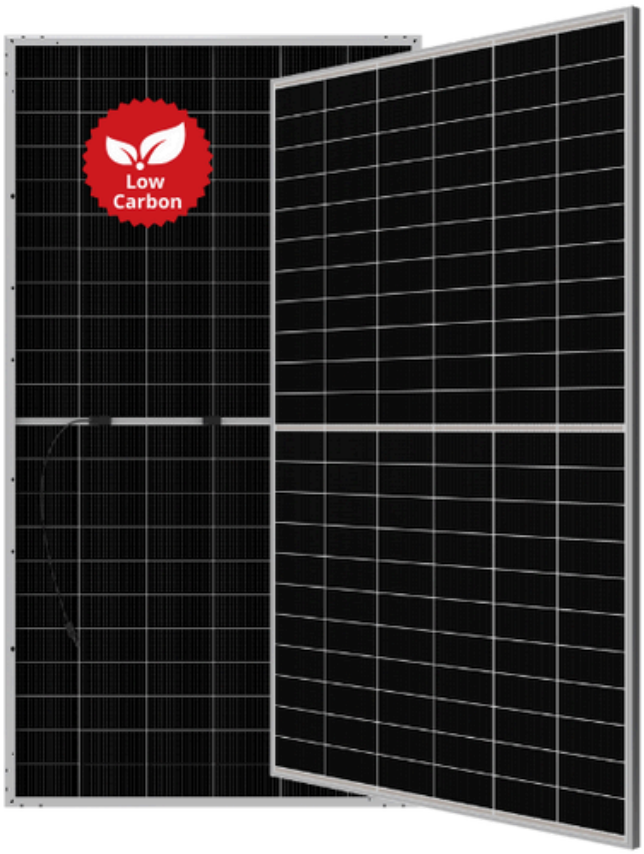
CanadianSolar

Next-generation Low-carbon PV Module

Technical White Paper

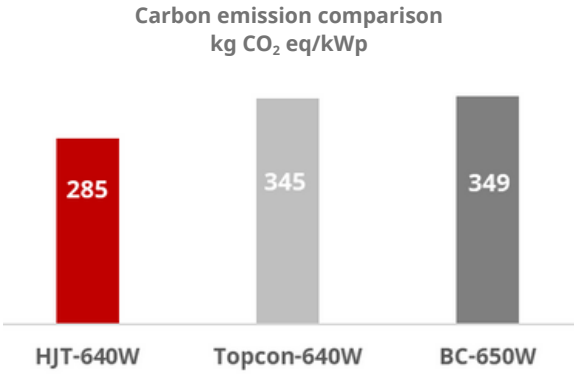


CSI Solar Co.,Ltd

September, 2025

Canadian Solar Inc. has launched its next-generation of low-carbon manufacturing modules, leading the industry in accelerating the emission reduction in manufacturing. These low-carbon modules are specially designed for utility-scale as well as commercial and industrial PV systems, with a power output of up to 660W and an efficiency of up to 24.4%, and will begin global deliveries in August 2025.

This latest low-carbon module adopts Canadian Solar's independently developed silicon ingot and wafer technologies, combined with HJT cell technology, achieving a carbon emission level of only 285 kg CO_2/kWp from "cradle to gate" (i.e., from raw material development to module manufacturing, calculated according to the French ECS carbon footprint rules.). This represents about an 18% reduction compared with other mainstream technologies currently on the market, such as TOPCon and BC.

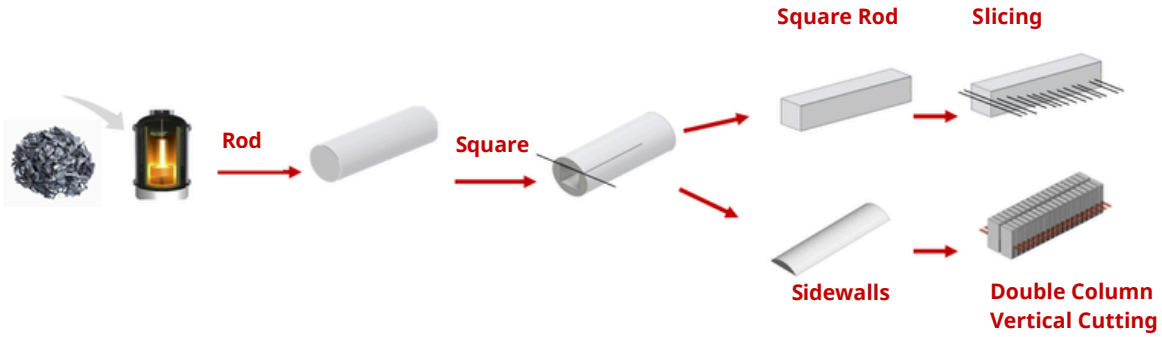


The low-carbon modules achieved the following technological breakthroughs:

1. Innovative silicon ingot slicing process to maximize silicon utilization and reduce carbon emissions

Canadian Solar has pioneered the industry's first "dual half-cut" wafer technology, which utilizes the edge part of silicon ingots to produce half-cut wafers. This eliminates the need to remelt edge materials for ingot pulling, improving ingot utilization by 20% and reducing carbon emissions by 9.7%—equivalent to about 30 kg CO_2 per kWp reduction.

By adopting the "dual half-cut" technology, the edge materials of silicon ingots can be directly sliced into half-cut wafers, minimizing the risk of breakage in subsequent processes (such as texturing, coating, screen printing, and handling), and significantly improving production yield.



2. Adoption of ultra-thin wafers to reduce silicon consumption and carbon emissions

Canadian Solar's low-carbon modules use ultra-thin wafers with a thickness of only 110 μm (with potential for further reduction in the future), compared with the current mainstream wafer thicknesses of 130 μm for TOPCon and 135 μm for BC. As a result, the low-carbon modules reduce carbon emissions from wafers by 4.5% and 5.5% respectively compared with TOPCon and BC, equivalent to about 14–19 kg CO_2 per kWp.

3. Streamlined cell process with shorter production flow and lower temperatures

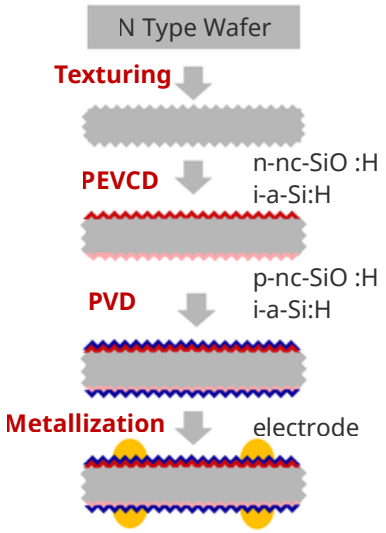
Canadian Solar's low-carbon modules adopt HJT (heterojunction) technology in cell production. With an ultra-simplified manufacturing process and lower processing temperatures, carbon emissions in the cell production stage are further reduced.

HJT cells manufacturing mainly includes the following four core steps:

- Cleaning & Texturing
- PEVCD: Deposition of Double-Sided Passivating Contact Films (i-a-Si:H / p-nc-Si:H / n-nc-Si:H)
- PVD: Double-Sided Transparent Conductive Oxide (TCO) Deposition
- Metallization （Screen printing）

While mainstream TOPCon and BC processes involve 11 and 13 steps, respectively.

HJT Cell Processing



The maximum processing temperature of HJT cells does not exceed 230 °C, compared with 960–1050 °C for TOPCon and BC cells.

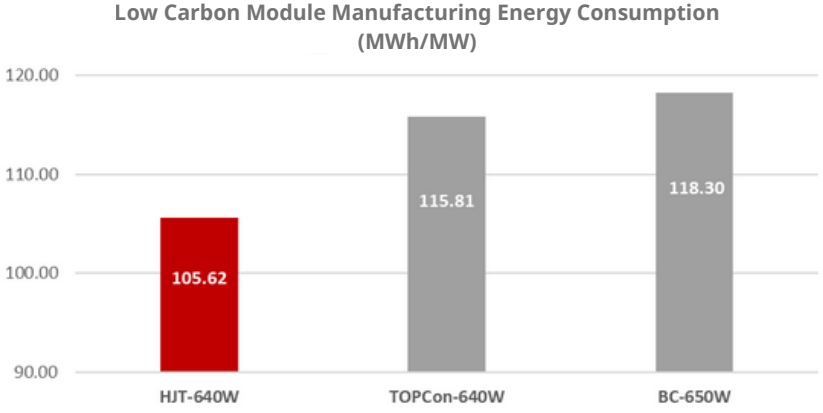
By combining a more streamlined process flow with lower processing temperatures, Canadian Solar's low-carbon modules achieve 4.2% and 5.7% lower carbon emissions in cell production compared with TOPCon and BC, respectively—equivalent to a reduction of about 14–21 kg CO_2 per kWp.

The Highest Temperature in Manufacturing Process

HJT Cell (4 steps in total)	**TOPCon Cell** (Typical steps and temperatures)	**BC Cell** (Typical steps and temperatures)
Texturing <90℃ PECVD <230℃ PVD <230℃ Screen Printing <230℃	Boron diffusion-deposition <940℃ Boron diffusion-oxidation <1050℃ Front Side SiNx <570℃ Back Side SINx <570℃ Screen Printing <720℃	LP1/2 <650℃ Boron/Phosphorus diffusion <960℃ Alumina <960℃ Front and Backside Films <960℃ Screen Printing <760℃

Achieving comprehensive low-carbon from "cradle to gate"

Throughout the entire production process—from ingot casting, wafering, and cell manufacturing to module assembly—Canadian Solar's low-carbon modules have a total energy consumption of 105.62 MWh per MW, which is 8.8%–10.7% lower than TOPCon and BC technologies.



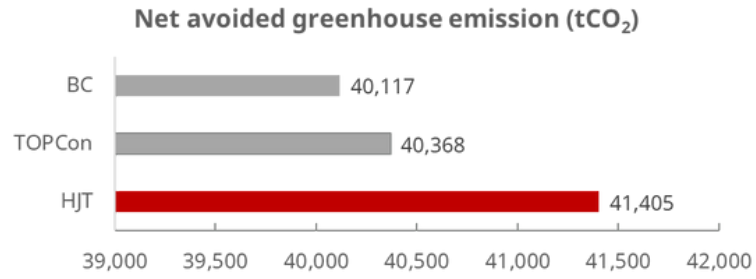
Shorter carbon payback period

Net avoided greenhouse gas emissions (the total reduction in greenhouse gases over the entire lifecycle of a PV system) and carbon payback period (the time required for the system to offset its own carbon footprint from production through electricity generation) are two core metrics for assessing environmental benefits.

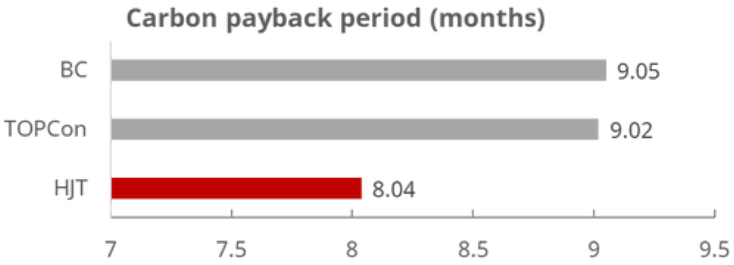
Compared to TOPCon and BC modules of equivalent specifications, HJT technology exhibits a lower carbon footprint, higher net avoided greenhouse gas emissions, and a shorter carbon payback period.

	BC 650W	TOPCon 640W	HJT 640W
Total carbon emmision (incl. BOS) (tCO_2e)	1,035	1,037	946
Carbon emmision per kWh (gCO2e/kWh)	14.73	14.67	13.08
Net avoided greenhouse emission (tCO_2)	40,117	40,368	41,405
Carbon payback period (months)	9.05	9.02	8.04

*Calculation assumption:
Project location: Madrid, Spain; Project capacity: 1.5MW; Flat roof, fixed tilt mounting method; Operation time: 30 years



Net avoided greenhouse emission increased by 2.57% v.s. TOPCon and by 3.21% v.s. BC.



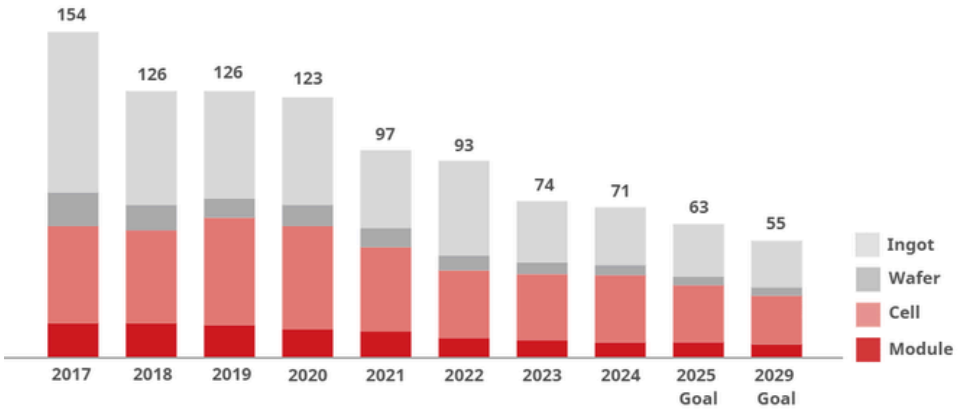
The carbon payback period (in months) is 10.86% lower than that of TOPCon and 11.16% lower than that of BC.

Canadian Solar Low-carbon Modules Powers Recurrent Energy's Spain Project, Completing in 2025

Canadian Solar's commitment to reducing carbon footprint and promoting sustainable development

Canadian Solar is actively engaged in the construction and upgrade of its carbon management system. It has established a new and more powerful gas emission detection and management process and plans to reduce carbon emissions by approximately 13% per megawatt from 2025 to 2029.

Canadian Solar GHG Emission Intensity (tCO_2e/MWp)



To further decarbonize its operations, Canadian Solar is actively advancing the development of "Zero-Carbon Factories." To date, the company has established 2 Zero-Carbon Factories, with 100% of its manufacturing bases having completed GHG Protocol greenhouse gas inventories. As of June 30, 2025, 19 products have obtained Italian Environmental Product Declaration (EPD) certification, including all 10 mainstream N-type products currently on sale. 37 models have received French Carbon Footprint ECS certification, covering all 4 mainstream N-type products in current sales. Additionally, 5 products have acquired ISO 14067 carbon footprint certificates.


Canadian Solar Yangzhou Factory Solar Rooftop System, 23.9 MW

Canadian Solar is committed to sustainable development, minimizing the environmental impact of our products from design and manufacturing to installation and end-of-life processing. Canadian Solar conducts R&D in new materials, module structural design, and recycling technologies. Key innovations include:

Lead-Free Ribbon
- Removing heavy metal leads to interference and reduces reccycling complexity.
- Enables safer, more reliable solutions for environmentally sensitive applications.

Low-Carbon Frames
- Steel frames use advanced cold roll forming, saving metal and reducing processing energy by up to 30%. Achieves ~77% lower lifecycle carbon emissions vs. traditional aluminum frames.
- Composite material frames carbon emission is only around 20%-25% of aluminum frames.

Long-Life Modules
- Shipped 40-year-lifespan modules in 2024, reduceing replacement frequency, resource consumption, and waste generation.
- Superior performance with lower degradation rates cuts lifecycle emissions.

Recycling Initiatives
- As the member of PV Cycle and Take-e-way, Canadian Solar strictly adhering to EU WEEE Directive and fulfills extended producer responsibility (EPR) for end-of-life module recycling, reuse, and waste management.

Appendix: Canadian Solar Low Carbon Module Portfolio

	CS6.2-66HB	CS6.2-66HB-H	CS6.2-66HB-HP
Module Power (the highest)	660W	660W	660W
Module Efficiency（the highest）	24.4%	24.4%	24.4%
Module Dimension (mm)	2382 x 1134 x 30	2382 x 1134 x 40	2382 x 1134 x 35
Frame Thickness (mm)	30	40	35
Glass Thickness (mm)	2.0+2.0	2.0+2.0	2.5+2.5
Module Weight （kg）	32.8Kg	33.4Kg	40.6Kg
Product Features	High Bifaciality, Low Temperature Coefficient	Higher loads (up to+6000 Pa/-5400Pa)	Higher hail resistant (Up to 55mm hails)

CS6.2-66HB-H: Equipped with a 40 mm frame and double 2.0 mm glass, it offers excellent load-bearing capability, making it suitable for high-wind areas. It can withstand load tests up to +6000/-5400 Pa.

CS6.2-66HB-HP: Featuring double 2.5 mm glass and a 35 mm frame, it provides outstanding resistance to fire, wind, and hail. It passes load tests up to +6000/-6450 Pa and hail tests with diameters up to 55 mm. Fire rating reaches Class A according to IEC 61730 and Type 30 according to UL 61730.

Click and learn more about Canadian Solar Low-carbon module.