TAIYANGNEWS

ALL ABOUT SOLAR POWER

Special Edition 2023

Tongwei Solar's Module Products Overview

Expanding Frontiers – Capacities And Technologies

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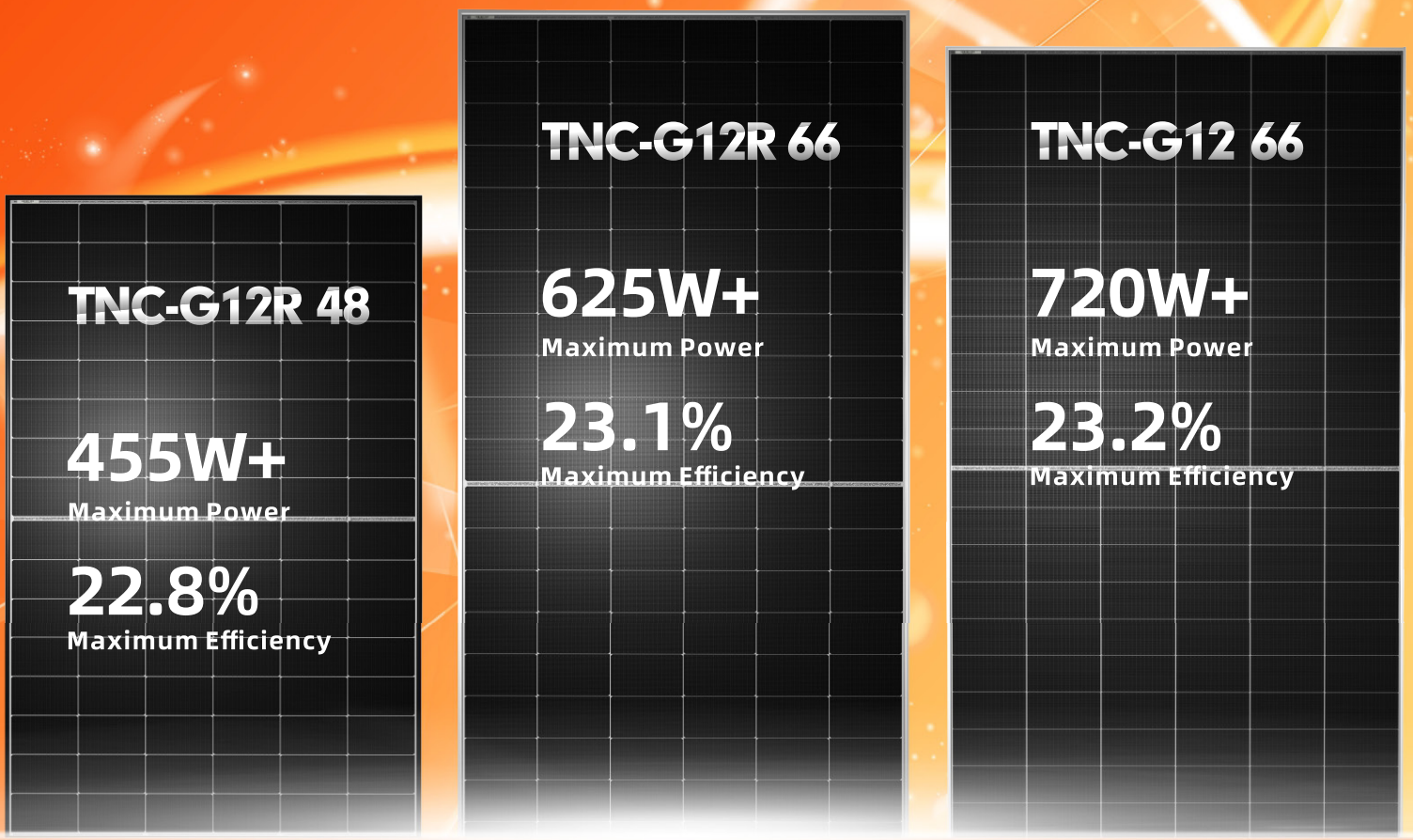
Tongwei Gene Repower

Intersolar A2-550&650



Tongwei Gene

Tongwei Solar

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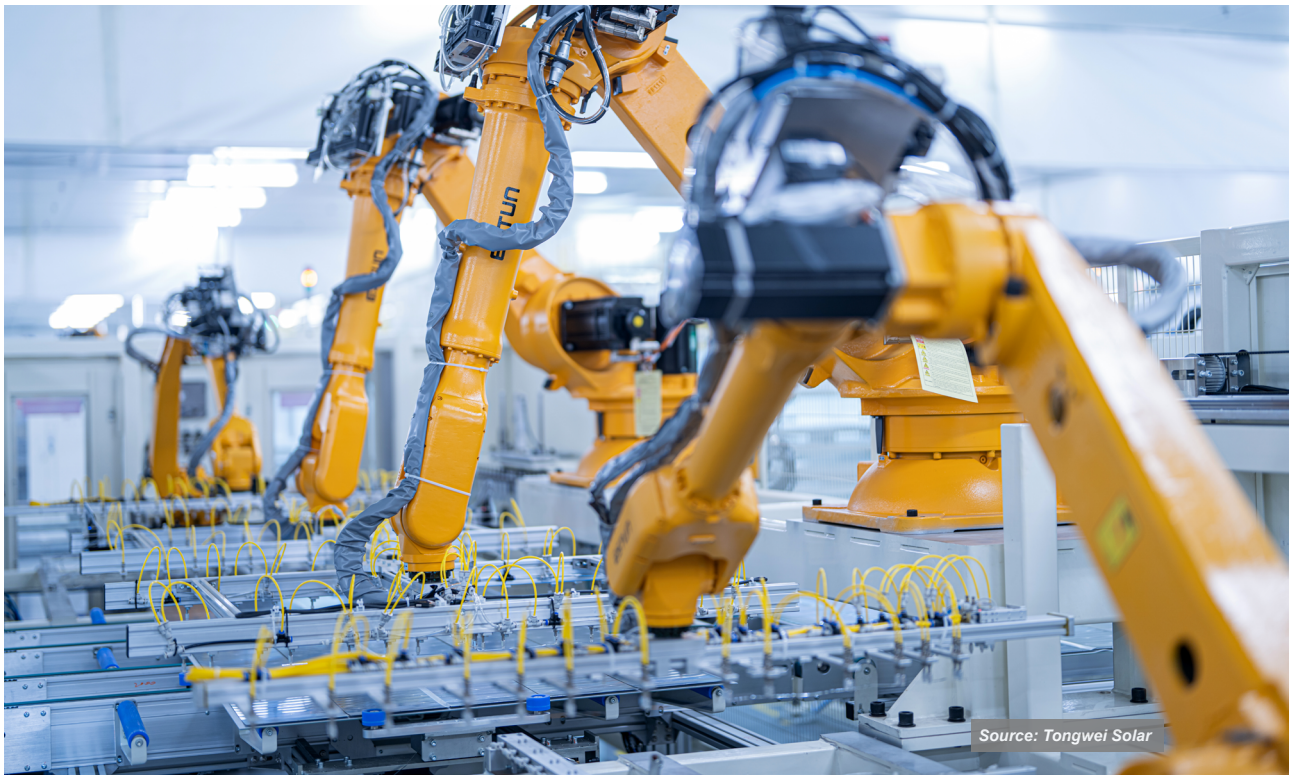
Tongwei Advances with Diverse Cell Tech and Value Chain Growth

Tongwei Solar, the world's largest polysilicon manufacturer and a leading supplier of solar cells, has ventured into solar module manufacturing. Its product lineup includes PERC, TOPCon, and HJT technologies, offering a diverse range of products tailored to meet customer demands. As of the end of 2023, Tongwei Solar boasts a high-purity polysilicon capacity of 450,000 tons, a cell capacity of 95 GW, and a module capacity of 75 GW. The company emphasizes an integrated approach to constructing the photovoltaic industry chain and initiated a new 32 GW silicon wafer project in 2023. Upon completion, this project will establish a complete integrated capacity for Tongwei, spanning from polysilicon to modules. From 2024 to 2026, Tongwei Solar plans to increase its cell capacity to 130 to 150 GW, dedicating more than 66 GW of this capacity to TOPCon technology-based TNC cells, and aiming for 800,000 to 1,000,000 tons of polysilicon and 80 to 100 GW of modules.

Tongwei also extends its investments to downstream photovoltaic power applications. The company is particularly dedicated to developing large-scale 'Fishing-Solar Complementarity' projects. As of December 2023.these projects have achieved a cumulative grid connection of 4.07 GW.

As a global leader in solar cell manufacturing, Tongwei is committed to the research and development of advanced cell technologies. In December 2023, its THC modules, based on 210 mm HJT cells, set a new world record in a laboratory setting by achieving a power output of 755.03 W and a conversion efficiency of 24.31%, certified by an independent third party.



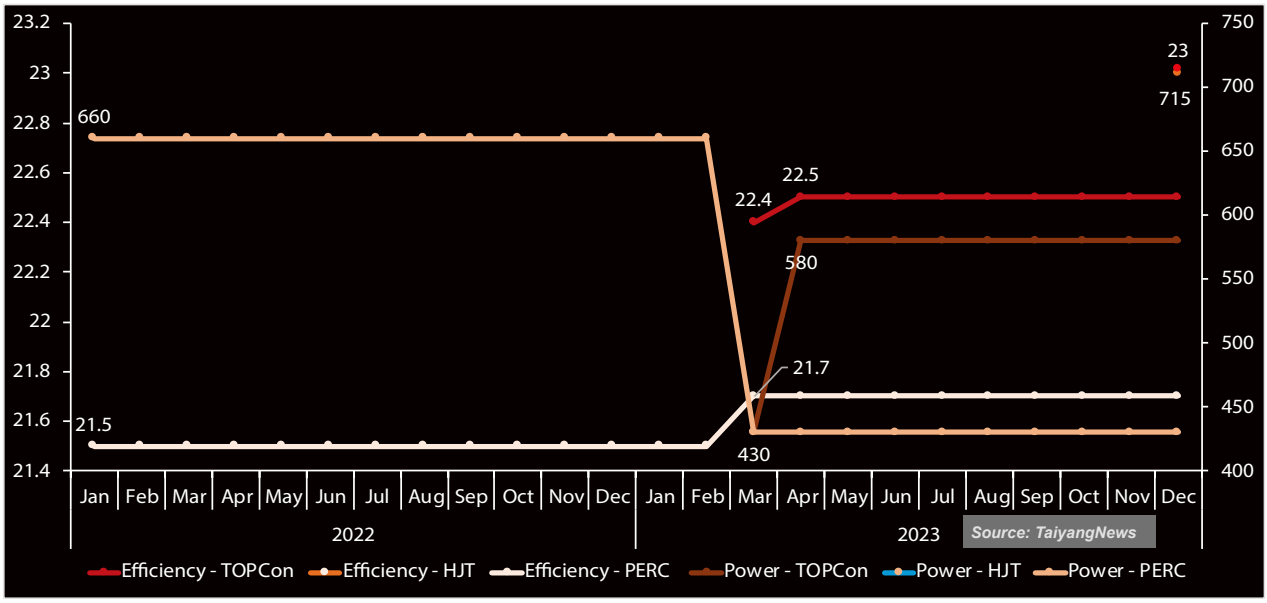
Achieving Integration: Tongwei reaches 75 GW module production capacity in 2023, just two years after committing to full integration in 2021.

Efficiency and power progress

By the end of 2023, Tongwei was among a handful companies featured in 3 technology streams in our TOP SOLAR MODULES listing: The highest efficiency product from the company is based on HJT technology and was debuted in the last month of the year, December 2023 with an efficiency of 23% and a power output of 715 W. This module, built with 132 half-cells of G12 format, ranked 4th for the month. The company's TOPCon product was first listed in March 2023 with an efficiency of 22.4% and a power rating of 430 W, using 108 G12 half-cells. In the following month, April, its efficiency was increased to 22.5% and power to 580 W for its top commercial TOPCon module, which is constructed with 144 half-cells of M10 size. This product remained the leading TOPCon module for the company throughout the rest of 2023. As for PERC, Tongwei has been utilizing a unique shingling technology. These modules, built with 66 G12- cells each cut into 6 pieces, were part of the list from the beginning with an efficiency of 21.5% and a power rating of 660 W. The product remained unchanged until February 2023, when a smaller variant in the series with a power rating of 430 W and an efficiency of 21.7% became Tongwei's top PERC product, a position it held until the end of the year.

As module efficiency is the parameter that truly reflects the ability of the solar device to convert sunlight into power per area, TaiyangNews tracks the progress of the best commercially available high-efficiency panels to publish them in our TOP SOLAR MODULES listing on our website. In addition to this monthly update, we are publishing bi-annual reports analyzing the developments of these TOP SOLAR MODULES. As a further extension of that project, TaiyangNews started an excellence badge scheme in Dec. 2023. Manufacturers who are featured in the TOP 10 for at least 6 months within a calendar year are eligible to apply for the Badge of Excellence. JA Solar, with its TOPCon product DeepBlue 4.0, was one of the top 10 companies in the TOP SOLAR MODULES List from January to December 2023. For 2023, the Badge of Excellence has been granted to Aiko Solar, Huasun, JA Solar, JinkoSolar, LONGi Solar, Risen Energy, **Tongwei Solar**, Trina Solar (status: Feb. 2024)

Tongwei Solar Efficiency & Power Progress - 2022 / 2023



In 3 technologies: Tongwei among a handful of companies that was represented in 3 technology streams, though the HJT module was included only in December 2023.

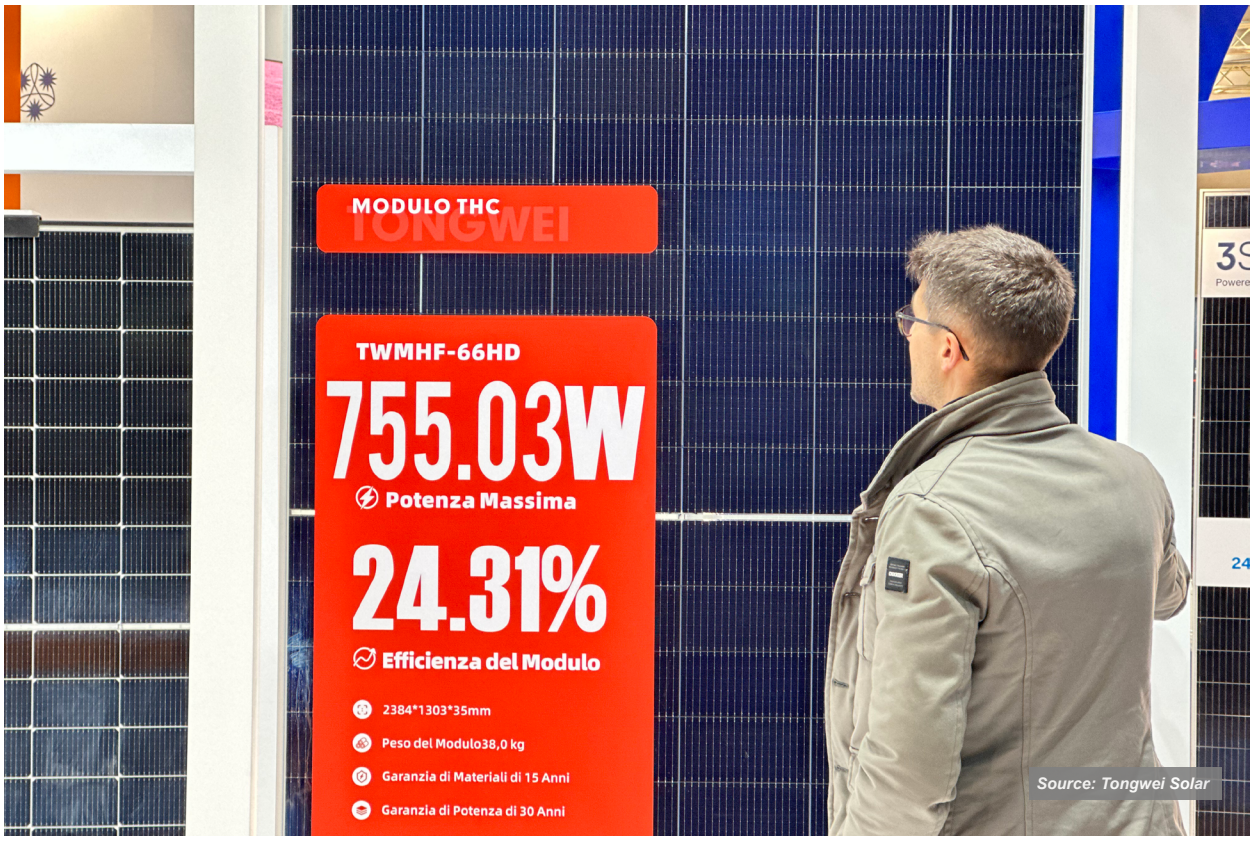
Tongwei betting on both horses - TOPCon & HJT

The vertical integration trend in PV manufacturing is gaining momentum. Manufacturers are seeking greater control over quality, costs, and supply chain resilience in the face of fluctuating market conditions. At first glance, it's evident that several cell-only manufacturers have successfully ventured into the module business. Tongwei Solar is a very relevant company in this context. The world's largest cell maker has begun selling modules under its own brand. Beyond cells, Tongwei is also a leading silicon producer, and the company has expanded its operations to include ingot and wafer production, effectively covering every link in the value chain, albeit with varying levels of capacity and integration at each stage.

Cell development

While TOPCon remains the mainstream cell technology, Tongwei Solar is also advancing its development with HJT. For TOPCon, the company embarked on its development journey in 2020, choosing the PECVD method to execute all the 3 critical steps of rear surface engineering. This process involves applying a tunnelling oxide layer, a thin polysilicon layer, and in-situ doping – all achieved through a novel tube-type PECVD tool it co-developed with Leadmicro and Nantong University. Beyond rear surface engineering, Tongwei incorporates selective emitter (SE) technology to create emitters with high sheet resistance, improving cell performance as a result. Tongwei says that it has attained 24.65% mass production efficiency with cells based on M10 wafers by 2021, which was further improved to 25.3% in 2022 followed by 26.1% by October 2023. Tongwei calls its TOPCon technology as TNC.

Tongwei is one of the early adopters of HJT technology on a commercial scale, with the installation of a GW-scale production facility commissioned in 2021, building upon R&D activities that had already commenced in 2018. Tongwei



Record performance: with its extensive R&D efforts, Tongwei has reached a certified module efficiency of 24.31% and a power rating of about 755 W for its HJT module, which is characterized as a record by the company.

Choice for utility: Tongwei is offering an array of products for utility scale projects based on HJT and TOPCon, the latter is also offered based on different wafer formats.

played a leading role in introducing a bifacial nano-crystalline silicon layer into the HJT cell structure. Furthermore, the company built a pilot line to develop silver-free copper metallization technology that enabled it to thin down the contact fingers to less than 15 µm, enhancing cell efficiency by 0.2% compared to the traditional screen-printing process. By Q1 2023, the champion cell efficiency of its HJT technology reached 26.49%. Tongwei Solar has named its high-efficiency HJT cell 'THC.'

Product portfolio

Based on its proprietary cell technologies, Tongwei Solar offers a diverse portfolio of modules. Among these are the TPC Shingled modules based on PERC, tailored for residential rooftop applications. The Chinese manufacturer offers 2 model utilizing the shingling technology: the Terra-5K and Terra-5E. These models boast power ranges between 425 W and 445 W, with efficiencies of 21.7% and 21.4%, respectively. In its TNC module lineup, the company's TOPCon product brand, the 26.1% efficient TNC cell enables a module rated power of 585 W to 590 W. These modules are based on the M10 cell size in a 72-cell configuration, designed for utility and C&I applications. The series consists of 2 models: the TWMND-72HS with an efficiency of 22.8%, and TWMND-72HD with 22.6%. In addition, the company recently introduced a new TOPCon module based on the M12R size cell, which has a power rating of up to 620 W and an efficiency of 23%, designed for the utility segment.

Regarding HJT modules, the company has launched its first M12 size ultra-thin wafer bifacial nano-crystalline THC module. This TWMHF-66HD module has a power rating of up to 730 W and an efficiency of 23.5%. The products also feature advanced silver-free metallization technology and zero-busbar (0BB) interconnection technology, which collectively improves performance and reliability while reducing costs. Tongwei Solar plans to begin mass production of these latest HJT module series to be based on M12 or M12R sized cells in Q1 2024.

Tongwei Solar's Module Series (As of 2023)

Product Series	THC	TNC	TNC	TNC
Model name	TWMHF-66HD-715W	TWMNH-66HS-615W	TWMND-72HS-590W	TWMND-60HS-490W
Wafer type	n-type	n-type	n-type	n-type
Cell technology	HJT	TOPCon	TOPCon	TOPCon
Cell size	210 mm	182 mm	182 mm	182 mm
No. of cells	132	132	144	120
Module technology	Bifacial, half-cell, MBB	Half-cell, MBB	Half-cell, MBB	Half-cell, MBB
No. of busbars	18 BB	16 BB	16 BB	16 BB
Maximum power (Pmax)	715 W	615 W	590 W	490 W
Module efficiency STC	23%	22.8%	22.8%	22.6%
Bifaciality	90 ± 5%	-	-	-
Dimensions	2,384±2 x 1,303±2 x 35 mm	2,278±2 x 1,134±2 x 35 mm	2,278±2 x 1,134±2 x 35 mm	1,908±2 x 1,134±2 x 35 mm
Weight	37.5 kg	29 kg	27 kg	23.2 kg
Warranty	30 years	30 years	30 years	30 years
Applications	Utility	C&I	C&I	Residential

Source: TaiyangNews

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This Special Edition was independently written by the TaiyangNews Team based on recent conference presentations of the company featured. Those companies among the top 10 of TOP SOLAR MODULES List granted a Badge of Excellence are each featured in an individual Special Edition

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