

Building Quality Excellence in PV Manufacturing

Yash R. Kotecha, Product Manager
Qcells North America | June 16, 2026



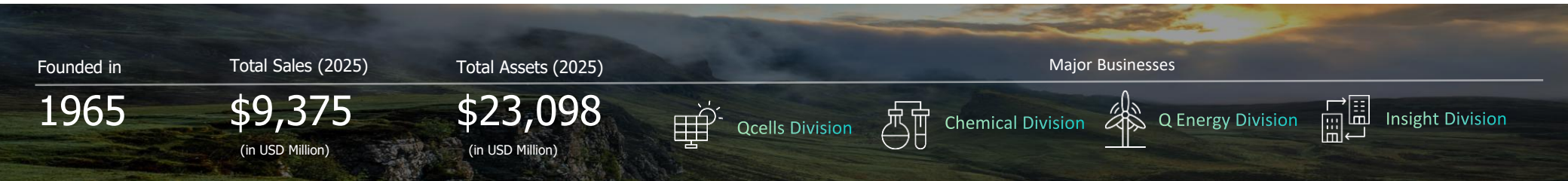
Company Overview



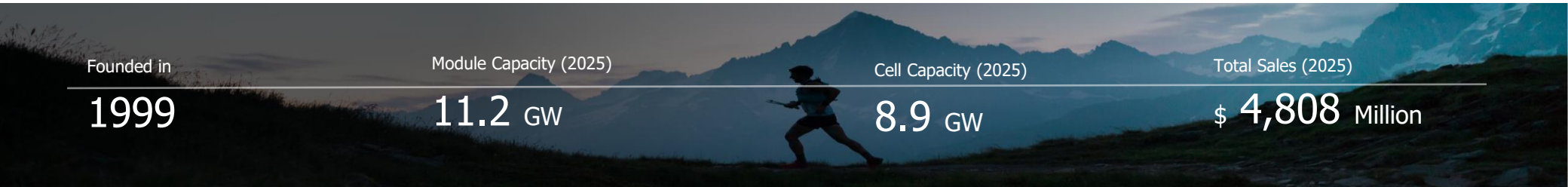
Hanwha is South Korea’s seventh-largest business group with a diverse portfolio that includes innovative businesses in the areas of energy, ocean, aerospace, finance, and retail & services.



Hanwha Solutions provides a range of solutions in various fields with differentiated technology and innovation. We are growing as a global leader in responding to climate change with smart, eco-friendly energy solutions.



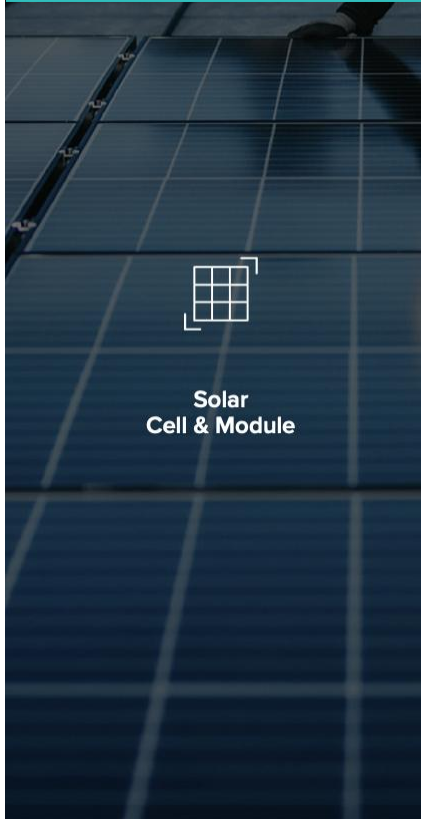
Qcells is a global leading and fully bankable energy solutions provider with more than 20 years of history and financial stability.



Business Evolution & Transformation

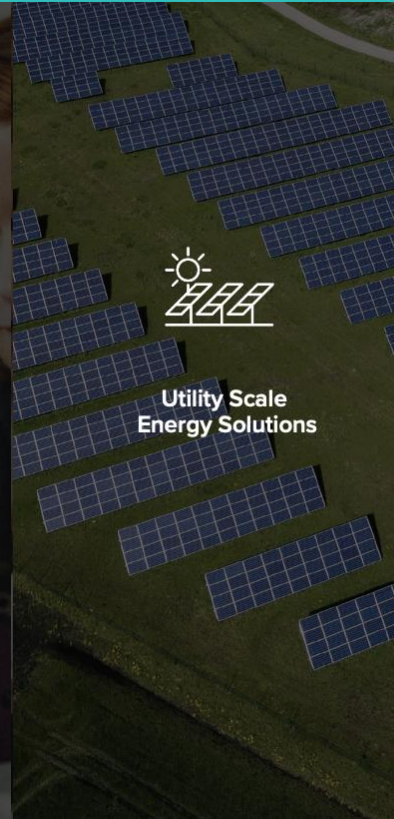
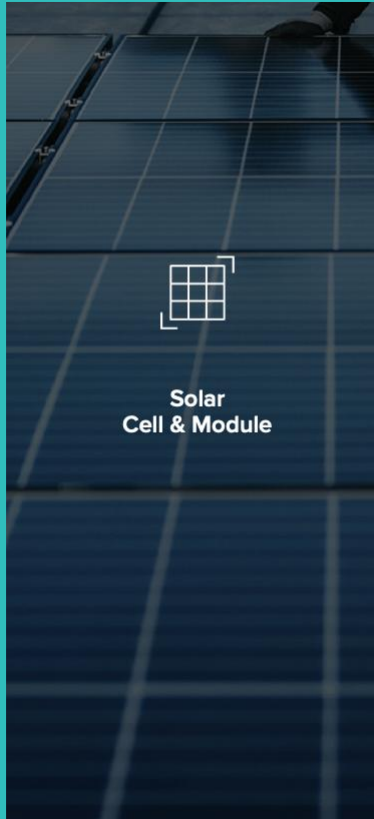
1999 - 2021

Module Excellence Era



2022 - Present

Energy Solutions Provider Era



Qcells has a long history and deep know-how in the solar industry. Our technology is regularly recognized as top quality and our brand is the top choice for global customers. With our expertise, we are now moving forward in providing complete energy solutions for each of the energy market segments including residential, CCI and utility sectors.

Global Network

Qcells works closely with global R&D and manufacturing sites to deliver the highest level of quality in manufacturing, sales and support.

1

Headquarters

Seoul, South Korea

4

R&D Centers

Germany, South Korea, U.S.

6

Global Test Fields

Germany, U.S., Cyprus, Qatar, Australia

4

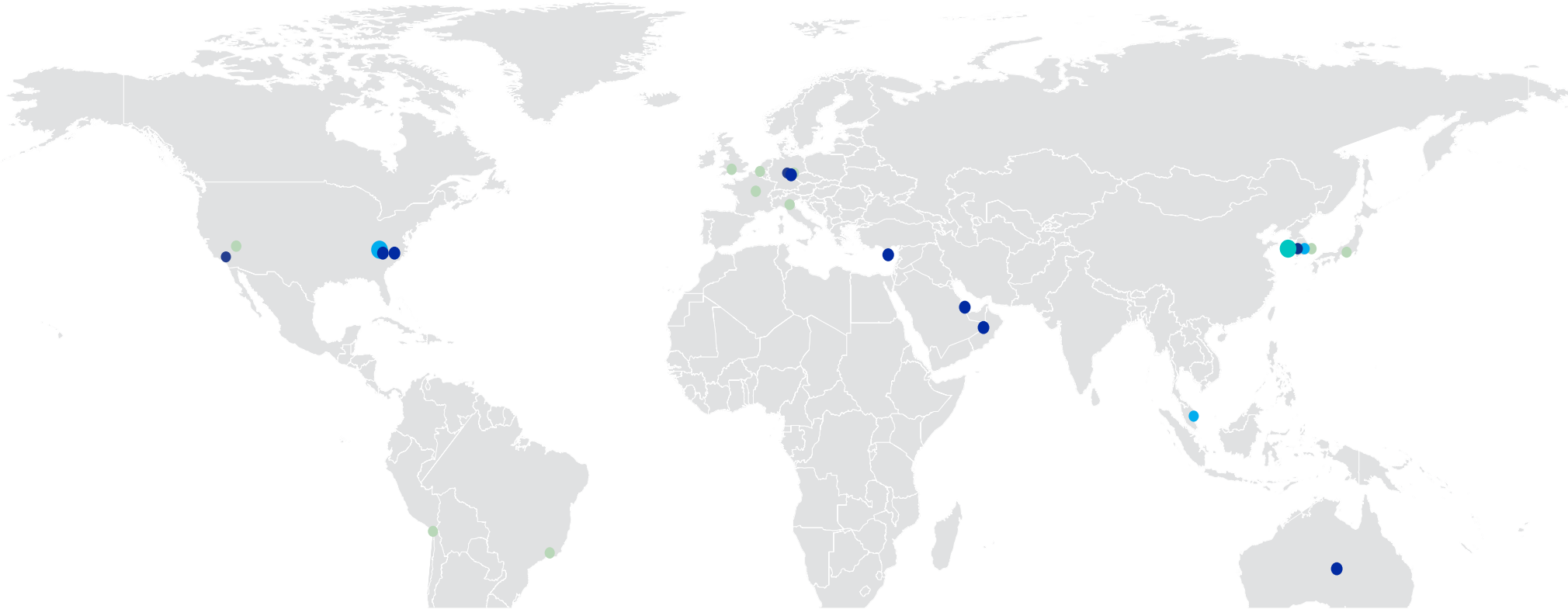
Manufacturing Sites

South Korea, Malaysia, U.S.

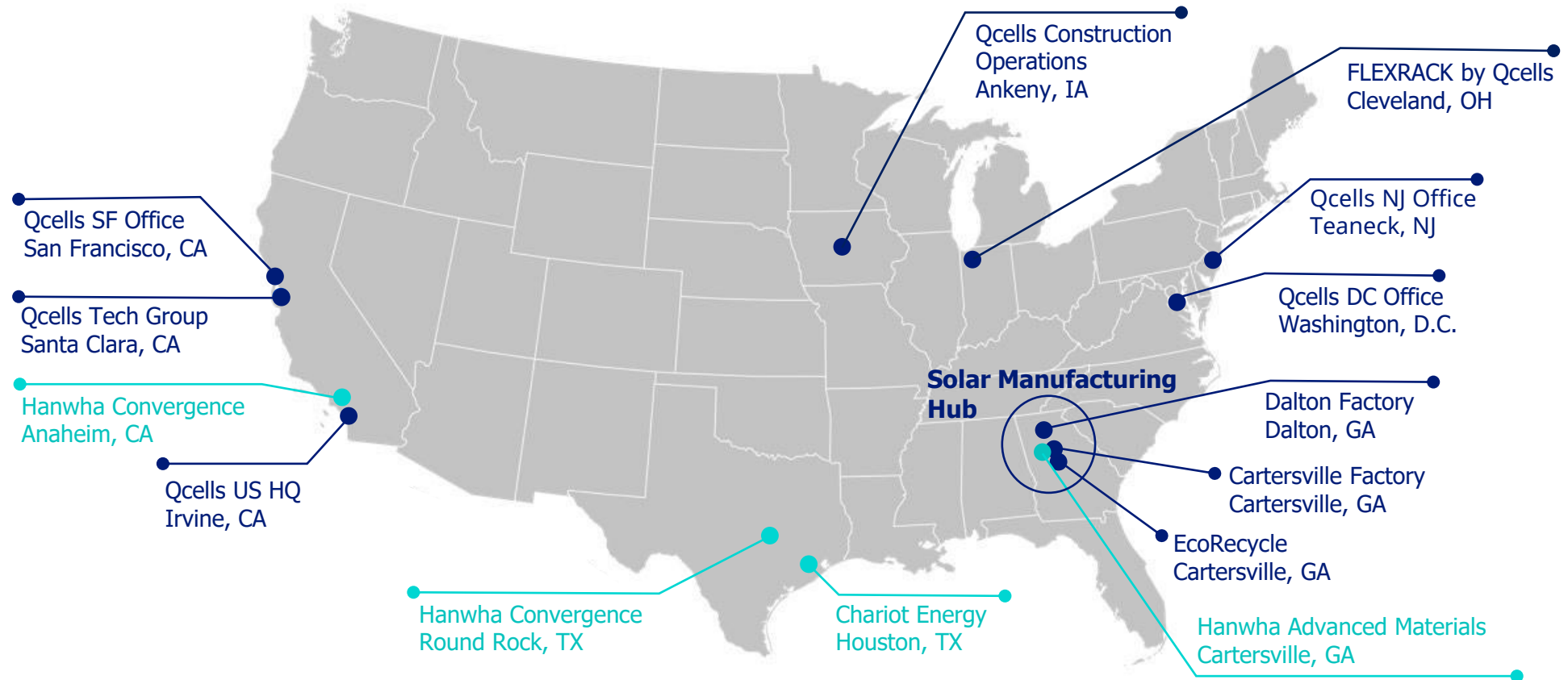
8+

Global Sales Network

North America, Europe, Asia and more



Qcells' Commitment to the Future of U.S. Energy

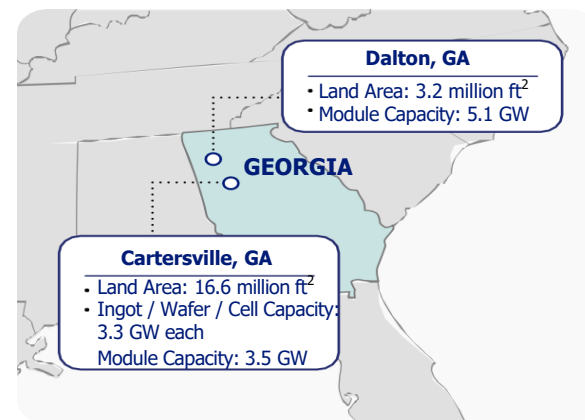


Qcells' Long-Haul Commitment to U.S. Manufacturing



- **\$2.8 billion+** investment to build an integrated solar supply chain in the U.S.
- Cartersville facility to manufacture **3.3 GW of ingots, wafers, cells** and **3.5 GW of finished modules**
- **8.6 GW** total U.S. solar module production capacity by 2026
- **4,000+** Georgia advanced manufacturing jobs created

Solar Manufacturing Hub



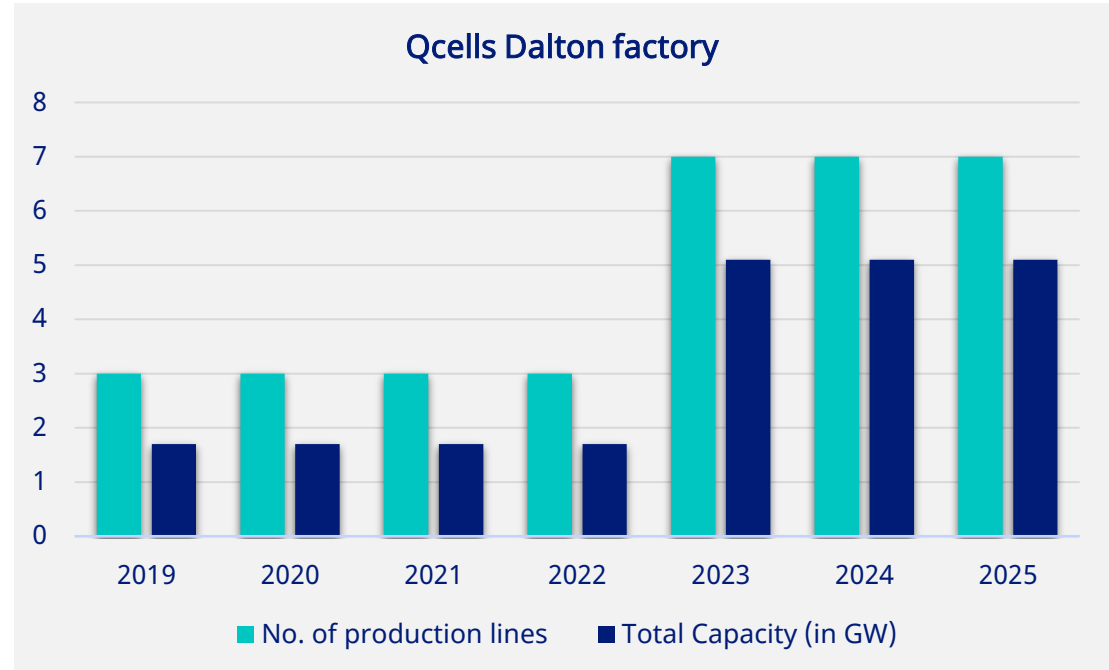
Dalton, GA Manufacturing Facility

MAY 2018
Dalton Plant
Announcement

SEPTEMBER 2019
Grand Opening

MAY 2022
Expansion Plan
Announcement

NOVEMBER 2023
Expansion
Completed



- In 2019, the Dalton factory started with a total capacity of 1.7 GW
- With the expansion completed in Q4 2023, the Dalton facility now has a total capacity of 5.1 GW

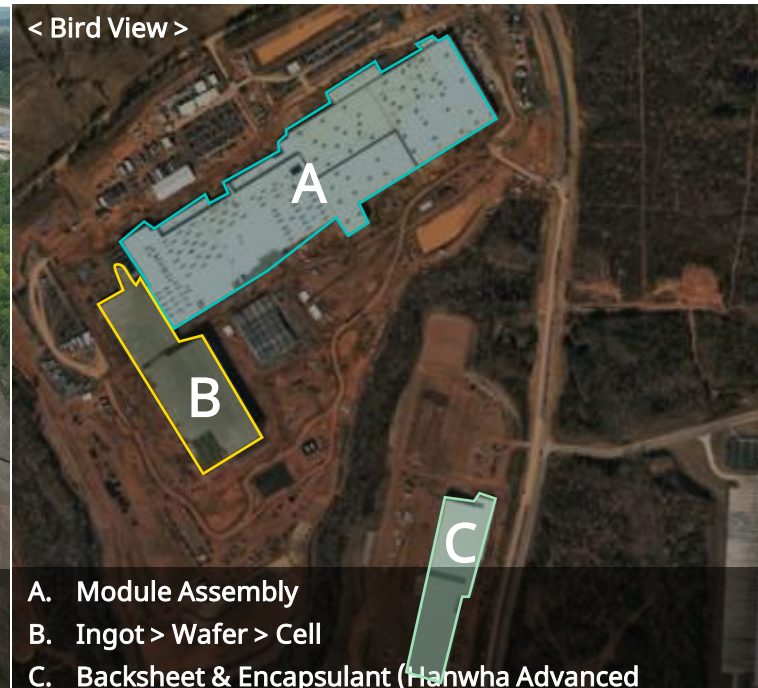
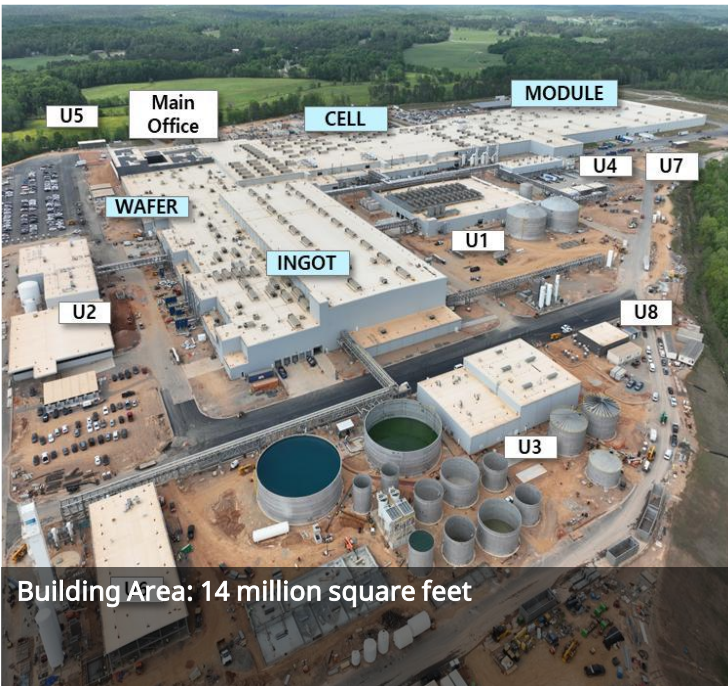
Cartersville Manufacturing Facilities

JANUARY 2023
**Cartersville Plant
Announcement**

MARCH 2023
**Hanwha Advanced
Materials Plant
Announcement**

MAY 2024
**Module Assembly
Started**

JUNE 2026
**Cell Production
Started**



Polysilicon



Ingot



Wafer



Cell



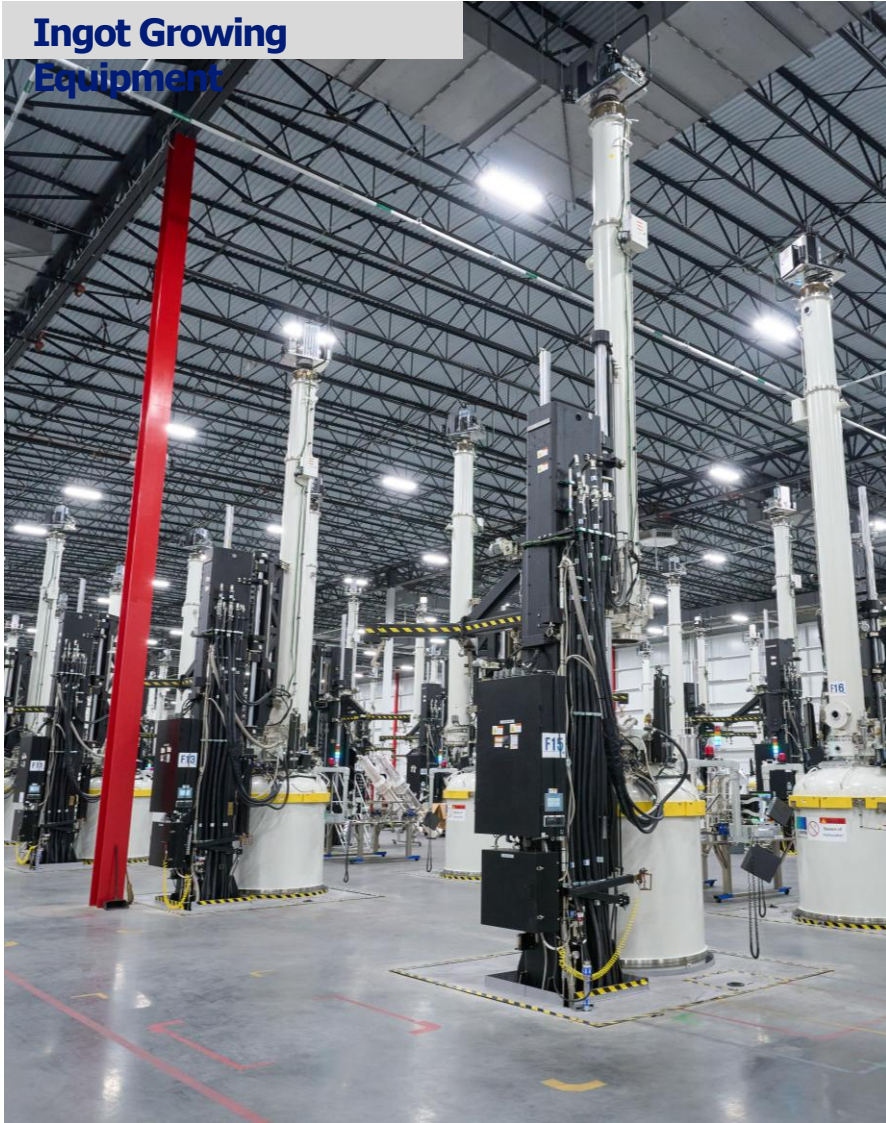
Encapsulant &
Backsheet



C-Si PV Module

Cartersville Manufacturing Facilities

**Ingot Growing
Equipment**



**Wafer
Equipment**



Cell Equipment

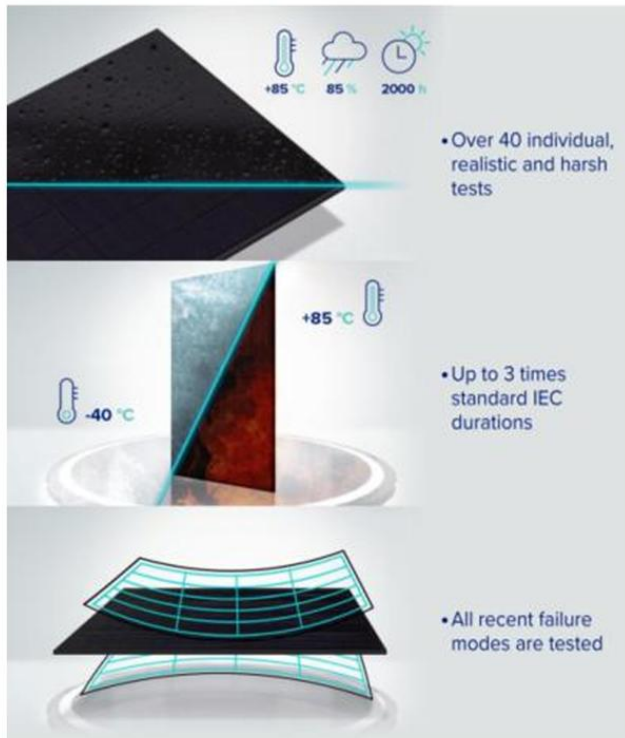


Qcells Quality Assurance Program

Superior Quality

Qcells' Comprehensive Quality Program:
Qcells tests its products to assure outstanding quality & performance.

1 Initial qualification



Initial qualification tests include:

- Over 40 individual, realistic and harsh tests (represented by icons for temperature, humidity, and light)
- Up to 3 times standard IEC durations (represented by a temperature icon at +85 °C and -40 °C)
- All recent failure modes are tested (represented by a diagram of a solar panel with a grid pattern)

2 Monitoring of production



Monitoring of production includes:

- Random production sampling to guarantee quality (represented by a diagram of a solar panel being inspected)
- Continuous monthly monitoring for all products manufactured in the U.S. and Korea (represented by a diagram of a person monitoring a solar panel)

3 Monitoring of material & supplier



Monitoring of material & supplier includes:

- Special tests to immediately detect fluctuations in material quality (represented by icons for a microscope, test tube, and chemical reaction)
- All tests are completed at every factory (represented by a world map with a Qcells location pin)
- Check of suppliers via audits and change control (represented by a diagram of a solar panel with a grid pattern)

Qcells' Comprehensive Quality Program

Qcells' Comprehensive Quality Program is one of the strictest and most extensive testing programs in the industry. Outstanding quality & performance is ensured in three parts, from new module design to core materials used in production.

Part 1

Module Qualification (Extended Duration Testing)

- Test sequences following IEC TS 63209-1
- Additional module tests defined e.g. LeTID
- Modification of every design characteristics are tested acc. to retesting guideline within IEC/UL standard
- High confidence in
 - **Reliability**
 - **Long lifespan cycle**
- Part 1 strictly manages quality from the product development stage

Part 2

Production Monitoring (Regular Surveillance Monitoring)

- **Monthly Quality Testing** Program
- Randomly selected sample
- **Continuous monitoring** of modules during mass production
- Part 2 is continuously and internally managing mass-produced products

Part 3

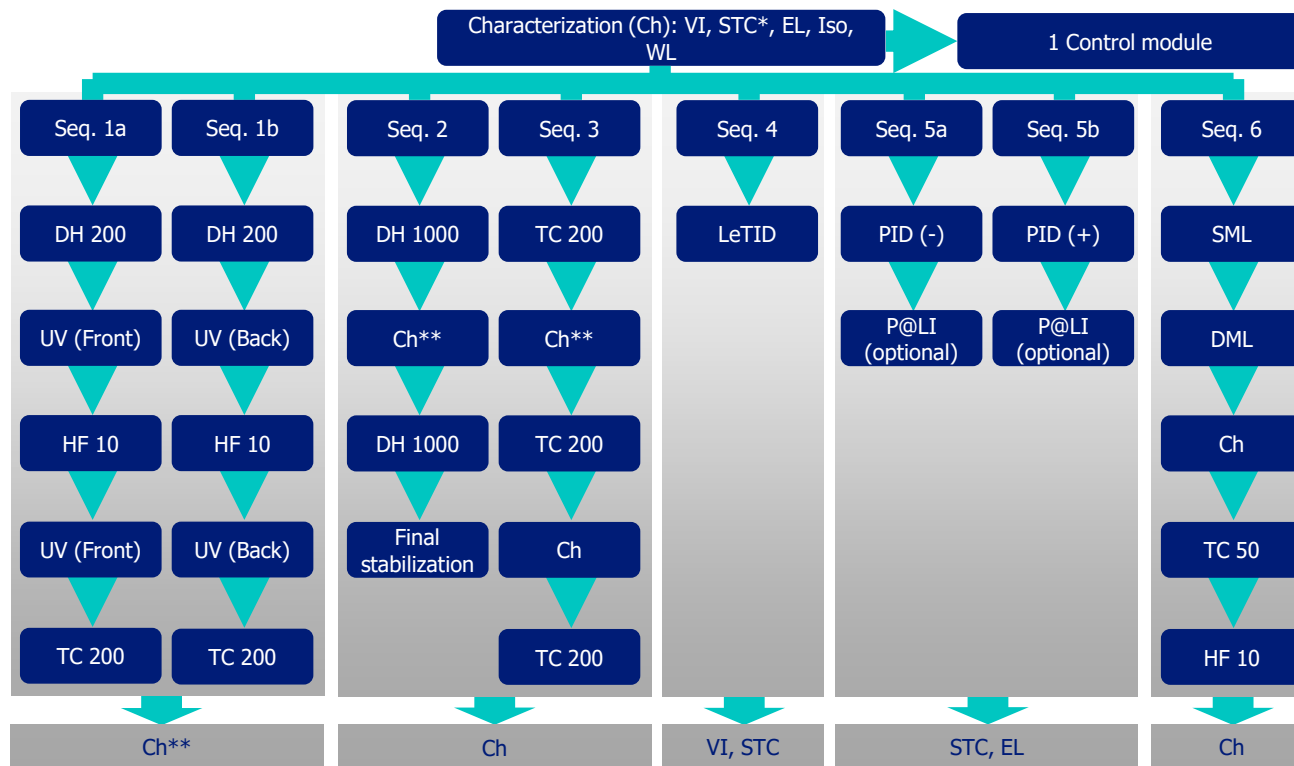
Material Monitoring (Supplier and Materials Monitoring)

- Master-list of **critical core suppliers and materials created / maintained**
- Enhanced random sampling for polymeric footprint
- Review of suppliers through audits and testing
- Part 3 is conducting strict quality control from the components used in the product

Qcells' Comprehensive Quality Program

Part 1: Module Qualification

High confidence in product reliability and long lifespan cycle is created.



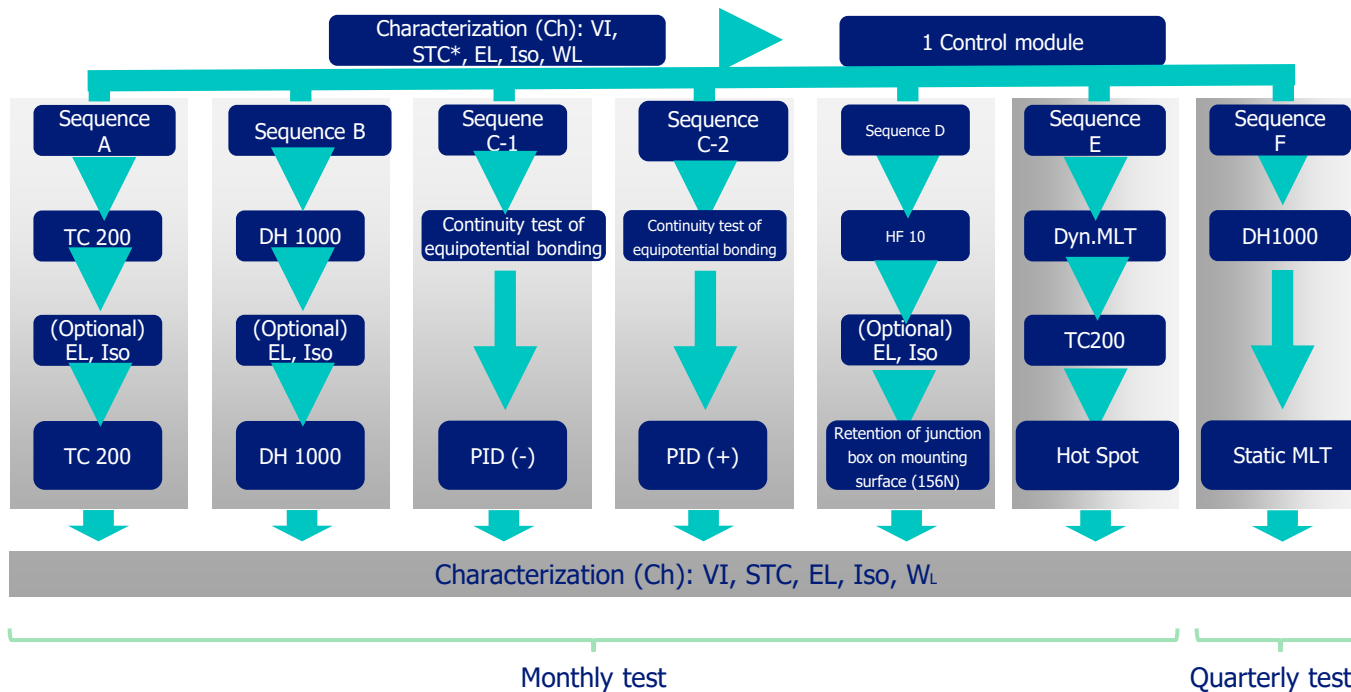
- Test procedure based on draft status of **IEC TS 63209-1 (Extended stress testing of photovoltaic modules for risk analysis)**
- LeTID: following IEC TS 63342
75 ± 3 °C / 2× (162 +8 / –0) hours
- PID: following IEC 62804-1
85 °C / 85 % RH / 192 hours (chamber)
- Test conditions vary depending on the model (Some models require separate Hail and UVID tests)

Qcells' Comprehensive Quality Program

Part 2: Production Monitoring

High confidence in quality stability is created.

Module Production Monitoring Program ensures high reliability.



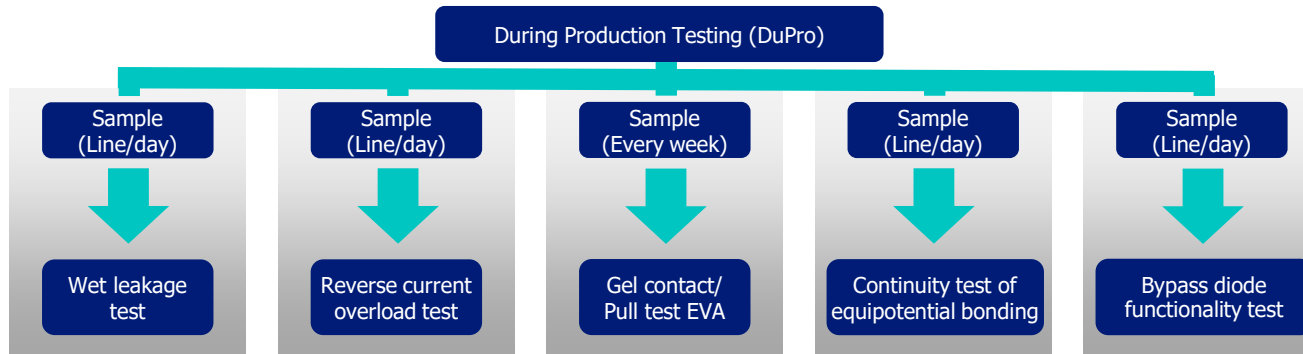
- Monthly random sample picking at each production site from out of Comprehensive Quality Program applied module types
- Random selection of required test samples of each factory
- Test results are verified and evaluated by Quality excellence office

Pass Criteria

- VI, Iso, WL following IEC 61215-2
- Monthly report is finished and approved by Qcells Quality Department

Qcells' Comprehensive Quality Program

Part 2: Regular Surveillance Monitoring (During Production Testing)



- Daily / weekly sample picking at each production site out of Comprehensive Quality Program applied module types
- Requirements according to IEC 61215-2 and IEC 61730-2 after testing
- Test evaluation results are monitored and verified by Quality excellence office

Qcells' Comprehensive Quality Program

Part 3: Material Monitoring

High confidence in supplier and material reliability is created.

Master List of Suppliers

- Definition of a master list of suppliers including supplier evaluation (material risk assessment)
- Double check by comparing the data sent by the supplier with the data evaluated directly by Qcells

Material Footprint

- Material analysis or identification measures are defined and implemented, e.g. GCMS (Gas chromatography with mass spectrometry / DSC (differential scanning calorimetry) or other microsection analysis methods

Regular Supplier Audit

- Yearly audits of core* material suppliers
- Cyclical process to ensure that every supplier is audited over time

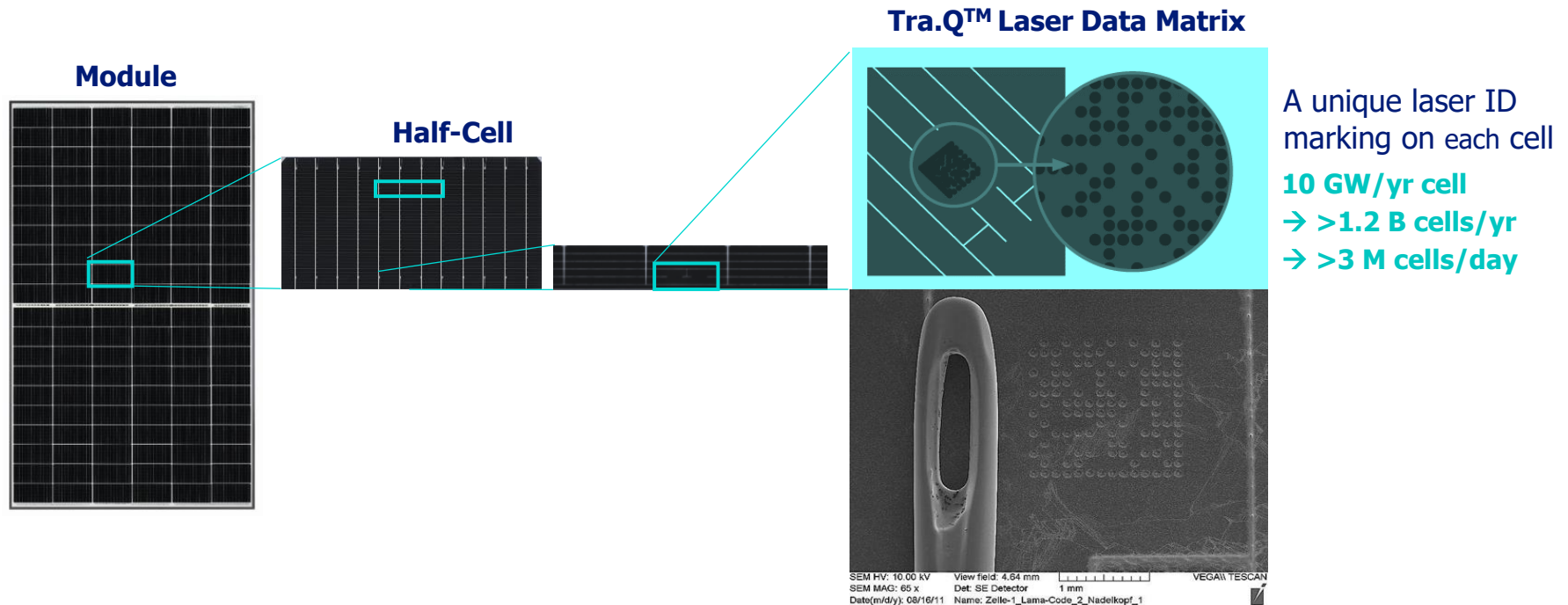
* Core materials are rated as critical or major according to the material risk assessment

Cell Traceability & Quality Assurance – TRA.Q™



Tra.Q™

- Every Q.ANTUM DUO and Q.ANTUM NEO solar cell contains Traceable Quality technology (Tra.Q™) since 2009
 - Wafer to cell-level tracking for all cells
 - Electrical performance tracking (IV data)
- Linking process & inline measured parameters with cell IV data enables big data analytics & machine learning
- Enables rapid manufacturing line ramp-up and ease of production optimization



Qcells In-process Quality Control



Incoming inspection

Incoming inspection based on defined AQL sampling

Tabbing & String

Automated cell stringing and soldering process

Lamination

Matrix lamination with defined process parameters

Framing

Automated frame assembly with controlled silicone application

J-Box attach

Automated j-box soldering and silicone potting process

Electrical tests

Electrical performance testing with calibrated sun simulator (qualified by ISE/Freiburg)

Final optical inspection

Final visual inspection of completed modules

Quality Sampling check

Quality sampling and surveillance monitoring

Sampling inspection for all incoming raw materials

100% automated optical inspection for alignment, chipping, and cracks

EVA gel content measurement and peel force testing

100% automated insulation distance check (AOI) and silicone weight verification

Daily inspection of silicone weight and potting condition

100% insulation test, final EL performance test, continuity test of equipotential bonding, and by-pass diode test

100% visual inspection on front and back side of modules

Sampling tests based on defined monitoring plans for appearance, dimensional, safety, and reliability compliance

Qcells' Quality Leadership

Top Brand

Robust 20+ year history of award-winning innovations and rated as a top module brand for 5 consecutive years in the U.S.



Top Quality & Technology

Outstanding durability and world-class performance as validated by top global institutions including RETC and Kiwa PVEL.



Best-in-Class Warranty

Extended 25-year product and performance warranties* that reflect our commitment to quality products built to last.



*Applicable to select solar module products

No.1 Market Share

Top market share in the U.S. residential & commercial markets.*

*Source: Wood Mackenzie US Distributed Solar Leaderboard



Tier 1 Bankability

Tier 1 solar manufacturer backed by Hanwha Group, a multi-national corporation and 7th largest conglomerate in South Korea.

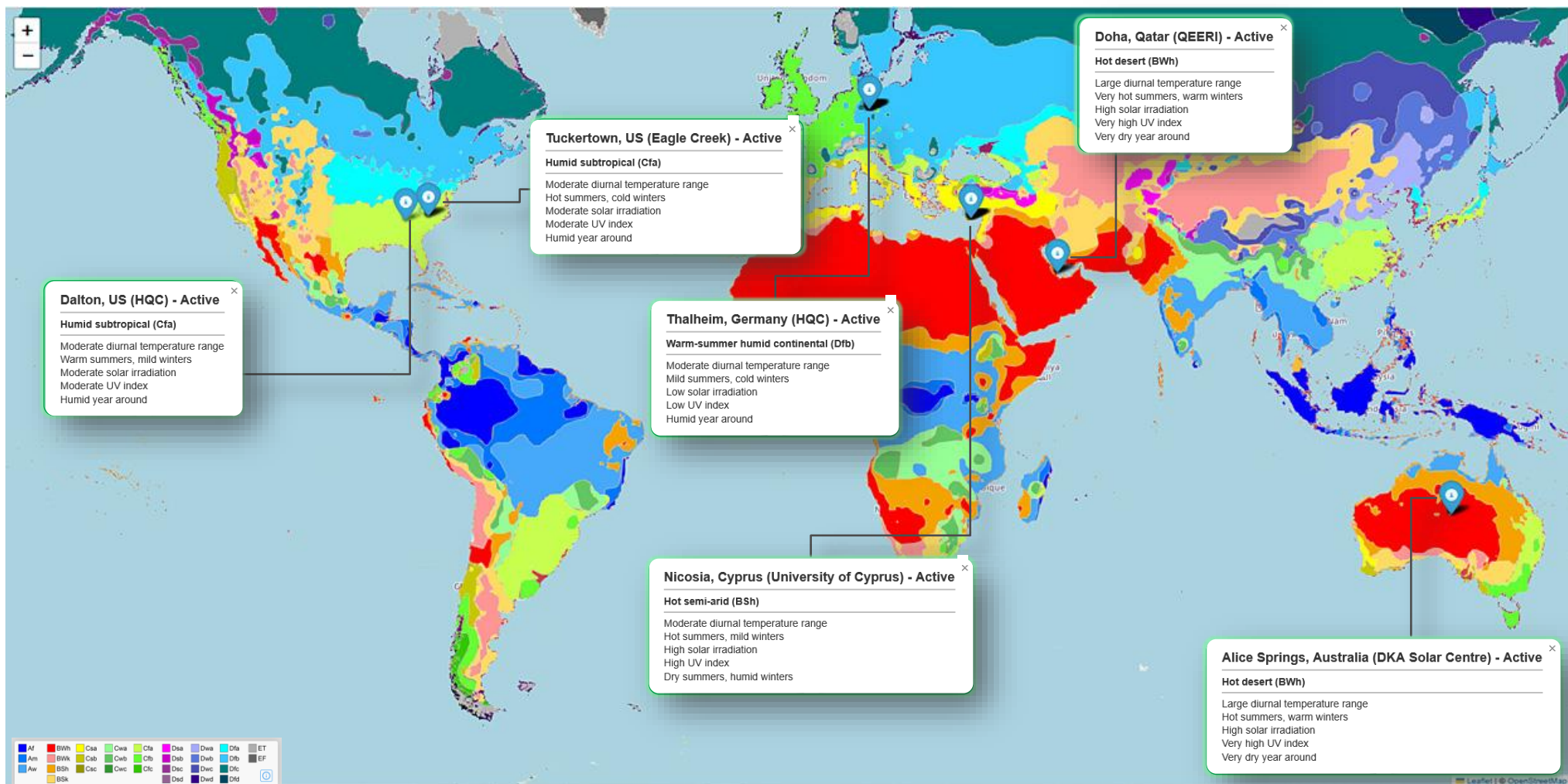


U.S. Manufacturing

Qcells operates the largest solar module factory of its kind in the Western Hemisphere and is building an integrated silicon based solar supply chain, manufacturing components to finished products here in the U.S.



Qcells Global Outdoor Testing Network by Climate Zone



Real-world module testing conducted across 6 climate zones to ensure global reliability and performance validation.

Long Term Verification: Degradation Rates



Location: Bitterfeld, Germany

- Monitoring of the performance of relevant product generations
- Solar-data-tools used for degradation rate determination

Year of Installation	Modules	Annual Degradation	All degradation rates observed within the warranty range
Oldest system from 2012	10 c-Si modules	-0.24% / a	Annual Degradation Convergence Years in Field Annual Degradation Rate [%/yr] Calendar Year Legend: Annual Degradation Rate (Data used: Day 1 → Year X), 95% Confidence Interval
Oldest Q.ANTUM system from 2012	10 early Q.ANTUM modules	-0.31% / a	Annual Degradation Convergence Years in Field Annual Degradation Rate [%/yr] Calendar Year Legend: Annual Degradation Rate (Data used: Day 1 → Year X), 95% Confidence Interval
Q.ANTUM system from 2014	9 Q.ANTUM modules	-0.55% / a	Annual Degradation Convergence Years in Field Annual Degradation Rate [%/yr] Calendar Year Legend: Annual Degradation Rate (Data used: Day 1 → Year X), 95% Confidence Interval

Complete Energy Solutions

Qcells offers a full suite of residential products and services to complement any home.



Qcells' Mainstay Module Products: Residential

Residential AC Module

108 Half-cells
**Q.TRON BLK
M-G2+ /AC**



Power (Wp in DC)
440

Max
Efficiency (%)
22.5

Weight (lbs)
50.6

Size (in)
67.8 x 44.6 x 1.57

Warranty

25
Year
Warranty
Product & Manufacturer

Residential AC Module

132 Half-cells
**Q.PEAK DUO
BLK ML-G10+ /AC**



Power (Wp in DC)
415

Max
Efficiency (%)
21.1

Weight (lbs)
52.36

Size (in)
74 x 41.1 x 1.57

Warranty

25
Year
Warranty
Product & Manufacturer

Residential DC Module

108 Half-cells
**Q.TRON BLK
M-G2+**



Power (Wp)
440

Max
Efficiency (%)
22.5

Weight (lbs)
46.7

Size (in)
67.8 x 44.6 x 1.18

Warranty

25
Year
Warranty
Product & Manufacturer

Residential DC Module

132 Half-cells
**Q.PEAK DUO
BLK ML-G10+**



Power (Wp)
415

Max
Efficiency (%)
21.1

Weight (lbs)
48.5

Size (in)
74 x 41.1 x 1.26

Warranty

25
Year
Warranty
Product & Manufacturer

AC Modules Q.TRON AC / Q.PEAK DUO AC

Qcells offers top-quality AC module options featuring an embedded US-assembled microinverter, all designed and assembled by Qcells.



Solar simplified.



Streamlined Installation & Product Management

Fast & easy installation enabled by an integrated Qcells microinverter that's manufactured in Detroit, Michigan.



Module-Level Monitoring & Control

Easily and intelligently monitor system performance at the module level using the Q.OMMAND app.



Fully Backed by One Brand, One Warrantor

Top-quality after-market customer support and backed by a 25-year product & performance warranty.



Qcells' Mainstay Module Products: Community, Commercial & Industrial (CCI)

CCI Module

156 Half-cells

Q.TRON
XL-G2/BFG



Power (Wp)
645

Max Efficiency (%)
23.1

Weight (lbs)
77.8

Size (in)
96.9 x 44.6 x 1.38

Warranty

CCI Module

132 Half-cells

Q.PEAK DUO
ML-G12S/BFG



Power (Wp)
680

Max Efficiency (%)
21.9

Weight (lbs)
84.2

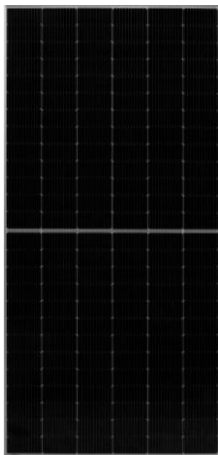
Size (in)
93.8 x 51.3 x 1.38

Warranty

CCI Module

156 Half-cells

Q.PEAK DUO
XL-G11S.3/BFG



Power (Wp)
605

Max Efficiency (%)
21.7

Weight (lbs)
80.2

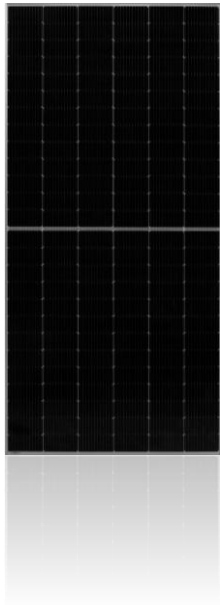
Size (in)
96.9 x 44.6 x 1.38

Warranty

Qcells' Mainstay Module Products: Utility

Utility Module

156 Half-cells
Q.PEAK DUO
XL-G11S/BFG



Power (Wp)
605

Max Efficiency (%)
21.7

Weight (lbs)
80.2

Size (in)
96.9 x 44.6 x 1.38

Warranty

Utility Module

132 Half-cells
Q.PEAK DUO
ML-G12S/BFG



Power (Wp)
680

Max Efficiency (%)
21.9

Weight (lbs)
84.2

Size (in)
93.8 x 51.3 x 1.38

Warranty

Coming Q3 2026

Utility Module

132 Half-cells
Q.TRON
ML-G3/BFG



Power (Wp)
725

Max Efficiency (%)
23.3

Weight (lbs)
84.2

Size (in)
93.9 x 51.3 x 1.38

Warranty

Qcells' Upcoming Module Products

Hail Resistant & Steel Frame Products

Steel Frame
Coming Q2 2027

Hail Resistant:
Coming Q1 2027

Utility Module

132 Half-cells

Q.PEAK DUO
ML-G12S/BGH



Power (Wp)
680

Max Efficiency (%)
21.9

Weight (lbs)
84.2

Size (in)
93.8 x 51.3 x 1.38

Warranty

12
YEARS
Warranty
Product

30
YEARS
Warranty
Performance

Steel Frame
Coming Q4 2027

Hail Resistant:
Coming Q1 2028

Utility Module

132 Half-cells

Q.TRON
ML-G3/BGH



Power (Wp)
725

Max Efficiency (%)
23.3

Weight (lbs)
84.2

Size (in)
93.9 x 51.3 x 1.38

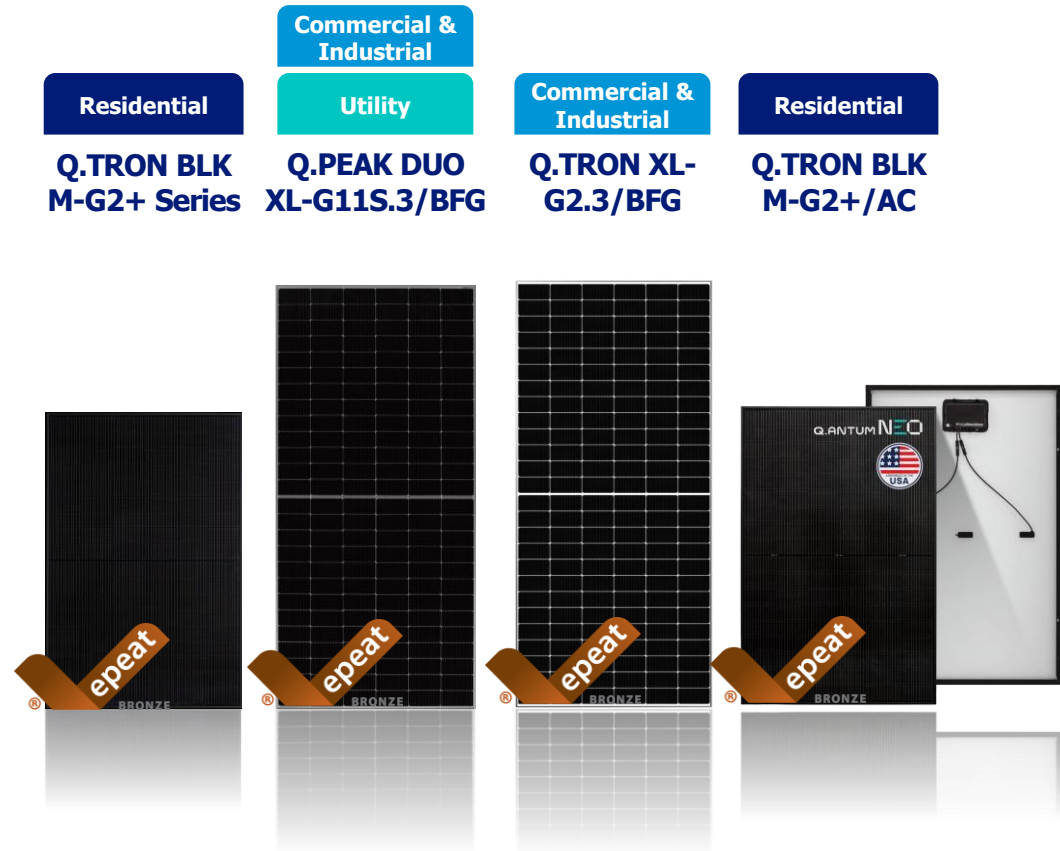
Warranty

12
YEARS
Warranty
Product

30
YEARS
Warranty
Performance

EPEAT – Sustainability Ecolabel

- Sustainability Ecolabels for electronics products empower consumer choice & purchasing decisions
- EPEAT is a Type I Ecolabel created by the **Global Electronics Council (GEC)**
 - Individual product-level certification per country
 - Leading global resource for sustainable electronic products, with registered products from Fortune 500 leaders to emerging brands
 - EPEAT follows a strict, comprehensive criteria verified by an independent third party
- Federal Acquisition Regulation (FAR) Part 23 requires all U.S. Federal Agencies to procure 95% EPEAT-registered electronics

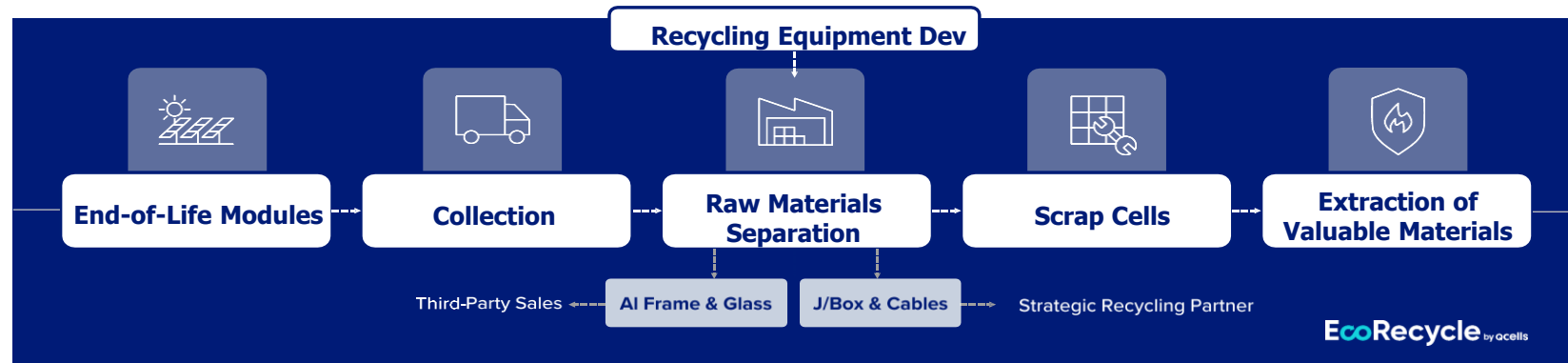


Commitment to Sustainability

Closed Loop Recycling

- EcoRecycle addresses solar waste in factory and as first-generation installations reach end-of-life
- Qcells will be the first U.S. company with a complete solar value chain from manufacturing to recycling
- Facility in Cartersville, GA, spans 68,000 sq ft and will recycle up to 500,000 modules annually (250 MW/year), reducing CO₂ by 10,000 tons by 2028

EcoRecycle by qcells



Thank Q!



qcells