

Stringer Machines: Essential for Top-Grade Solar Panels

Automating Quality: The Core of Modern Module Assembly

Content Partner: J. v. G. technology GmbH

Turnkey solar module production lines – since 1997

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Technical Overview of Stringer Machines in PV Manufacturing



Created as part of the PVKnowHow Knowledge Network



Prepared by J. v. G. Technology GmbH



European specialists in turnkey solar module production lines

Key Project Data

7000+

Cells/Hour

Maximum throughput of a fully automated stringer machine in PV production

100%

Automation Level

Fully automated cell stringing and interconnection — no manual handling required

1997

Founded

Turnkey manufacturing concept developed by an experienced European provider

90+

Factory Projects

Delivered worldwide across global PV manufacturing regions

📄 Process: Solar cell stringing & interconnection · Throughput: up to ~7,000 cells/hour · Application: PV module manufacturing · Automation level: Fully automated · Region: Global PV manufacturing · Source: PVKnowHow / J.v.G. Technology GmbH

Introduction: Role of Stringer Machines in PV Manufacturing

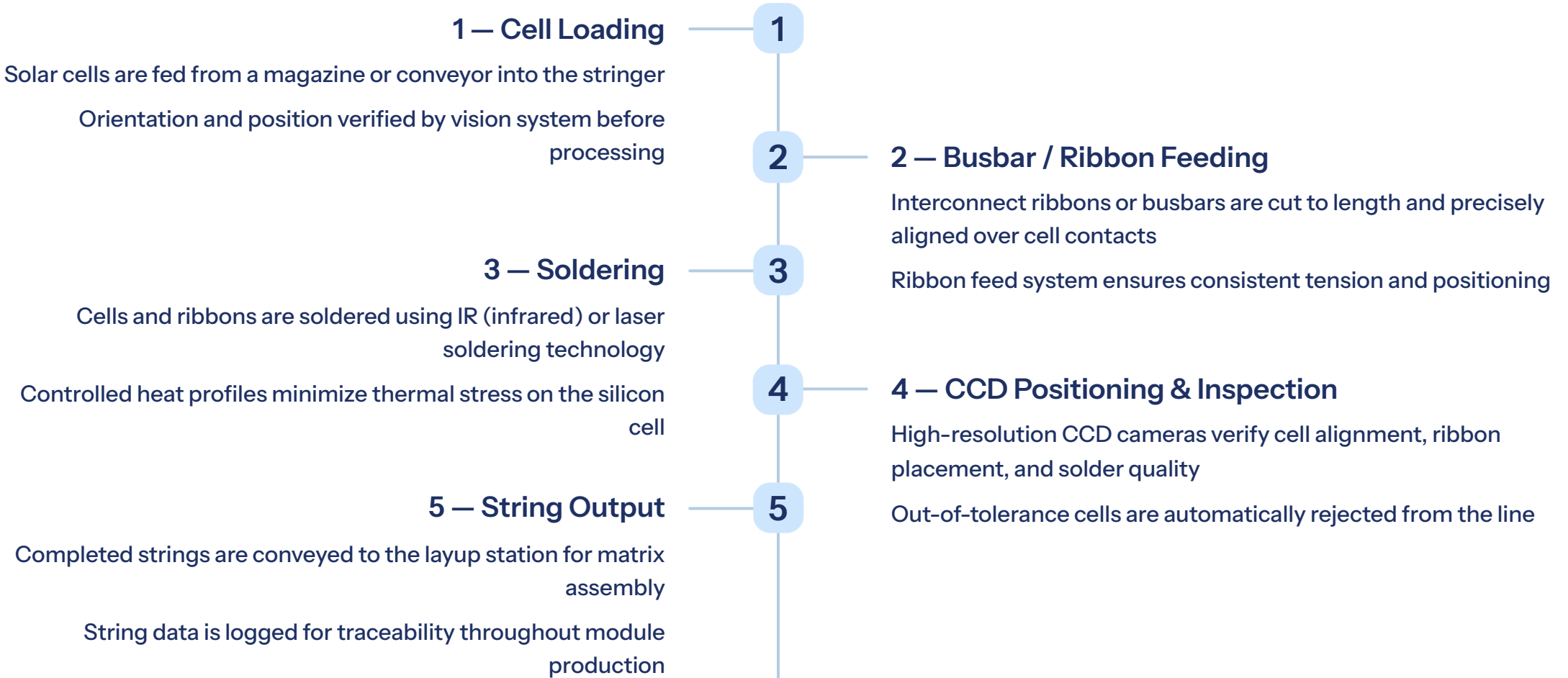
What Is a Stringer Machine?

- Interconnects individual solar cells using copper busbars or ribbons
- Forms "strings" — series-connected cell rows that become the core of a module
- Operates as the first critical assembly step in the module production line
- Directly determines module electrical performance and long-term reliability

Why It Is Critical

- Interconnection quality affects power output, cell breakage rates, and yield
- A weak solder joint can cause resistance losses or cell disconnection
- Consistent busbar placement ensures reliable current collection across the module
- Automation eliminates human variation — essential for high-volume production

Process Overview: How Stringing Works



Key Technologies in Modern Stringer Machines

IR Soldering

- Infrared lamp arrays deliver contactless, uniform heat to the cell-ribbon interface
- Heating profile precisely controlled to avoid thermal shock or cell breakage
- Industry-standard technology — proven across all mainstream cell formats

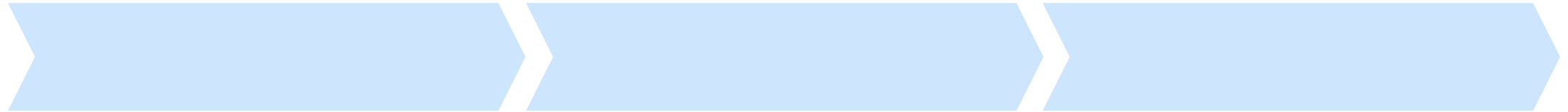
CCD Optical Positioning

- High-resolution cameras verify cell position, gap spacing, and ribbon alignment
- Real-time correction loops ensure sub-millimeter placement accuracy
- Defect detection integrated into the production cycle — no separate inspection step required

Full Automation

- PLC-controlled cell handling, ribbon cutting, soldering, and string output
- Automatic cell magazine loading reduces operator intervention
- HMI interface enables recipe management for different cell formats and module types

Production Performance: Speed and Throughput



Cell Throughput

Up to approximately 7,000 cells per hour in high-capacity stringer configurations

Cycle Time

Short individual cell cycle times enable seamless integration with downstream layup and lamination

Yield & Uptime

High mechanical repeatability and automatic reject handling maintain consistent net output per shift

- ❏ Stringer throughput is a primary constraint in module production line design. Line balancing requires stringer capacity to match laminator and framing station output — a key consideration in turnkey factory planning.

Importance for Quality and Efficiency

Interconnection Quality

- Solder joint integrity directly impacts module power output and degradation rate
- Poor connections cause resistive losses, hotspots, and potential cell failure
- Automated optical inspection at the stringer catches defects before lamination

Process Consistency

- Automated stringing eliminates cell-to-cell variation caused by manual handling
- Consistent solder profiles reduce crack rates in thin and bifacial cell formats
- Statistical process control data supports continuous yield improvement

Line Efficiency

- Inline reject handling prevents defective strings from reaching downstream stations
- Reduced rework cost — defects caught at stringing are far cheaper to address than post-lamination
- High uptime and fast format changeover support flexible production scheduling

Economic Impact: Cost and Scalability

Capital Investment Factors

- Stringer machines represent a significant share of total module line CAPEX
- Higher-automation models command premium pricing but deliver lower cost-per-watt at scale
- Turnkey procurement bundles stringer, layup, laminator, and framing into a validated line
- European turnkey providers offer factory planning, installation, and operator training

Operational Economics

- Lower defect rates at stringing reduce scrap cost per module produced
- Higher throughput reduces direct labor cost per watt
- Reduced consumable waste through precise ribbon cutting and controlled solder application
- Scalable line design allows capacity expansion without full line replacement

Key Purchasing Considerations

Technical Compatibility

- Cell format support: standard, M6, M10, G12, half-cut, bifacial
- Busbar configuration: 2BB, 3BB, 4BB, 5BB, MBB (multi-busbar)
- Integration compatibility with upstream cell handling and downstream layup systems

Performance & Support

- Verified throughput and yield data from reference installations
- Availability of spare parts, remote diagnostics, and on-site service
- Operator training included — critical for markets without prior manufacturing experience

Supplier Qualification

- Track record of delivered factory projects and documented line performance
- Certification compliance: IEC, TÜV, CE, and relevant regional standards
- Turnkey capability — single-source responsibility from planning through commissioning

Technology Comparison: IR vs. Laser Soldering

Criterion	IR (Infrared) Soldering	Laser Soldering
Heat Application	Radiant heat from IR lamps applied to full ribbon area	Focused laser beam applied at the cell-ribbon junction only
Thermal Stress	Moderate — controlled profile required for thin cells	Lower — highly localized heat minimizes cell thermal stress
Cell Compatibility	Proven for standard, PERC, and most mainstream formats	Preferred for HJT and temperature-sensitive cell types
Speed	High — well-suited for volume production up to ~7,000 cells/hr	Comparable — high precision may marginally reduce cycle time
Cost	Lower equipment and operating cost; mature technology	Higher initial investment; laser source requires maintenance
Maturity	Industry standard — widely deployed globally	Increasingly adopted for advanced cell technologies

Operational Factors: Maintenance and Training

Mechanical Maintenance

- Regular inspection of ribbon feed rollers, cutting blades, and conveyor belts
- Solder tip or IR lamp replacement at defined service intervals
- Preventive maintenance schedules reduce unplanned downtime on the production-critical stringer

Optical & Electrical Systems

- CCD camera calibration required periodically to maintain alignment accuracy
- Power supply stability critical — voltage variation affects solder joint quality
- PLC recipes and process parameters should be version-controlled and backed up

Operator Training

- On-site training by the turnkey provider essential for new manufacturing teams
- Operators trained in format changeover, reject handling, and basic fault diagnosis
- No prior manufacturing experience required when supported by an experienced turnkey partner

Future Trends: Automation and Smart Manufacturing

Advanced Cell Format Adaptation

- MBB (multi-busbar) and shingled cell stringing becoming standard requirements
- Half-cell and 1/3-cell formats driving faster, more flexible stringer designs
- HJT-compatible low-temperature soldering expanding laser stringing adoption

Smart Manufacturing & IoT

- Integration with MES (Manufacturing Execution Systems) for full cell-to-module traceability
- IoT-enabled remote monitoring of stringer status, throughput, and reject rates
- Closed-loop feedback adjusts process parameters automatically based on inline inspection data

AI & Process Intelligence

- AI-assisted vision systems for real-time defect classification at stringing speed
- Predictive maintenance algorithms reduce unplanned downtime
- Data-driven process optimization continuously improves yield and solder joint quality

Conclusion: Stringer Machines as a Manufacturing Cornerstone



Process Foundation

Stringer machines define interconnection quality — the primary determinant of module power output and long-term reliability

Scalability Driver

High-throughput automated stringing is the enabling technology for cost-competitive, gigawatt-scale PV module manufacturing

Turnkey Integration

A proven turnkey manufacturing concept integrates stringer expertise into a complete, validated production line — reducing risk for new factory entrants

- ❏ An experienced European turnkey provider delivers stringer machine know-how as part of a fully integrated production line — from factory planning and equipment supply through operator training and commissioning. Source: PVKnowHow / J.v.G. Technology GmbH

About the Content Partner

J. v. G. Technology GmbH – The DESERT Company

Founded in 1997 in Bavaria, Germany. Family-owned engineering company specializing in turnkey solar module production lines.

More than 90 factory projects delivered worldwide. On-site team training included – no prior manufacturing experience required.

Key areas:

Turnkey PV manufacturing lines | DESERT Technology® | TÜV-certified module designs
| Factory planning to production

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