	HJT	22.5	22.5	22.5	22.5	22.5	22.5	
Risen	PERC	21.7	21.7	21.7	21.7	21.7	21.7	
Runergy	PERC	21.5	21.5	21.5	21.5	21.5	21.5	
Runergy	TOPCon	22.5	22.5	22.5	22.5	22.5	22.5	
Seraphim	PERC	21.57	21.57	21.57	21.57	21.57	21.57	
SolarSpace	PERC	21.57	21.57	21.57	21.57	21.57	21.57	
SolarSpace	TOPCon	22.45	22.45	22.45	22.45	22.45	22.45	
SPIC	IBC	22.8	22.8	22.8	22.8	22.8	22.8	
Suntech	PERC	21.7	21.7	21.7	21.7	21.7	21.7	
Suntech	TOPCon	22.4	22.4	22.4	22.4	22.4	22.4	
Talesun	PERC	21.6	21.6	21.6	21.6	21.6	21.6	
Trina Solar	PERC	21.6	21.6	21.6	21.6	21.6	21.6	
Trina Solar	TOPCon	22.5	22.5	22.5	22.5	22.5	22.5	
Tongwei	HJT	23	23	23	23	23	23	
Tongwei	PERC	21.7	21.7	21.7	21.7	21.7	21.7	
Tongwei	TOPCon	22.5	22.8	22.8	22.8	22.8	22.8	
URECO	HJT	22.44	22.44	22.44	22.44	22.44	22.44	
URECO	PERC	21.57	21.57	21.57	21.57	21.57	21.57	
URECO	TOPCon	22.45	22.45	22.45	22.45	22.45	22.45	
Yingli	PERC	21.57	21.57	21.57	21.57	21.57	21.57	
Yingli	TOPCon	22.36	22.36	22.36	22.36	22.36	22.36	
ZNSHINE	PERC	21.57	21.57	21.57	21.57	21.57	21.57	

TOP SOLAR MODULES Producer's Power Ratings Progress For Different Cell Technologies In 2023

Company	Techno-logy	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Progress
Aiko Solar	IBC	-	-	610	610	610	620	620	620	620	620	620	620	
Akcome	HJT	690	690	690	690	690	690	690	690	690	690	690	695	
Akcome	PERC	560	560	560	560	560	560	560	560	560	560	560	560	
Astronergy	PERC	550	550	670	670	670	670	670	670	555	555	555	555	
Astronergy	Topcon	570	570	625	625	580	580	580	580	585	585	585	585	
CSI	TOPCon	-	-	575	575	575	580	580	580	580	580	580	580	
CSI	HJT	440	440	440	440	440	440	440	440	440	440	440	440	
CSI	PERC	675	675	675	675	675	675	675	675	675	675	675	675	
DAS Solar	PERC	555	555	555	560	560	560	560	560	560	560	560	560	
DAS Solar	TOPCon	570	570	570	435	435	435	580	630	630	630	630	630	
DMEGC	TOPCon						580	580	580	580	580	580	580	
EGing	PERC	670	670	670	670	670	670	670	670	670	670	670	670	
EGing	TOPCon	685	685	685	685	685	685	580	580	580	580	580	580	
Qcells	PERC	590	590	590	590	590	590	590	590	590	590	590	590	
Qcells	TOPCon	395	395	395	395	395	395	-	-	-	-	-	-	
Qn-SOLAR	PERC	-	-	-	-	-	-	670	670	670	670	670	670	
Qn-SOLAR	TOPCon	-	-	-	-	-	-	580	580	580	580	580	580	
Runergy	PERC	-	-	-	-	-	-	555	600	600	600	600	600	
Runergy	TOPCon	-	-	-	-	-	-	625	625	625	625	625	580	
GCL-Si	PERC	-	-	-	-	-	-	555	670	670	670	670	670	
GCL-Si	TOPCon	-	-	-	-	-	-	580	575	575	575	575	575	
Huasun	HJT	700	700	700	700	700	700	700	700	715	715	715	715	
JA Solar	PERC	605	605	605	605	605	605	605	605	605	605	605	605	
JA Solar	TOPCon	625	625	625	580	580	580	580	630	630	630	630	630	
Jinergy	HJT	395	395	395	395	395	395	395	395	475	475	475	475	
Jinergy	PERC	670	670	670	670	670	670	670	670	670	670	670	670	
JinkoSolar	PERC	560	560	560	560	560	560	560	560	560	560	560	560	
JinkoSolar	TOPCon	585	585	585	585	585	585	585	585	585	585	585	585	
Jolywood	TOPCon	440	440	440	440	440	440	440	440	440	440	440	440	
LONGi	IBC	590	590	590	590	600	600	600	600	600	600	600	600	
LONGi	PERC	560	560	560	560	560	560	560	560	560	560	560	560	
Maxeon	IBC	440	440	440	440	440	440	440	445	445	445	445	445	
Meyer Burger	HJT	390	390	390	390	390	390	390	390	390	390	390	390	

Source: TaiyangNews 2024

TOP SOLAR MODULES Producer's Power Ratings Progress For Different Cell Technologies In 2023

Company	Techno-logy	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Progress
REC	HJT	430	430	430	430	430	430	430	430	430	430	430	430	
Risen	PERC	450	450	450	675	675	675	675	675	675	675	675	675	
Risen	HJT	-	-	-	-	-	700	700	700	700	700	700	700	
Seraphim	PERC	670	670	670	670	670	670	670	670	670	670	670	670	
SolarSpace	PERC	-	-	-	-	-	-	670	670	670	670	670	670	
SolarSpace	TOPCon	-	-	-	-	-	-	430	430	430	430	430	580	
SPIC	IBC	440	440	440	440	440	440	440	440	410	410	410	410	
Suntech	PERC	670	670	670	670	670	670	560	560	560	560	560	560	
Suntech	TOPCon	-	-	-	-	-	-	625	625	625	625	625	625	
Talesun	PERC	670	670	670	670	670	670	670	670	670	670	670	670	
Trina Solar	PERC	670	670	670	670	670	670	670	670	670	670	670	670	
Trina Solar	TOPCon	425	425	425	445	445	450	450	450	700	700	700	700	
Tongwei	HJT	-	-	-	-	-	-	-	-	-	-	-	715	
Tongwei	PERC	660	660	430	430	430	430	430	430	430	430	430	430	
Tongwei	TOPCon	-	-	430	580	580	580	580	580	580	580	580	580	
URECO	HJT	-	-	-	-	-	-	-	635	635	635	635	635	
URECO	TOPCon	-	-	-	-	-	-	-	580	580	580	580	580	
URECO	PERC	-	-	-	-	-	-	670	670	670	670	670	670	
Yingli	PERC	670	670	670	670	670	670	670	670	670	670	670	670	
Yingli	TOPCon	-	-	-	-	-	-	-	-	-	625	625	625	
Yingli	PERC	-	-	-	-	-	-	-	-	-	670	670	670	
ZNSHINE	PERC	-	-	-	-	-	-	-	-	-	670	670	670	

Source: TaiyangNews 2024

TOP SOLAR MODULES Producer's Power Ratings Progress For Different Cell Technologies In H1 2024

Company	Technology	Jan	Feb	Mar	Apr	May	Jun	Progress
AikoSolar	ABC	620	620	620	620	655	655	
Akcome	HJT	695	695	695	695	695	695	
Akcome	PERC	560	560	560	560	560	560	
Astronergy	PERC	555	555	555	555	555	555	
Astronergy	Topcon	585	585	590	590	590	590	
CSI	HJT	440	440					
CSI	TOPCon	580	580	580	580	580	580	
CSI	PERC	675	675	675	675	675	675	
CECEP	PERC	555	555	555	555	555	555	
CECEP	TOPCon	570	570	570	570	570	570	
DASSolar	PERC	560	560	560	560	560	560	
DASSolar	TOPCon	630	630	630	630	630	630	
DMEGC	TOPCon	580	580	580	580	580	580	
Eging PV	PERC	670	670	670	670	670	670	
Eging PV	TOPCon	580	580	580	580	580	580	
GCL-Si	PERC	670	670	670	670	670	670	
GCL-Si	TOPCon	575	575	575	575	575	575	
Huasun	HJT	715	715	715	715	715	715	
JA Solar	PERC	605	605	605	605	605	605	
JA Solar	TOPCon	630	630	630	630	630	630	
Jinergy	HJT	475	475	475	475	475	475	
Jinergy	PERC	670	670	670	670	670	670	
JinkoSolar	PERC	560	560	560	560	560	560	
JinkoSolar	TOPCon	585	585	585	585	585	585	
Jolywood	TOPCon	440	440	440	440	440	440	
Kalyon PV	PERC	380	380	380	380	380	380	
Kalyon PV	TOPCon	580	580	580	580	580	580	
LONGi	HPBC	600	600	600	600	600	600	
LONGi	PERC	560	560	560	560	560	560	
Maxeon	IBC	445	445	445	445	445	445	
Meyer Burger	HJT	390	390	390	390	390	390	
QCells	PERC	590	590	590	590	590	590	
QCells	TOPCon		400	435	435	435	435	
Qn-SOLAR	PERC	670	670	670	670	670	670	
Qn-SOLAR	TOPCon		580	580	580	580	580	

Source: TaiyangNews 2024

TOP SOLAR MODULES Producer's Power Ratings Progress For Different Cell Technologies In H1 2024

Company	Technology	Jan	Feb	Mar	Apr	May	Jun	Progress
REC	HJT	430	430	430	430	430	430	
Risen	HJT	700	700	700	700	700	700	
Risen	PERC	675	675	675	675	675	675	
Runergy	PERC	600	600	600	600	600	600	
Runergy	TOPCon	580	580	580	580	580	580	
Seraphim	PERC	670	670	670	670	670	670	
SolarSpace	PERC	670	670	670	670	670	670	
SolarSpace	TOPCon	580	580	580	580	580	580	
SPIC	IBC	410	410	410	410	410	410	
Suntech	PERC	560	560	560	560	560	560	
Suntech	TOPCon	605	605	605	605	605	605	
Talesun	PERC	670	670	670	670	670	670	
Trina Solar	PERC	670	670	670	670	670	670	
Trina Solar	TOPCon	700	700	700	700	700	700	
Tongwei	HJT	715	715	715	715	715	715	
Tongwei	PERC	430	430	430	430	430	430	
Tongwei	TOPCon	580	590	590	590	590	590	
URECO	HJT	635	635	635	635	635	635	
URECO	PERC	670	670	670	670	670	670	
URECO	TOPCon	580	580	580	580	580	580	
Yingli	PERC	670	670	670	670	670	670	
Yingli	TOPCon	625	625	625	625	625	625	
ZNSHINE	PERC	670	670	670	670	670	670	

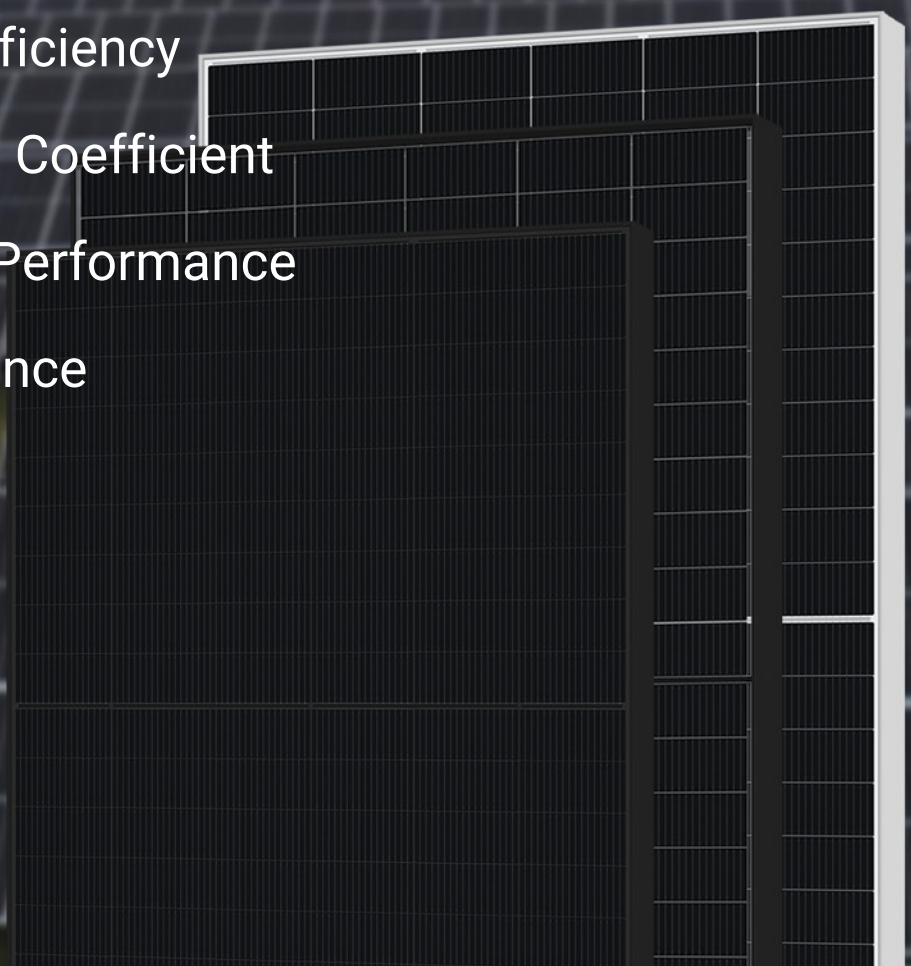
Source: TaiyangNews 2024

DMEGC SOLAR

Infinity Power, Infinity Future

iNFINITY RT Series modules

- New N-type Rectangular Wafer Technology
- Ultra-high Power and Efficiency
- Optimized Temperature Coefficient
- Outstanding Low Light Performance
- Exceptional PID Resistance
- Enhanced Reliability
- Lower Degradation
- Higher Bifacial Gain



www.dmegcsolar.com

Annex: Monthly TOP SOLAR MODULE H1 2024 Rankings

TAIYANGNEWS ALL ABOUT SOLAR POWER

TaiyangNews Top Modules: Highest Efficient Commercial Solar Modules 1-2024

Rank	Company	Series	Model	Wafer type	Cell Size	Cells No.	Cell Tech	Module Technology	Power (W)	Efficiency (%)
1	AIKO	ABC White hole	AIKO-A620-MAH72Mw	n-type	182	144	ABC	Half-cell, Back Contact	620	24.0
2	LONGi	Hi-MO X6	LR5-72HTH-600M	p-type	182	144	HPBC	Half-cell, Back Contact	600	23.2
3	HUASUN	Himalaya	HS-210-B132DS	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.02
4	TW SOLAR	-	TWMHF-66HD715	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.0
4	Maxeon	Maxeon 6	SPR-MAX6-445-E4-AC	n-type	166	66	IBC	Back Contact	445	23.0
6	SPIC	ANDROMEDA 3.0	SPICN6(LDF)-60/BIH	n-type	166	120	TBC	Back Contact, Half-cell, MBB	410	22.8
7	ASTRONERGY	Astro N5	CHSM72N(DG)/F-BH	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	585	22.65
7	JinKO	Tiger Neo	JKM585N-72HL4-V	n-type	-	144	TOPCon	Half-cell, MBB	585	22.65
9	中来股份	Niwa Pro	JW-HD108N	n-type	182	108	TOPCon	Bifacial, Half-cell, MBB	440	22.53
10	risen	Hyper-ion	RSM132-8-700BHDG	n-type	210	132	HJT	Bifacial,Half-cell, MBB	700	22.5
10	Trinasolar	Vertex N	TSM-NEG21C.20	n-type	210	132	TOPCon	Bifacial, Half-cell, MBB	700	22.5
10	DASOLAR	-	DAS-DH156NA	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	630	22.5
10	JA SOLAR	DeepBlue 4.0 Pro	JAM72D42 630/LB	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	630	22.5
10	Canadian Solar	TOPHiKu6	CS6W-560-580T	n-type	182	144	TOPCon	Half-cell, MBB	580	22.5
10	DMEGC	-	DM580M10T-B72HSW/HBW	n-type	182	144	TOPCon	Bifacial, halfcell, MBB	580	22.5
10	RUNERGY	-	HY-DH144N8	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.5
10	TW SOLAR	-	TWMND-72HS580W	n-type	182	144	TOPCon	Half-cell, MBB	440	22.5
10	Canadian Solar	HiHero	CS6R-420-440H-AG	n-type	182	108	HJT	Half-cell, MBB	580	22.45
19	Eging PV	STAR Pro	EG-580NT72-HL/BF-DG	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	Qn-SOLAR	-	QNN182-HG-72	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	SolarSpace	Lumina II	SS8-72HD-580N	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	URECO	GLORY	FBF580B8D	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
23	URECO	HELLO	FCG635B7Y	n-type	210	120	HJT	Bifacial, Half-cell, MBB	635	22.44
24	Suntech	Ultra V Pro Plus	STP625S - C78/Nsh+	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	625	22.4
25	Akcome	Ak iPower	SKA611HDGDC	n-type	210	132	HJT	Bifacial, Half-cell, MBB	695	22.37
26	Yingli	PANDA 3.0 PRO	YL625CF78 e/2	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	625	22.36
27	GCL-Si	GCL GEMINI	GCL-NT10/72GDF	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	575	22.3
27	REC	Alpha Pure-R	REC430AA Pure-R	n-type	210	80	HJT	Half-cell, SWCT	430	22.3
29	CECEP	-	CEC6-72-570TDHV	n-type	182	144	TOPcon	Bifacial, Half-cell, MBB	570	22.1
30	Jinergy	-	JNHM144-475	n-type	166	144	HJT	Bifacial, Half-cell, MBB	475	21.85
31	Meyer Burger	Meyer Burger Glass	Heterojunction Bifacial	n-type	-	120	HJT	Bifacial, Half-cell, SWCT	390	21.8
32	Canadian Solar	HiKu7	CS7N-645-675MS	p-type	210	132	PERC	Half-cell, MBB	675	21.7
32	risen	TITAN	RSM132-8-655M-675M	p-type	210	132	PERC	Half-cell, MBB	675	21.7
32	DASOLAR	-	DAS-DH144PA	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.7
32	LONGi	Hi-MO 5m	LR5-72HPH 540 - 560M	p-type	182	144	PERC	Half-cell, MBB	560	21.7
32	Suntech	Ultra V	STP560S-C72/Vmh	p-type	182	144	PERC	Half-cell, MBB	560	21.7
32	TW SOLAR	-	TH400-430PMB7 44SCS	p-type	210	305 (61x5)	PERC	Shingle	430	21.7
38	Akcome	Ak iChaser	SK9612MDGDC	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.68
38	JinKO	Tiger Pro	JKM560M-72HL4-V	p-type	182	144	PERC	Half-cell, MBB	560	21.68
40	GCL-Si	GCL GEMINI	GCL-M12/66GDF	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
40	Talesun	BIPRO	TD8G66M	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
40	Trinasolar	Vertex	TSM-DE21	p-type	210	132	PERC	Half-cell, MBB	670	21.6
40	JA SOLAR	DeepBlue 3.0	JAM78D30 585-605/MB	p-type	182	156	PERC	Bifacial, Half-cell, MBB	605	21.6
44	Jinergy	PERC Series	JNBM132-650-670	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
44	Qn-SOLAR	-	QNM210-HG-66	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
44	Seraphim	S5 Bifacial	SRP-670-BMC-BG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
44	SolarSpace	Lumina I	SS9-66HS 650-670M	p-type	210	132	PERC	Half-cell, MBB	670	21.57
44	URECO	PEACH	FCK670MED	p-type	210	132	PERC	Half-cell, MBB	670	21.57
44	Yingli	YLM 3.0 Plus	YLxxxDF66 f/2	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
44	ZNSHINE	-	ZXM8-TPLDD	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
51	Eging PV	Aurora	EG-670M66-HU/BF-DG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.56
52	RUNERGY	-	HY-DH156P8	p-type	182	156	PERC	Bifacial, Half-cell, MBB	600	21.5
52	Qcells	Q PEAK	DUO XL-G11.3	p-type	-	156	PERC	Half-cell, MBB	590	21.5
52	ASTRONERGY	Astro5 Twins	CHSM72M(DG)/F-BH	p-type	210	144	PERC	Bifacial, Half-cell, MBB	555	21.5
52	CECEP	-	CEC6-72-555MDHV	p-type	182	144	PERC	Bifacial, Half-cell, MBB	555	21.5

Top Solar Modules 2023 Badge of Excellence

TaiyangNews Top Modules: Highest Efficient Commercial Solar Modules 2-2024

Rank	Company	Series	Model	Wafer type	Cell Size	Cells No.	Cell Tech	Module Technology	Power (W)	Efficiency (%)
1	AIKO	ABC White hole	AIKO-A620-MAH72Mw	n-type	182	144	ABC	Half-cell, Back Contact	620	24.0
2	LONGi	Hi-MO X6	LR5-72HTH-600M	p-type	182	144	HPBC	Half-cell, Back Contact	600	23.2
3	HUASUN	Himalaya	HS-210-B132DS	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.02
4	TW SOLAR	-	TWMHF-66HD715W	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.0
4	Maxeon	Maxeon 6	SPR-MAX6-445-E4-AC	n-type	166	66	IBC	Back Contact	445	23.0
6	TW SOLAR	-	TWMND-72HS590W	n-type	182	144	TOPCon	Half-cell, MBB	590	22.8
6	SPIC	ANDROMEDA 3.0	SPICN6(LDF)-60/BIH	n-type	166	120	TBC	Back Contact, Half-cell, MBB	410	22.8
8	ASTRONERGY	Astro N5	CHSM72N(DG)/F-BH	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	585	22.65
8	JinKO	Tiger Neo	JKM585N-72HL4-BDV	n-type	-	144	TOPCon	Bifacial, Half-cell, MBB	585	22.65
10	中来股份 JOLYWOOD	Niwa Pro	JW-HD108N	n-type	182	108	TOPCon	Bifacial, Half-cell, MBB	440	22.53
11	risen	Hyper-ion	RSM132-8-700BHDG	n-type	210	132	HJT	Bifacial,Half-cell, MBB	700	22.5
11	Trinasolar	Vertex N	TSM-NEG21C.20	n-type	210	132	TOPCon	Bifacial, Half-cell, MBB	700	22.5
11	DASOLAR	-	DAS-DH156NA	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	630	22.5
11	JA SOLAR	DeepBlue 4.0 Pro	JAM72D42 630/LB	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	630	22.5
11	Canadian Solar	TOPHiKu6	CS6W-560-580T	n-type	182	144	TOPCon	Half-cell, MBB	580	22.5
11	DMEGC	Infinity	DM580M10T-B72HSW	n-type	182	144	TOPCon	Bifacial, halfcell, MBB	580	22.5
11	RUNERGY	-	HY-DH144N8	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.5
11	Canadian Solar	HiHero	CS6R-420-440H-AG	n-type	182	108	HJT	Half-cell, MBB	440	22.5
19	Eging PV	STAR Pro	EG-580NT72-HL/BF-DG	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	Qn-SOLAR	-	QNN182-HG-72	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	SolarSpace	Lumina II	SS8-72HD-580N	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	URECO	GLORY	FBF580B8D	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
23	URECO	HELLO	FCG635B7Y	n-type	210	120	HJT	Bifacial, Half-cell, MBB	635	22.44
24	Suntech	Ultra V Pro Plus	STP625S - C78/Nsh+	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	625	22.4
25	Akcome	Ak iPower	SKA611HDGDC	n-type	210	132	HJT	Bifacial, Half-cell, MBB	695	22.37
26	Yingli	PANDA 3.0 PRO	YL625CF78 e/2	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	625	22.36
27	GCL-Si	GCL GEMINI	GCL-NT10/72GDF	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	575	22.3
27	REC	Alpha Pure-R	REC430AA Pure-R	n-type	210	80	HJT	Half-cell, SWCT	430	22.3
27	Qcells	Q.TRON SMART	Q.TRON SMART-G1+	n-type	-	120	TOPCon	Half-cell, MBB	400	22.3
30	CECEP	-	CEC6-72-570TDHV	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	570	22.1
31	Jinergy	-	JNHM144-475	n-type	166	144	HJT	Bifacial, Half-cell, MBB	475	21.85
32	Meyer Burger	Meyer Burger Glass	Heterojunction Bifacial	n-type	-	120	HJT	Bifacial, Half-cell, SWCT	390	21.8
33	Canadian Solar	HiKu7	CS7N-645-675MS	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	risen	TITAN	RSM132-8-655M-675M	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	DASOLAR	-	DAS-DH144PA	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.7
33	LONGi	Hi-MO 5m	LR5-72HPH 540 - 560M	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	Suntech	Ultra V	STP560S-C72/Vmh	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	TW SOLAR	-	TH400-430PMB7 44SCS	p-type	210	305 (61x5)	PERC	Shingle	430	21.7
39	Akcome	Ak iChaser	SK9612MDGDC	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.68
39	JinKO	Tiger Pro	JKM560M-72HL4-V	p-type	182	144	PERC	Half-cell, MBB	560	21.68
41	GCL-Si	GCL GEMINI	GCL-M12/66GDF	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
41	Talesun	BIPRO	TD8G66M	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
41	Trinasolar	Vertex	TSM-DE21	p-type	210	132	PERC	Half-cell, MBB	670	21.6
41	JA SOLAR	DeepBlue 3.0	JAM78D30 585-605/MB	p-type	182	156	PERC	Bifacial, Half-cell, MBB	605	21.6
45	Jinergy	PERC Series	JNBM132-650-670	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
45	Qn-SOLAR	-	QNM210-HG-66	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
45	Seraphim	S5 Bifacial	SRP-670-BMC-BG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
45	SolarSpace	Lumina I	SS9-66HS 650-670M	p-type	210	132	PERC	Half-cell, MBB	670	21.57
45	URECO	PEACH	FCK670MED	p-type	210	132	PERC	Half-cell, MBB	670	21.57
45	Yingli	YLM 3.0 Plus	YLxxxDF66 f/2	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
45	ZNSHINE	-	ZXM8-TPLDD	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
52	Eging PV	Aurora	EG-670M66-HU/BF-DG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.56
53	RUNERGY	-	HY-DH156P8	p-type	182	156	PERC	Bifacial, Half-cell, MBB	600	21.5
53	Qcells	Q PEAK	DUO XL-G11.3	p-type	-	156	PERC	Half-cell, MBB	590	21.5
53	ASTRONERGY	Astro5 Twins	CHSM72M(DG)/F-BH	p-type	210	144	PERC	Bifacial, Half-cell, MBB	555	21.5
53	CECEP	-	CEC6-72-555MDHV	p-type	182	144	PERC	Bifacial, Half-cell, MBB	555	21.5

Top Solar Modules 2023 Badge of Excellence

TaiyangNews Top Modules: Highest Efficient Commercial Solar Modules 3-2024

Rank	Company	Series	Model	Wafer type	Cell Size	Cells No.	Cell Tech	Module Technology	Power (W)	Efficiency (%)
1	AIKO	ABC White hole	AIKO-A620-MAH72Mw	n-type	182	144	ABC	Half-cell, Back Contact	620	24.0
2	LONGi	Hi-MO X6	LR5-72HTH-600M	p-type	182	144	HPBC	Half-cell, Back Contact	600	23.2
3	HUASUN	Himalaya	HS-210-B132DS	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.02
4	TW SOLAR	-	TWMHF-66HD715W	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.0
4	Maxeon	Maxeon 6	SPR-MAX6-445-E4-AC	n-type	166	66	IBC	Back Contact	445	23.0
6	ASTRONERGY	Astro N5	CHSM72N(DG)/F-BH	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	590	22.8
6	TW SOLAR	-	TWMND-72HS590W	n-type	182	144	TOPCon	Half-cell, MBB	590	22.8
6	SPIC	ANDROMEDA 3.0	SPICN6(LDF)-60/BIH	n-type	166	120	TBC	Back Contact, Half-cell, MBB	410	22.8
9	JinKO	Tiger Neo	JKM585N-72HL4-BDV	n-type	-	144	TOPCon	Bifacial, Half-cell, MBB	585	22.65
10	中来股份 JOLYWOOD	Niwa Pro	JW-HD108N	n-type	182	108	TOPCon	Bifacial, Half-cell, MBB	440	22.53
11	risen	Hyper-ion	RSM132-8-700BHDG	n-type	210	132	HJT	Bifacial,Half-cell, MBB	700	22.5
11	Trinasolar	Vertex N	TSM-NEG21C.20	n-type	210	132	TOPCon	Bifacial, Half-cell, MBB	700	22.5
11	DASOLAR	-	DAS-DH156NA	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	630	22.5
11	JA SOLAR	DeepBlue 4.0 Pro	JAM72D42 630/LB	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	630	22.5
11	Canadian Solar	TOPHiKu6	CS6W-580T	n-type	182	144	TOPCon	Half-cell, MBB	580	22.5
11	DMEGC SOLAR	Infinity	DM580M10T-B72HSW	n-type	182	144	TOPCon	Bifacial, halfcell, MBB	580	22.5
11	RUNERGY	-	HY-DH144N8	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.5
18	Eging PV	STAR Pro	EG-580NT72-HL/BF-DG	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
18	Qn-SOLAR	-	QNN182-HG-72	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
18	SolarSpace	Lumina II	SS8-72HD-580N	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
18	URECO	GLORY	FBF580B8D	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
22	URECO	HELLO	FCG635B7Y	n-type	210	120	HJT	Bifacial, Half-cell, MBB	635	22.44
23	Suntech	Ultra V Pro Plus	STP625S - C78/Nsh+	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	625	22.4
24	Kalyon PV	-	-	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.38
25	Akcome	Ak iPower	SKA611HDGDC	n-type	210	132	HJT	Bifacial, Half-cell, MBB	695	22.37
26	Yingli	PANDA 3.0 PRO	YL625CF78 e/2	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	625	22.36
27	GCL-Si	GCL GEMINI	GCL-NT10/72GDF	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	575	22.3
27	Qcells	Q.TRON	Q.TRON M-G2+	n-type	-	108	TOPCon	Half-cell, MBB	435	22.3
27	REC	Alpha Pure-R	REC430AA Pure-R	n-type	210	80	HJT	Half-cell, SWCT	430	22.3
30	CECEP	-	CEC6-72-570TDHV	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	570	22.1
31	Jinergy	-	JNHM144-475	n-type	166	144	HJT	Bifacial, Half-cell, MBB	475	21.85
32	Meyer Burger	Meyer Burger Glass	MB_TG120ByB_390W	n-type	-	120	HJT	Bifacial, Half-cell, SWCT	390	21.8
33	Canadian Solar	HiKu7	CS7N-645-675MS	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	risen	TITAN	RSM132-8-655M-675M	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	DASOLAR	-	DAS-DH144PA	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.7
33	LONGi	Hi-MO 5m	LR5-72HPH 540 - 560M	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	Suntech	Ultra V	STP560S-C72/Vmh	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	TW SOLAR	-	TH400-430PMB7 44SCS	p-type	210	305 (61x5)	PERC	Shingle	430	21.7
39	Akcome	Ak iChaser	SK9612MDGDC	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.68
39	JinKO	Tiger Pro	JKM560M-72HL4-V	p-type	182	144	PERC	Half-cell, MBB	560	21.68
41	Kalyon PV	-	-	p-type	158.75	144	PERC	Bifacial, Half-cell, MBB	380	21.61
42	GCL-Si	GCL GEMINI	GCL-M12/66GDF	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
42	Talesun	BIPRO	TD8G66M	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
42	Trinasolar	Vertex	TSM-DE21	p-type	210	132	PERC	Half-cell, MBB	670	21.6
42	JA SOLAR	DeepBlue 3.0	JAM78D30 585-605/MB	p-type	182	156	PERC	Bifacial, Half-cell, MBB	605	21.6
46	Jinergy	PERC Series	JNBM132-650-670	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	Qn-SOLAR	-	QNM210-HG-66	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	Seraphim	S5 Bifacial	SRP-670-BMC-BG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	SolarSpace	Lumina I	SS9-66HS 650-670M	p-type	210	132	PERC	Half-cell, MBB	670	21.57
46	URECO	PEACH	FCK670MED	p-type	210	132	PERC	Half-cell, MBB	670	21.57
46	Yingli	YLM 3.0 Plus	YLxxxDF66 f/2	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	ZNSHINE	-	ZXM8-TPLDD	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
53	Eging PV	Aurora	EG-670M66-HU/BF-DG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.56
54	RUNERGY	-	HY-DH156P8	p-type	182	156	PERC	Bifacial, Half-cell, MBB	600	21.5
54	Qcells	Q PEAK	DUO XL-G11.3	p-type	-	156	PERC	Half-cell, MBB	590	21.5
54	ASTRONERGY	Astro5 Twins	CHSM72M(DG)/F-BH	p-type	210	144	PERC	Bifacial, Half-cell, MBB	555	21.5
54	CECEP	-	CEC6-72-555MDHV	p-type	182	144	PERC	Bifacial, Half-cell, MBB	555	21.5

Top Solar Modules 2023 Badge of Excellence

TaiyangNews Top Modules: Highest Efficient Commercial Solar Modules 04-2024

Rank	Company	Series	Model	Wafer type	Cell Size	Cells No.	Cell Tech	Module Technology	Power (W)	Efficiency (%)
1	AIKO	ABC White hole	AIKO-A620-MAH72Mw	n-type	182	144	ABC	Half-cell, Back Contact	620	24.0
2	LONGi	Hi-MO X6	LR5-72HTH-600M	p-type	182	144	HPBC	Half-cell, Back Contact	600	23.2
3	HUASUN	Himalaya	HS-210-B132DS	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.02
4	TW SOLAR	-	TWMHF-66HD715W	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.0
4	Maxeon	Maxeon 6	SPR-MAX6-445-E4-AC	n-type	166	66	IBC	Back Contact	445	23.0
6	ASTRONERGY	Astro N5	CHSM72N(DG)/F-BH	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	590	22.8
6	TW SOLAR	-	TWMND-72HS570-590W	n-type	182	144	TOPCon	Half-cell, MBB	590	22.8
6	SPIC	ANDROMEDA 3.0	SPICN6(LDF)-60/BIH	n-type	166	120	TBC	Back Contact, Half-cell, MBB	410	22.8
9	JinKO	Tiger Neo	JKM585N-72HL4-BDV	n-type	-	144	TOPCon	Bifacial, Half-cell, MBB	585	22.65
10	DMEGC	Infinity	DM585M10T-72HSW-V	n-type	182	144	TOPCon	Half-cell, MBB	585	22.6
11	中来新材 JOLYWOOD	Niwa Pro	JW-HD108N	n-type	182	108	TOPCon	Bifacial, Half-cell, MBB	440	22.53
12	risen	Hyper-ion	RSM132-8-700BHDG	n-type	210	132	HJT	Bifacial,Half-cell, MBB	700	22.5
12	Trinasolar	Vertex N	TSM-NEG21C.20	n-type	210	132	TOPCon	Bifacial, Half-cell, MBB	700	22.5
12	DASOLAR	-	DAS-DH156NA	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	630	22.5
12	JA SOLAR	DeepBlue 4.0 Pro	JAM72D42 630/LB	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	630	22.5
12	Canadian Solar	TOPHiKu6	CS6W-580T	n-type	182	144	TOPCon	Half-cell, MBB	580	22.5
12	RUNERGY	-	HY-DH144N8	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.5
18	Eging PV	STAR Pro	EG-580NT72-HL/BF-DG	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
18	Qn-SOLAR	-	QNN182-HG-72	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
18	SolarSpace	Lumina II	SS8-72HD-580N	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
18	URECO	GLORY	FBF580B8D	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
22	URECO	HELLO	FCG635B7Y	n-type	210	120	HJT	Bifacial, Half-cell, MBB	635	22.44
23	Suntech	Ultra V Pro	STP605S-H66-Nsh+	n-type	182	132	TOPCon	Bifacial, Half-cell, MBB	605	22.4
24	Kalyon PV	-	-	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.38
25	Akcome	Ak iPower	SKA611HDGDC	n-type	210	132	HJT	Bifacial, Half-cell, MBB	695	22.37
26	Yingli	PANDA 3.0 PRO	YL625CF78 e/2	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	625	22.36
27	GCL-SI	GCL LOTUS	GCL-NT10/72GDF	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	575	22.3
27	Qcells	Q.TRON	Q.TRON M-G2+	n-type	-	108	TOPCon	Half-cell, MBB	435	22.3
27	REC	Alpha Pure-R	REC430AA Pure-R	n-type	210	80	HJT	Half-cell, SWCT	430	22.3
30	CECEP	-	CEC6-72-570TDHV	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	570	22.1
31	Jinergy	-	JNHM144-475	n-type	166	144	HJT	Bifacial, Half-cell, MBB	475	21.85
32	Meyer Burger	Meyer Burger Glass	MB_TG120ByB_390W	n-type	-	120	HJT	Bifacial, Half-cell, SWCT	390	21.8
33	Canadian Solar	HiKu7	CS7N-645-675MS	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	risen	TITAN	RSM132-8-655M-675M	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	DASOLAR	-	DAS-DH144PA	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.7
33	LONGi	Hi-MO 5m	LR5-72HPH 545 - 560M	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	Suntech	Ultra V	STP560S-C72/Vmh	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	TW SOLAR	-	TH400-430PMB7 44SCS	p-type	210	305 (61x5)	PERC	Shingle	430	21.7
39	Akcome	Ak iChaser	SK9612MDGDC	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.68
39	JinKO	Tiger Pro	JKM560M-72HL4-V	p-type	182	144	PERC	Half-cell, MBB	560	21.68
41	Kalyon PV	-	-	p-type	158.75	144	PERC	Bifacial, Half-cell, MBB	380	21.61
42	GCL-Si	GCL GEMINI	GCL-M12/66GDF	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
42	Talesun	BIPRO	TD8G66M	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
42	Trinasolar	Vertex	TSM-DE21	p-type	210	132	PERC	Half-cell, MBB	670	21.6
42	JA SOLAR	DeepBlue 3.0	JAM78D30 585-605/MB	p-type	182	156	PERC	Bifacial, Half-cell, MBB	605	21.6
46	Jinergy	PERC Series	JNBM132-650-670	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	Qn-SOLAR	-	QNM210-HG-66	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	Seraphim	S5 Bifacial	SRP-670-BMC-BG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	SolarSpace	Lumina I	SS9-66HS 650-670M	p-type	210	132	PERC	Half-cell, MBB	670	21.57
46	URECO	PEACH	FCK670MED	p-type	210	132	PERC	Half-cell, MBB	670	21.57
46	Yingli	YLM 3.0 Plus	YLxxxDF66 f/2	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	ZNSHINE	-	ZXM8-TPLDD	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
53	Eging PV	Aurora	EG-670M66-HU/BF-DG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.56
54	RUNERGY	-	HY-DH156P8	p-type	182	156	PERC	Bifacial, Half-cell, MBB	600	21.5
54	Qcells	Q PEAK	DUO XL-G11.3	p-type	-	156	PERC	Half-cell, MBB	590	21.5
54	ASTRONERGY	Astro5 Twins	CHSM72M(DG)/F-BH	p-type	210	144	PERC	Bifacial, Half-cell, MBB	555	21.5
54	CECEP	-	CEC6-72-555MDHV	p-type	182	144	PERC	Bifacial, Half-cell, MBB	555	21.5

Top Solar Modules 2023 Badge of Excellence

TaiyangNews Top Modules: Highest Efficient Commercial Solar Modules 05-2024

Rank	Company	Series	Model	Wafer type	Cell Size	Cells No.	Cell Tech	Module Technology	Power (W)	Efficiency (%)
1	AIKO	Comet 2U	AIKO-G655-MCH72Mw	n-type	182	144	ABC	Half-cell, Back Contact	655	24.2
2	Maxeon	Maxeon 7	SPR-MAX7-445-PT	n-type	125	112	IBC	Back Contact	445	24.1
3	LONGi	Hi-MO X6	LR5-72HTH-590-600M	p-type	182	144	HPBC	Half-cell, Back Contact	600	23.2
4	HUASUN	Himalaya	HS-210-B132DS715W	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.02
5	TW SOLAR	-	TWMHF-66HD690-715W	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.0
6	ASTRONERGY	Astro N5	CHSM72N(DG)/F-BH570-590W	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	590	22.8
6	TW SOLAR	-	TWMND-72HS570-590W	n-type	182	144	TOPCon	Half-cell, MBB	590	22.8
6	SPIC	ANDROMEDA 3.0	SPICN6(LDF)-60/BIH410W	n-type	166	120	TBC	Bifacial, Back Contact, Half-cell, MBB	410	22.8
9	JinKO	Tiger Neo	JKM570-585N-72HL4-BDV	n-type	-	144	TOPCon	Bifacial, Half-cell, MBB	585	22.65
10	DMEGC	Infinity	DM585M10T-72HSW-V	n-type	182	144	TOPCon	Half-cell, MBB	585	22.6
11	中来股份 ZHONGHUAN	Niwa Pro	JW-HD108N415-440W	n-type	182	108	TOPCon	Bifacial, Half-cell, MBB	440	22.53
12	risen	Hyper-ion	RSM132-8-700BHDG	n-type	210	132	HJT	Bifacial,Half-cell, MBB	700	22.5
12	Trinasolar	Vertex N	TSM-NEG21C.20	n-type	210	132	TOPCon	Bifacial, Half-cell, MBB	700	22.5
12	DASOLAR	-	DAS-DH156NA-610-630W	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	630	22.5
12	JA SOLAR	DeepBlue 4.0 Pro	JAM72D42 630/LB	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	630	22.5
12	Canadian Solar	TOPHiKu6	CS6W-570-580T	n-type	182	144	TOPCon	Half-cell, MBB	580	22.5
12	Eging PV	STAR Pro	EG-580NT72-HL/BF-DG	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.5
12	RUNERGY	-	HY-DH144N8	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.5
19	Qn-SOLAR	-	QNN182-HG-72	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	SolarSpace	Lumina II	SS8-72HD-580N	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	URECO	GLORY	FBF580B8D	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
22	URECO	HELLO	FCG635B7Y	n-type	210	120	HJT	Bifacial, Half-cell, MBB	635	22.44
23	Suntech	Ultra V Pro	STP605S-H66-Nsh+	n-type	182	132	TOPCon	Bifacial, Half-cell, MBB	605	22.4
24	Kalyon PV	-	-	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.38
25	Akcome	Ak iPower	SKA611HDGDC	n-type	210	132	HJT	Bifacial, Half-cell, MBB	695	22.37
26	Yingli	PANDA 3.0 PRO	YL625CF78 e/2	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	625	22.36
27	GCL-Si	GCL LOTUS	GCL-NT10/72GDF	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	575	22.3
27	Qcells	Q.TRON	Q.TRON M-G2+	n-type	-	108	TOPCon	Half-cell, MBB	435	22.3
27	REC	Alpha Pure-R	REC430AA Pure-R	n-type	210	80	HJT	Half-cell, SWCT	430	22.3
30	CECEP	-	CEC6-72-570TDHV	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	570	22.1
31	Jinergy	-	JNHM144-475	n-type	166	144	HJT	Bifacial, Half-cell, MBB	475	21.85
32	Meyer Burger	Meyer Burger Glass	MB_TG120ByB_390W	n-type	-	120	HJT	Bifacial, Half-cell, SWCT	390	21.8
33	Canadian Solar	HiKu7	CS7N-645-675MS	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	risen	TITAN	RSM132-8-655M-675M	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	DASOLAR	-	DAS-DH144PA-540-560W	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.7
33	LONGi	Hi-MO 5m	LR5-72HPH 545 - 560M	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	Suntech	Ultra V	STP560S-C72/Vmh	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	TW SOLAR	-	TH400-430PMB7 44SCS	p-type	210	305 (61x5)	PERC	Shingle	430	21.7
39	Akcome	Ak iChaser	SK9612MDGDC	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.68
39	JinKO	Tiger Pro	JKM560M-72HL4-V	p-type	182	144	PERC	Half-cell, MBB	560	21.68
41	Kalyon PV	-	-	p-type	158.75	144	PERC	Bifacial, Half-cell, MBB	380	21.61
42	GCL-Si	GCL GEMINI	GCL-M12/66GDF	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
42	Talesun	BIPRO	TD8G66M	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
42	Trinasolar	Vertex	TSM-DE21	p-type	210	132	PERC	Half-cell, MBB	670	21.6
42	JA SOLAR	DeepBlue 3.0	JAM78D30 580-605/MB	p-type	182	156	PERC	Bifacial, Half-cell, MBB	605	21.6
46	Jinergy	PERC Series	JNBM132-650-670	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	Qn-SOLAR	-	QNM210-HG-66	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	Seraphim	S5 Bifacial	SRP-670-BMC-BG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	SolarSpace	Lumina I	SS9-66HS 650-670M	p-type	210	132	PERC	Half-cell, MBB	670	21.57
46	URECO	PEACH	FCK670MED	p-type	210	132	PERC	Half-cell, MBB	670	21.57
46	Yingli	YLM 3.0 Plus	YLxxxDF66 f/2	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	ZNSHINE	-	ZXM8-TPLDD	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
53	Eging PV	Aurora	EG-670M66-HU/BF-DG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.56
54	RUNERGY	-	HY-DH156P8	p-type	182	156	PERC	Bifacial, Half-cell, MBB	600	21.5
54	Qcells	Q PEAK	DUO XL-G11.3	p-type	-	156	PERC	Half-cell, MBB	590	21.5
54	ASTRONERGY	Astro 5 Twins	CHSM72M(DG)/F-BH540-555W	p-type	210	144	PERC	Bifacial, Half-cell, MBB	555	21.5
54	CECEP	-	CEC6-72-555MDHV	p-type	182	144	PERC	Bifacial, Half-cell, MBB	555	21.5

Top Solar Modules 2023 Badge of Excellence

TaiyangNews Top Modules: Highest Efficient Commercial Solar Modules 06-2024

Rank	Company	Series	Model	Wafer type	Cell Size	Cells No.	Cell Tech	Module Technology	Power (W)	Efficiency (%)
1	AIKO	Comet 2U	AIKO-G655-MCH72Mw	n-type	182	144	ABC	Half-cell, Back Contact	655	24.2
2	Maxeon	Maxeon 7	SPR-MAX7-445-PT	n-type	125	112	IBC	Back Contact	445	24.1
3	LONGi	Hi-MO X6	LR5-72HTH-590-600M	p-type	182	144	HPBC	Half-cell, Back Contact	600	23.2
4	HUASUN	Himalaya	HS-210-B132DS715W	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.02
5	TW SOLAR	-	TWMHF-66HD690-715W	n-type	210	132	HJT	Bifacial, Half-cell, MBB	715	23.0
6	ASTRONERGY	Astro N5	CHSM72N(DG)/F-BH570-590W	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	590	22.8
6	TW SOLAR	-	TWMND-72HS570-590W	n-type	182	144	TOPCon	Half-cell, MBB	590	22.8
6	SPIC	ANDROMEDA 3.0	SPICN6(LDF)-60/BIH410W	n-type	166	120	TBC	Bifacial, Back Contact, Half-cell, MBB	410	22.8
9	JinKO	Tiger Neo	JKM570-585N-72HL4-BDV	n-type	-	144	TOPCon	Bifacial, Half-cell, MBB	585	22.65
10	DMEGC	Infinity	DM585M10T-72HSW-V	n-type	182	144	TOPCon	Half-cell, MBB	585	22.6
11	中润阳光	Niwa Pro	JW-HD108N415-440W	n-type	182	108	TOPCon	Bifacial, Half-cell, MBB	440	22.53
12	risen	Hyper-ion	RSM132-8-700BHDG	n-type	210	132	HJT	Bifacial,Half-cell, MBB	700	22.5
12	Trinasolar	Vertex N	TSM-NEG21C.20	n-type	210	132	TOPCon	Bifacial, Half-cell, MBB	700	22.5
12	DASOLAR	-	DAS-DH156NA-610-630W	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	630	22.5
12	JA SOLAR	DeepBlue 4.0 Pro	JAM72D42 630/LB	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	630	22.5
12	Canadian Solar	TOPHiKu6	CS6W-570-580T	n-type	182	144	TOPCon	Half-cell, MBB	580	22.5
12	Eging PV	STAR Pro	EG-580NT72-HL/BF-DG	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.5
12	RUNERGY	-	HY-DH144N8	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.5
19	Qn-SOLAR	-	QNN182-HG-72	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	SolarSpace	Lumina II	SS8-72HD-580N	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
19	URECO	GLORY	FBF580B8D	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.45
22	URECO	HELLO	FCG635B7Y	n-type	210	120	HJT	Bifacial, Half-cell, MBB	635	22.44
23	Suntech	Ultra V Pro	STP605S-H66-Nsh+	n-type	182	132	TOPCon	Bifacial, Half-cell, MBB	605	22.4
24	Kalyon PV	-	-	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	580	22.38
25	Akcome	Ak iPower	SKA611HDGDC	n-type	210	132	HJT	Bifacial, Half-cell, MBB	695	22.37
26	Yingli	PANDA 3.0 PRO	YL625CF78 e/2	n-type	182	156	TOPCon	Bifacial, Half-cell, MBB	625	22.36
27	GCL-SI	GCL LOTUS	GCL-NT10/72GDF	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	575	22.3
27	Qcells	Q.TRON	Q.TRON M-G2+	n-type	-	108	TOPCon	Half-cell, MBB	435	22.3
27	REC	Alpha Pure-R	REC430AA Pure-R	n-type	210	80	HJT	Half-cell, SWCT	430	22.3
30	CECEP	-	CEC6-72-570TDHV	n-type	182	144	TOPCon	Bifacial, Half-cell, MBB	570	22.1
31	Jinergy	-	JNHM144-475	n-type	166	144	HJT	Bifacial, Half-cell, MBB	475	21.85
32	Meyer Burger	Meyer Burger Glass	MB_TG120ByB_390W	n-type	-	120	HJT	Bifacial, Half-cell, SWCT	390	21.8
33	Canadian Solar	HiKu7	CS7N-645-675MS	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	risen	TITAN	RSM132-8-655M-675M	p-type	210	132	PERC	Half-cell, MBB	675	21.7
33	DASOLAR	-	DAS-DH144PA-540-560W	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.7
33	LONGi	Hi-MO 5m	LR5-72HPH 545 - 560M	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	Suntech	Ultra V	STP560S-C72/Vmh	p-type	182	144	PERC	Half-cell, MBB	560	21.7
33	TW SOLAR	-	TH400-430PMB7 44SCS	p-type	210	305 (61x5)	PERC	Shingle	430	21.7
39	Akcome	Ak iChaser	SK9612MDGDC	p-type	182	144	PERC	Bifacial, Half-cell, MBB	560	21.68
39	JinKO	Tiger Pro	JKM560M-72HL4-V	p-type	182	144	PERC	Half-cell, MBB	560	21.68
41	Kalyon PV	-	-	p-type	158.75	144	PERC	Bifacial, Half-cell, MBB	380	21.61
42	GCL-SI	GCL GEMINI	GCL-M12/66GDF	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
42	Talesun	BIPRO	TD8G66M	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.6
42	Trinasolar	Vertex	TSM-DE21	p-type	210	132	PERC	Half-cell, MBB	670	21.6
42	JA SOLAR	DeepBlue 3.0	JAM78D30 580-605/MB	p-type	182	156	PERC	Bifacial, Half-cell, MBB	605	21.6
46	Jinergy	PERC Series	JNBM132-650-670	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	Qn-SOLAR	-	QNM210-HG-66	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	Seraphim	S5 Bifacial	SRP-670-BMC-BG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	SolarSpace	Lumina I	SS9-66HS 650-670M	p-type	210	132	PERC	Half-cell, MBB	670	21.57
46	URECO	PEACH	FCK670MED	p-type	210	132	PERC	Half-cell, MBB	670	21.57
46	Yingli	YLM 3.0 Plus	YLxxxDF66 f/2	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
46	ZNSHINE	-	ZXM8-TPLDD	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.57
53	Eging PV	Aurora	EG-670M66-HU/BF-DG	p-type	210	132	PERC	Bifacial, Half-cell, MBB	670	21.56
54	RUNERGY	-	HY-DH156P8	p-type	182	156	PERC	Bifacial, Half-cell, MBB	600	21.5
54	Qcells	Q PEAK	DUO XL-G11.3	p-type	-	156	PERC	Half-cell, MBB	590	21.5
54	ASTRONERGY	Astro 5 Twins	CHSM72M(DG)/F-BH540-555W	p-type	210	144	PERC	Bifacial, Half-cell, MBB	555	21.5
54	CECEP	-	CEC6-72-555MDHV	p-type	182	144	PERC	Bifacial, Half-cell, MBB	555	21.5

Top Solar Modules 2023 Badge of Excellence

Solar
JinKO

Enable a Future of 100% Renewable Power

Unlock Solar's Full Potential – With JinkoSolar, Efficiency Meets Resilience

www.jinkosolar.com

RE+

RENEWING WHAT'S POSSIBLE

SEPTEMBER 9-12, 2024 | ANAHEIM, CA

POWERED BY SEIA Solar Energy Industries Association® | Smart Electric Power Alliance

RE+ 24 brings the modern energy industry together to foster a cleaner future and marks its **20th year** as the largest and most comprehensive event in North America for the clean energy industry. Get ready to explore solutions, exchange ideas, and discover new technologies!

REGISTER NOW | RE-PLUS.EVENTS

20th ANNIVERSARY RE+

SOLAR – MADE IN USA

Monday, September 9

9:00 am – 5:00 pm

Anaheim Convention Center, Level 3, Room 304A

Register Here

Join us for **"Solar Made in USA - How to Manufacture Solar Wafers, Cells, and Modules Competitively in the United States"** taking place on September 9, 2024, at the Anaheim Convention Center during RE+.

With the US being the hottest global market when it comes to solar manufacturing projects, EUPD Research hasteamed up with the largest US solar and storage trade show RE+ and leading PV technology platform TaiyangNews to create a knowledge exchange platform for all stakeholders involved or interested in solar manufacturing in the US.

Speakers include world leading manufacturing equipment and materials suppliers, PV producers, local solar project developers and industry lobbyists:


Michael Schmela
TaiyangNews


Radovan Kopecek
ISC Konstanz


Dr. Paul Basore
Department
of Energy


Stacy J. Ettinger
SEIA


Prof. Dr. Peter Fath
RCT Solutions


Dr. Zhixin Li
Linton
Technologies


Prof. Jerry Liao
Leadmicro


QJ Guo
Solamet


Dr. Sebastian Gatz
Von Ardenne


Adam Tesanovich
TALON PV


Terry Jester
Kiwa PI Berlin


Todd Templeton
NorSun


Martin Ma
ConfirmWare


Paulo Rocha
Autowell


Steven Akey
Hangzhou First


Laura Sartore
Ecoprogetti


Jim Wood
SEG Solar


Nadeem Haque
Heliene


Hitesh Doshi
Waaree


Markus A.W.
EUPD Research


Thomas Koerner
Canadian Solar


John Smirnow
Smirnow Law


Elissa Pierce
WoodMac


Phil Shen
Roth Capital