

# Adapting Module Technology for the Saudi Climate: A Business Case for Desert-Proofing

Climate-Specific Module Design · Soiling Loss Mitigation · Long-Term  
Project Profitability

**Content Partner: J. v. G. technology GmbH**

*Turnkey solar module production lines — since 1997*

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# Technical Overview: Desert-Proofing Solar Modules for the Saudi Climate



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

**~2–50%**

## Soiling Loss Range

PV performance reduction in Saudi Arabia depending on region and cleaning frequency

**12–18%**

## Thermal Power Loss

Output reduction at 65°C module temperature — realistic in Saudi summer conditions

**58.7 GW**

## Solar Target by 2030

Saudi Vision 2030 solar capacity target under the National Renewable Energy Program

**~10%**

## GCC Monthly Loss

Typical monthly PV power output decrease due to soiling across GCC installations

📄 Market focus: Saudi Arabia / GCC · Product type: Desert-adapted solar modules · Technology focus: Anti-soiling + high-temperature resistant design · Manufacturing concept: Climate-adapted turnkey production · Strategic goal: Lower LCOE and higher durability · Source: PVKnowHow / J.v.G. Technology GmbH

# The Saudi Arabia & GCC Solar Opportunity

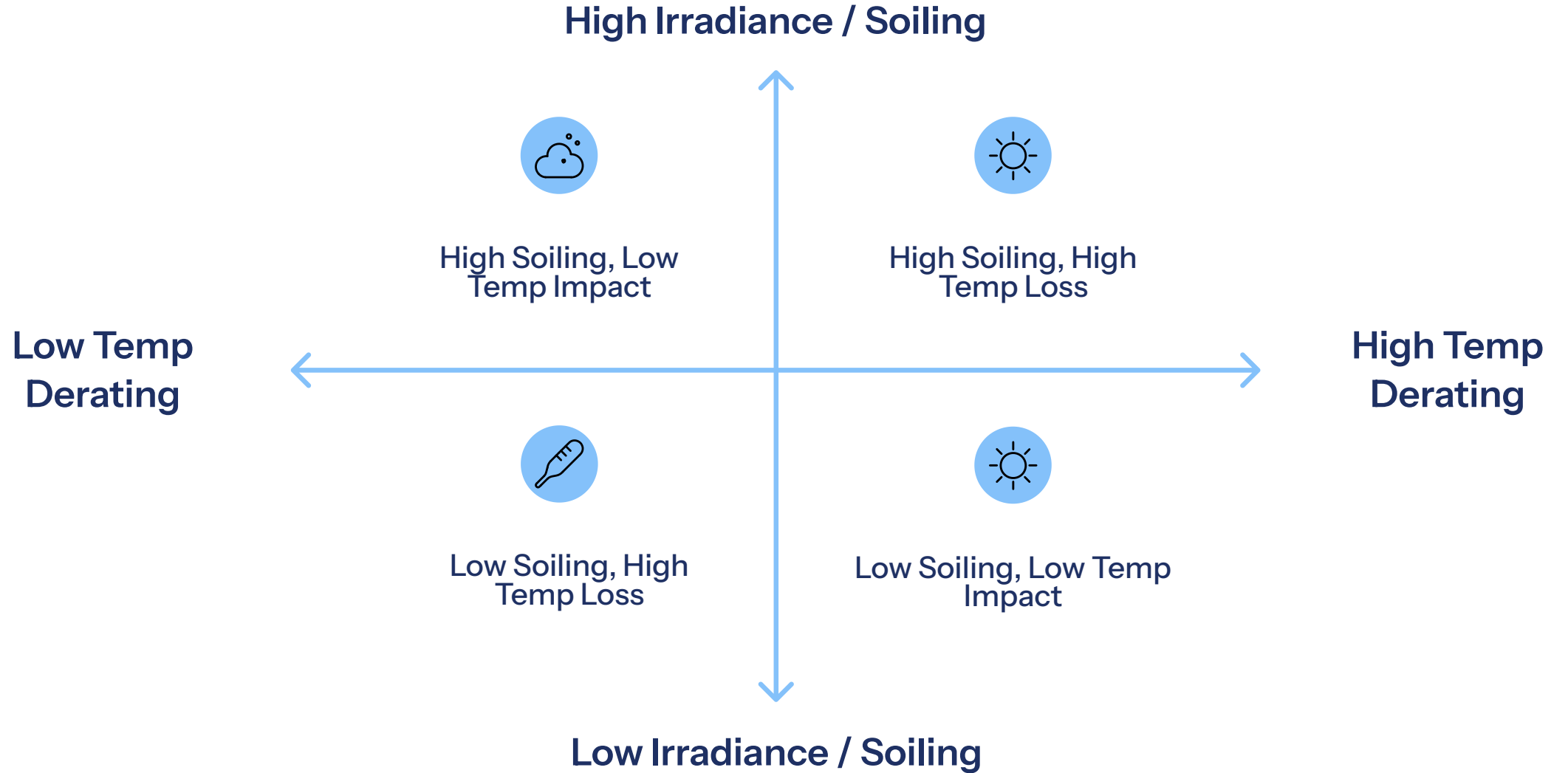
## Vision 2030 Scale

- Target: 50% of electricity from renewables by 2030
- Total renewable capacity goal: ~130 GW
- Solar PV target: 58.7 GW by 2030
- 14 GW of new renewable tenders planned for 2026 alone
- USD 32 billion investment pipeline through 2030

## Why Climate Adaptation Matters

- Exceptional solar irradiance — among the highest globally
- Desert dust and sandstorms are a persistent operational challenge
- Extreme summer temperatures routinely exceed 45°C ambient
- Standard imported modules are not optimized for these conditions
- Climate-adapted modules reduce long-term O&M costs and LCOE

# Desert Climate: The Two Core Performance Threats



In the Saudi desert environment, soiling and thermal stress act simultaneously — during peak irradiance hours, modules face maximum dust accumulation and maximum cell temperature at the same time. Standard module designs do not account for this compounding effect.

# Soiling Losses: Quantified Impact in Saudi Arabia & GCC

## Daily Accumulation Rate

- Soiling can cause up to 1% daily power loss in desert conditions
- Loss compounds rapidly without rain or active cleaning
- Dust adhesion increases with humidity and particle composition

## Documented Field Losses

- 2–50% power reduction depending on region and cleaning frequency
- Single sandstorm event: up to 20% power output loss
- 6 months without cleaning (Dhahran): >50% power drop
- 8 months soiling near Riyadh: 32% performance degradation

## GCC Regional Baseline

- Typical monthly soiling loss across GCC: ~10% of output
- Primary dust composition: silicon oxide, cement particles, industrial gypsum
- Industrial gypsum shows highest adhesion — hardest to dry-clean
- Rainfall is insufficient for natural self-cleaning in most regions

# High-Temperature Efficiency Reduction: Technical Parameters

## Temperature Coefficient Effect

- Standard c-Si modules: ~0.3%–0.45% power loss per °C above 25°C
- Module operating temperature in Saudi summer: realistically 65°C+
- At 65°C: estimated 12–18% power output reduction
- Cell temperature is consistently higher than ambient air temperature

## Design Response Required

- Low-temperature-coefficient cell technologies (TOPCon, HJT) reduce thermal losses
- Encapsulant selection affects thermal resistance and long-term durability
- Backsheet and frame materials must withstand sustained high-temperature exposure
- UV stabilizers must be rated for high-irradiance, high-UV desert environments

# Climate-Adapted Module Engineering: Key Technical Features

## Anti-Soiling Glass Coatings

- Ultra-thin transparent coatings applied to module front glass
- Hydrophobic variants: water beads and rolls off, carrying dust particles
- Hydrophilic variants: water sheets across surface, evaporates cleanly
- Both approaches reduce dust adhesion and soiling accumulation rate

## High-Temperature Resistant Encapsulation

- POE (polyolefin elastomer) encapsulants offer superior thermal stability vs. standard EVA
- Lower water absorption — critical in high-humidity coastal desert zones
- Reduced yellowing and delamination risk under sustained UV and heat exposure
- Material selection adds marginal cost relative to total module cost

## Structural & Frame Durability

- Reinforced frame design to withstand sandstorm mechanical impact
- Corrosion-resistant anodized aluminum rated for high-temperature cycling
- Backsheet materials certified for sustained high-temperature environments
- Junction box sealing rated for sand ingress and thermal expansion cycles

# Standard Module vs. Desert-Adapted Module: Comparison

Design Parameter	Standard Module	Desert-Adapted Module
Front Glass Coating	Standard AR coating	Anti-soiling + AR coating
Encapsulant	Standard EVA	POE or heat-stabilized EVA
Temperature Coefficient	-0.40 to -0.45%/°C (typical)	-0.30 to -0.35%/°C (TOPCon/HJT)
UV Stabilization	Standard grade	Enhanced desert-grade UV package
Backsheet / Rear Cover	Standard polymeric backsheet	High-temp rated or glass-glass design
25-Year Yield Expectation	Lower in desert (soiling + heat)	Maintained – climate degradation controlled

# Impact on Project Profitability and LCOE

## Higher Energy Yield

- Consistent output not degraded by uncontrolled soiling and heat
- Anti-soiling coatings reduce cleaning frequency requirements
- Lower thermal losses preserve annual generation vs. standard modules

## Lower O&M Costs

- Reduced water consumption and labor for module cleaning
- Fewer field failures driven by heat-induced delamination and yellowing
- Lower warranty exposure over 25-year project lifetime

## Improved Bankability

- Technology proven for local climate lowers perceived investor risk
- Climate-specific certification supports project financing conditions
- Predictable yield curves are essential for long-term PPA structures

# Local Manufacturing: The Strategic Case

1

## Market Demand Signal

Saudi Vision 2030 requires 58.7 GW of solar — creating sustained domestic demand that generic imported modules are not optimized to serve

2

## Climate Differentiation

Local production lines configured for desert-adapted module specifications address a clear performance gap that mass-produced imports leave open

3

## Localization Policy

Saudi Vision 2030 actively incentivizes local manufacturing; PIF has committed investment to localize solar equipment supply chains within the Kingdom

- ❑ A proven turnkey manufacturing concept enables new producers to enter climate-adapted module production without prior manufacturing experience — incorporating desert-specific process know-how from the production line design stage.

# Strategic Summary: Desert PV Manufacturing for Saudi Arabia

## The Core Problem

- Soiling losses: 2–50% power reduction; ~10% monthly baseline across GCC
- Thermal losses: 12–18% at realistic Saudi summer module temperatures
- Standard modules designed for temperate climates underperform in desert conditions

## The Engineering Response

- Anti-soiling coatings + POE encapsulants + low-temperature-coefficient cells
- Desert-grade UV stabilization and high-temp structural components
- Climate-adapted production: turnkey lines configured for desert module specifications

## The Strategic Outcome

- Lower LCOE through sustained yield and reduced O&M over 25-year lifetime
- Higher bankability and investor confidence in project cash flows
- Alignment with Saudi Vision 2030 localization and renewable capacity targets

**i** **Source:** PVKnowHow / J.v.G. Technology GmbH · **Market:** Saudi Arabia / GCC · **Technology:** Desert-adapted module engineering · **Goal:** Lower LCOE, higher durability, local value creation

# 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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