The Rajasthan Advantage: Building a High-Efficiency Facility to Supply India's Largest Solar Parks

A Strategic Case for Local Production in India's Solar Heartland

Content Partner: J. v. G. technology GmbH

Turnkey solar module production lines — since 1997

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Technical Overview: Building High-Efficiency Solar Facilities in Rajasthan

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

50 MW	€4–6M	9–15mo	DESER...
Facility Scale	**Investment Range**	**Ramp-Up Period**	**Line Type**
Semi-automated glass-glass production	Estimated total capital investment	From equipment delivery to full production	Semi-automated climate-adapted glass-glass

Region: Rajasthan / India · Line Type: Semi-automated DESERT+ glass-glass · Source: PVKnowHow / J.v.G. Technology GmbH

Rajasthan: India's Solar Opportunity

Natural Endowment

- Solar potential assessed at 142 GW by National Institute of Solar Energy
- Over 325 days of sunshine per year
- Vast areas of barren and uncultivable land available
- Among the highest solar irradiance levels in India

Current Status

- Installed solar capacity: ~33 GW as of early 2025
- India's largest solar state by installed capacity
- Integrated Clean Energy Policy 2024: targets 90 GW solar by 2029–30
- Only ~7% of assessed renewable potential realized to date

India's Large-Scale Solar Ambitions

National Target

- 500 GW of non-fossil fuel capacity by 2030
- Solar is the primary driver of this expansion
- Rajasthan positioned as a key contributor state

Domestic Manufacturing Push

- Approved List of Models and Manufacturers (ALMM) mandates local sourcing
- Production Linked Incentive (PLI) scheme supports module manufacturing
- Import duties on cells and modules reinforce local production economics

Investment Scale

- Major industrial groups committing multi-GW projects in Rajasthan
- Rajasthan RE Policy 2023 expected to attract ~₹4 lakh crore in investment
- Over 1,11,000 jobs projected across the state's renewable energy sector

Strategic Value of Local Manufacturing

1

Supply Security

Reduces dependence on imported modules; insulates projects from global supply chain disruptions

2

Policy Compliance

ALMM-listed domestic production is required for government-tendered solar projects in India

3

Economic Value

Local manufacturing retains margin in-country; creates skilled employment and technology transfer

A proven turnkey manufacturing concept allows new entrants to establish production without prior factory experience — reducing the learning curve significantly.

Why Rajasthan Matters for Module Production

Locational Advantages

- Proximity to India's largest solar deployment zones
- State policy actively supports RE manufacturing investment
- RIPS 2019: stamp duty and land tax exemptions for eligible projects
- Land availability at comparatively low cost

Market Access

- Direct supply to Rajasthan's own 90 GW pipeline
- Proximity to Gujarat, Maharashtra, and Delhi demand centers
- RE park development zones create co-location options
- Strong grid infrastructure investment under state policy

Climate Challenges for Solar Modules in Rajasthan

Extreme Heat

- Ambient temperatures regularly exceed 45°C in summer
- Module operating temperatures can reach 70–80°C on-site
- Thermal stress accelerates encapsulant aging and cell micro-cracking

High UV Irradiance

- Rajasthan receives some of India's highest annual UV dose
- UV-induced degradation (UVID) identified as a major reliability challenge for n-type cells
- Standard IEC testing (15 kWh/m^2) may be insufficient for desert field conditions

Sand, Dust & Humidity Cycles

- Thar Desert dust causes significant soiling losses
- Monsoon humidity cycles create damp-heat stress on module interfaces
- Combined UV + damp-heat degradation is particularly severe for TOPCon and HJT cells

Heat-Related Performance Losses

Temperature Coefficient Effect

- Standard module output is rated at 25°C (STC)
- Output decreases ~0.3–0.45% per °C above STC depending on cell type
- At 70°C module temperature: ~13–20% output loss vs. rated power
- HJT cells offer the lowest temperature coefficient among commercial technologies

Long-Term Thermal Degradation

- Repeated thermal cycling causes solder joint fatigue and ribbon cracking
- Backsheet-based modules more susceptible to rear-surface heat damage
- Glass-glass construction provides superior thermal mass and heat dissipation
- Properly laminated modules show lower thermal degradation over 25+ years

UV Degradation and Long-Term Reliability

UVID: A Documented Risk

- 40% of tested n-type modules showed ⩾5% performance loss after UV testing (RETC, 2024)
- Some TOPCon modules showed up to 16.6% loss under extended UV exposure (Kiwa PVEL)
- Degradation linked to surface passivation breakdown in TOPCon and HJT cells

Desert Climate Amplification

- Field tests in desert climates show early degradation in 62% of inspected HJT modules
- Combined UV + damp-heat cycling is more destructive than either stressor alone
- TOPCon cells with proper passivation optimization can limit UV efficiency loss to <1%

Mitigation at Module Level

- Encapsulant selection is critical — UV-blocking properties degrade over time
- Glass-glass construction provides mechanical UV barrier on both module faces
- Correct lamination quality is the primary defence against moisture and UV ingress

Climate-Adapted DESERT+ Module Concept

Design Rationale

- Specifically engineered for extreme-climate deployment conditions
- Addresses heat, UV, dust, and humidity cycling simultaneously
- TÜV-certified module designs available for regulatory compliance

Glass-Glass Construction

- Dual-glass enclosure replaces conventional backsheet
- Superior UV and moisture barrier on both module faces
- Extended field lifetime target: 30+ years in harsh climates

Encapsulant Selection

- TPO or POE encapsulants preferred for desert conditions
- Lower water absorption (<0.1%) vs. standard EVA
- Reduced yellowing and delamination risk under sustained UV exposure

Glass-Glass Module Advantages

1

Durability

Eliminates backsheet failure modes; resists rear-face UV, moisture, and mechanical damage throughout module lifetime

2

Bifacial Compatibility

Transparent rear glass enables bifacial energy harvest — additional yield gain relevant on Rajasthan's reflective desert soil

3

Certification & Bankability

TÜV-certified glass-glass designs are recognized by lenders and EPCs; supports project finance in regulated markets

Glass-glass modules require a dual-chamber lamination process with precise temperature and vacuum control — this is a core design parameter in a DESERT+ production line.

TOPCon / HJT: Future-Ready Technology

Criterion	TOPCon	HJT
Cell Efficiency (mass production)	24–26.5%	25–26%+
Temperature Coefficient	~−0.30%/°C	~−0.24%/°C (best-in-class)
UV Sensitivity	Moderate; mitigated by passivation design	Higher; encapsulant selection critical
Manufacturing Compatibility	Upgradeable from PERC lines	Requires new dedicated equipment
Desert Climate Suitability	Good with correct BOM selection	Strong if module design is optimized
Bankability	Established; widely financed	Growing; premium positioning

Factory Roadmap and Setup Process

1

Phase 1 — Feasibility & Planning

Market analysis, site selection, regulatory approvals, business case finalization

Line specification defined based on target cell technology and module format

2

Phase 2 — Equipment Procurement

Turnkey line ordered from an experienced European industrial solutions provider

Equipment package includes laminator, stringer, framing, testing, and quality systems

3

Phase 3 — Factory Construction & Installation

Civil works, cleanroom preparation, equipment delivery and installation

No prior manufacturing experience required — on-site team training included

4

Phase 4 — Ramp-Up & Certification

Trial production, process optimization, and quality system validation

TÜV module certification for market access in regulated tender programs

5

Phase 5 — Full Production

Sustained 50 MW/year semi-automated output; ongoing process support available

Ramp-up to full capacity: 9–15 months from equipment delivery

Investment and Operational Timeline

Capital Investment

- Total estimated investment: €4–6 million
- Covers turnkey line, civil preparation, and initial working capital
- Semi-automated configuration: lower capex than fully automated lines
- Suitable for 50 MW/year production scale

Operational Parameters

- Ramp-up period: 9–15 months from equipment delivery
- Line type: Semi-automated DESERT+ glass-glass production
- Cell technology: TOPCon or HJT compatible
- Source: PVKnowHow / J.v.G. Technology GmbH

Investment figures are indicative composite estimates based on comparable projects. Final costs depend on site conditions, civil scope, and equipment specification.

FAQ Highlights

Do we need prior manufacturing experience?

No. A proven European turnkey manufacturing concept includes on-site team training and process handover. No prior PV manufacturing experience is required to begin production.

Can the line be certified for Indian tenders?

Yes. TÜV-certified module designs are included. ALMM registration requires domestic production — this line is structured to meet that requirement.

Why glass-glass for Rajasthan specifically?

Standard backsheet modules degrade faster under sustained UV and heat stress. Glass-glass construction provides a superior moisture and UV barrier for 30+ year field lifetime in extreme climates.

What is the minimum viable scale?

The reference case is a 50 MW/year semi-automated facility. This scale provides commercially viable output while keeping initial capital requirements within the €4–6M range.

Strategic Conclusion

1

Market Timing

India's 500 GW target and ALMM mandates create a near-term structural demand for domestically produced, climate-adapted modules

2

Technology Fit

Glass-glass DESERT+ with TOPCon or HJT cells is the technically defensible choice for Rajasthan's extreme UV and heat environment

3

Entry Pathway

A 50 MW semi-automated turnkey line at €4–6M investment provides a credible, bankable entry into Indian domestic module production

Rajasthan's 142 GW solar potential, active state manufacturing policy, and proximity to major demand centers make it a strategically sound location for a first domestic PV manufacturing facility.

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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