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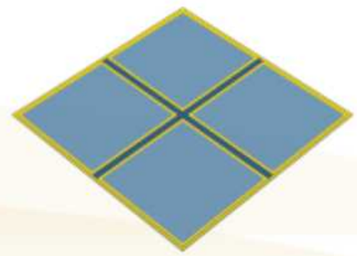
Photovoltaic Local Manufacturing Project

——In Saudi Arabia

Supporting Saudi Vision 2030
– Energy Transition Strategy



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Introduction & Project Background

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Saudi Energy Transition and Vision 2030

- Saudi Arabia is undergoing a deep energy transition closely aligned with its Vision 2030 goals.
- The country is committed to sustainable development and energy structure transformation.
- The strategy aims to achieve economic diversification and reduce dependence on fossil fuels.
- Developing renewable energy, especially solar photovoltaic (PV), is a key pillar in achieving national targets.

Market Gap & Strategic Significance

Market Gap

- Saudi Arabia has abundant solar resources, with high annual sunlight and strong solar radiation.
- In 2024, the local solar market is worth USD 5.92 billion, projected to grow to USD 67.67 billion by 2030.
- As of September 2024, only 6.55 GW of renewable capacity is installed, far below the 58.7 GW target by 2030.

Strategic Significance

- **Support energy transition:** Target of 50% renewable electricity by 2030, with 40 GW PV capacity.
- **Diversify the economy:** Reduce oil dependence, grow new industries.
- **Strengthen energy independence:** Reduce reliance on imported solar components.
- **Create employment opportunities:** From technical to managerial roles.
- **Meet local content requirements:** 40–45% localization target by 2028.

Market Gap and Strategic Opportunity

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Market Size and Growth Potential

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2024 Market Size:
USD 5.92 billion

2030 Forecasted Market Size:
USD 67.67 billion

CAGR (2024–2030):
50.1%

Installed Capacity vs. 2030 Target

Current Installed Capacity
(as of Sep 2024)

approx.6.55 GW

There is a significant gap between current status and 2030 targets

2030 Targets:

Total Renewable Capacity: 58.7 GW

Solar PV Capacity: 40GW

Requires rapid deployment acceleration

Strategic Opportunities

Local Manufacturing Gap:

Most solar components are still imported, with weak local production capacity, especially in upstream and midstream sectors.

Massive Market Growth Room:

CAGR of 50.1% from 2024 to 2030 shows huge potential.

Urgent Demand for Localization:

Fast-tracking local production is key to meeting deployment and policy goals.

Basic Knowledge of Photovoltaic (PV) Power Generation

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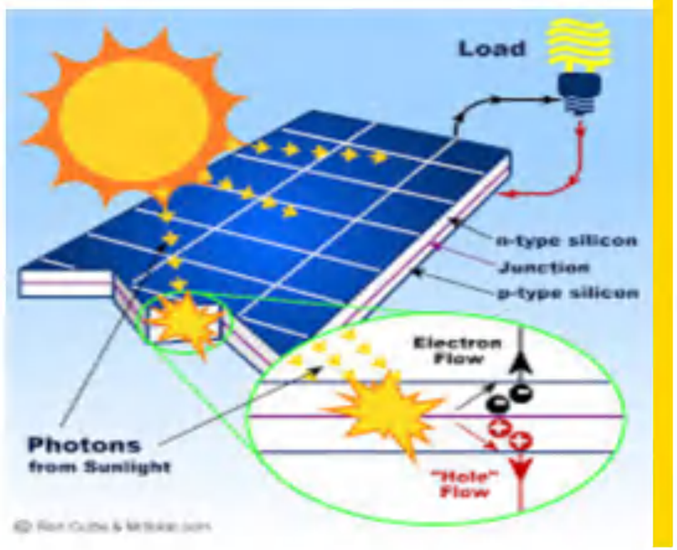
How PV Power Generation Works



To support the goal of 50% renewable electricity by 2030, Saudi Arabia promotes photovoltaic (PV) power, which converts sunlight into electricity using semiconductor materials.

Solar cells are made of P-type and N-type semiconductor layers.

When sunlight hits the solar panel:

1.Photons are absorbed, creating electron-hole pairs.

2.An internal electric field moves electrons to the N-region, holes to the P-region.

3.This movement creates DC — turning sunlight into usable electricity.

PV Modules:

Groups of solar cells that generate DC power from sunlight.
The core part of the system.

Inverter:

Converts DC from the PV modules into alternating current (AC) for homes, industries, or grid use.

Mounting System:

Holds panels at the best tilt angle for maximum power output.

Cables & Connectors:

Connect all parts and carry the current.

Distribution & Protection Box:

Includes switches and breakers for system safety.

Energy Storage System (ESS):

Stores excess energy for later use, improving stability — especially for off-grid or microgrid setups.

Photovoltaic Industry Chain Structure

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Upstream:
Raw Materials and Equipment Manufacturing

Polysilicon Production
Purify quartz sand into high-purity polysilicon — the base material for solar cells.

Ingot and Wafer
Melt polysilicon into ingots and slice them into thin wafers.

PV Equipment
Produce specialized machinery for cell and module production.

Midstream:
Cell and Module Manufacturing

Solar Cell Production
Process wafers through doping, etching, coating, and other steps to make electricity-generating solar cells.

Module Assembly
Connect and encapsulate cells into glass, EVA, and backsheet materials to form durable and high-efficiency solar modules.

Downstream:
Power Plant Development and Application

Engineering, Procurement, and Construction(EPC)
Design, procure, and build PV power stations.

Operation & Maintenance (O&M)
Handle daily operation, monitoring, and maintenance of solar power stations.

Distributed PV
Rooftop solar, industrial and commercial PV systems.

Sales & Services
Sell modules, inverters, and other related products.

Climate Adaptation for Saudi Arabia’s Harsh Environment

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Climate Challenges in Saudi Arabia

Saudi Arabia’s extreme high temperatures and dusty conditions create unique technical challenges for PV system performance and reliability.

Adaptation for High-Temperature

- Optimize PV materials and structure for better thermal stability
- Use low-temperature coefficient cells to reduce efficiency loss
- Design inverters for stable operation under heat

Solutions for Dusty Environments

- Develop anti-dust PV components or self-cleaning features
- Strengthen structural design to resist sandstorms
- Build local O&M systems suited to desert conditions

Other Weather Considerations

- Improve material corrosion resistance for high-humidity coastal areas
- Account for UV exposure on material degradation
- Address day-night temperature shifts with proper thermal design

Targeted Technical Solutions

- Localized Design: Customize systems for desert conditions and high temperatures
- Advanced Technology Selection: Prefer N-type cells (e.g., TOPCon, HJT) for better performance
- Smart O&M Systems: Develop automated cleaning and maintenance systems for desert use

Implementation Recommendations

- Local R&D Partnerships: Work with Saudi institutions on climate-adapted PV system design
- Supply Chain Localization: Build local supply chains to lower cost and increase reliability
- Field Testing & Validation: Test PV systems in real desert conditions to ensure performance

Policy Trends & Market Opportunities

Local Content Requirement

- 33 – 35% (2024 – 2025), 40 – 45% from 2028 onwards
- NEOM targets 45% local content by 2030
- Local manufacturers will gain market share and pricing advantages

Advanced Technology Development

- Government support for next-gen PV tech (e.g., TOPCon, HJT)
- N-type technologies are better for Saudi's climate
- Promoting high-efficiency, globally competitive local production

Investment Climate Improvement

- Continuous optimization of the business environment with clear regulations
- Strong government incentives: tax exemptions, financing support, land discounts
- Attracting more international enterprises into the Saudi market

Export Opportunities

- Saudi Arabia's strategic geographic location
- Growing manufacturing capacity
- Potential to become a regional solar export hub

Summary of Market Opportunities

Localization Advantage:

Meeting LCR boosts government support and local market competitiveness

Tech Leadership:

Import advanced solar tech and tailor to desert climate for differentiated products

Financial Advantage:

Long-term PPA policies, strong incentive packages, and cost efficiency

SWOT Analysis of the Local PV Manufacturing Project in Saudi Arabia

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Strengths

- **Policy Support:** Aligned with Saudi Vision 2030 goals, gaining strong government support and incentives
- **High Market Demand:** Large domestic PV installation targets and market growth potential.
- **Strategic Location:** Links to Asia, Europe, and Africa — ideal for future exports.
- **Low Energy Costs:** Affordable industrial power and water reduce production costs.
- **Localization Protection:** LCR policies create a local market entry barrier for foreign competitors.

Weaknesses

- **High Initial Investment:** Large capital needed to set up manufacturing facilities.
- **Technology Dependency:** Early stages rely on foreign tech; local R&D still developing.
- **Immature Supply Chain:** Key materials and parts still imported; local suppliers not yet reliable.
- **Talent Shortage:** Lack of local technical workforce and large-scale manufacturing experience.

Opportunities

- **Energy Transition Growth:** Rising global and Saudi demand for renewables.
- **Tech Advancement:** Mature high-efficiency PV tech (TOPCon, HJT) with falling costs.
- **Export Market Expansion:** Chance to enter Middle East and African solar markets.
- **Industry Clustering:** Manufacturing can drive upstream and downstream sector growth.
- **ESG Positioning:** Aligns with global sustainability goals and improves corporate image.

Threats

- **Global Competition:** Low-cost PV products from China and others dominate the market.
- **Fast Tech Evolution:** Risk of outdated investment if tech changes too quickly.
- **Policy Risk:** Incentive policies may change or be reduced.
- **Raw Material Volatility:** Global silicon price swings may impact production costs.
- **Supply Chain Disruption:** Global instability may threaten material availability.

Comparison of Main PV Technology Routes

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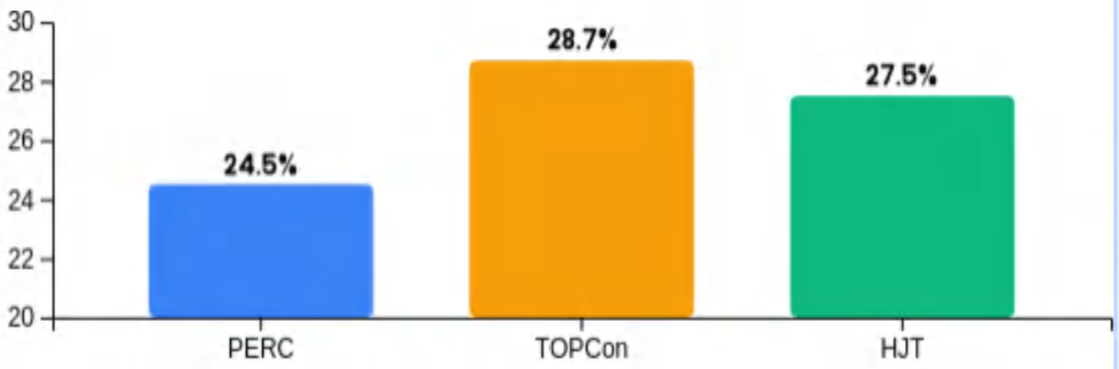
The current mainstream PV cell technologies include PERC, TOPCon, and HJT. Choosing the right path is key for long-term competitiveness, especially under Saudi Arabia's high-temperature, high-radiation environment.

Technology	Maturity	Conversion Efficiency	Production Cost	Temp Coefficient	Bifaciality	Saudi Suitability
PERC	Most mature, dominant for years	~24.5% (theoretical limit, near bottleneck)	Relatively low	Moderate, efficiency drops in heat	Moderate	Cost-effective, but limits long-term efficiency growth
TOPCon	Fast-growing, gaining market share	~28.2%–28.7%, close to 29.43% for crystalline silicon	Higher than traditional	Good high-temp performance	Good	High efficiency and good performance under Saudi climate, strong long-term potential
HJT	Rapid development, smaller commercial scale	~27.5%	Currently high, but falling	Excellent high-temp performance	High	Very suitable for hot climates, high efficiency

Theoretical Efficiency Chart

(PERC vs TOPCon vs HJT)



Technology Recommendation

- Considering Saudi Arabia's high-temperature, high-irradiance conditions, TOPCon and HJT are more competitive.
- TOPCon is near the theoretical limit of silicon cells, with superior efficiency potential.
- HJT has high efficiency and great heat performance, but higher cost.
- TOPCon offers the best trade-off in maturity, cost, and performance, making it the optimal choice for Saudi Arabia.

Implementation Model Matrix Comparison

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To realize the goal of local PV manufacturing in Saudi Arabia, four models are compared in terms of localization level, investment scale, technical complexity, and risk control

	Module Encapsulation	Solar Cells	Complete Industry Chain	Supporting Equipment
Localization	Medium local auxiliary supply chain	Medium local cell production	High full localization	Medium local equipment manufacturing
Investment Scale	Low initial investment	Medium Medium investment	High Very large investment	Medium Medium investment
Technical Barrier	Low Low complexity	Medium Medium complexity	High High integration complexity	Medium specialization
Risk Control	Low Controllable	Medium Market volatility	High Cycle risk	Medium Market dependence
	Fast start-up, meets LCR, suitable for early-stage entry	Improves competitiveness, but longer payback and higher technical demand	Highest added value, full localization, but long cycle and high cost	Supports the ecosystem, but market demand fluctuates

Key Takeaways

- Module Encapsulation: Moderate localization, low cost, fast to implement
- Solar Cells: Enhances core competitiveness, but requires tech & capital
- Full Industry Chain: Maximizes value, but long-term and complex
- Supporting Equipment: Ecosystem support role, high dependency on industry maturity

Recommended Implementation Path

Recommendation: Start with Module Encapsulation

Considering Saudi Arabia's local content requirements (LCR), investment risk, technology maturity, and market response speed, we recommend module encapsulation as the starting point.
This path allows for fast local production, meets the growing PV demand in Saudi Arabia, and lays the groundwork for deeper localization in later stages.

Why Start with Module Encapsulation?

Quick Market Response

Low technical barriers, fast return, suitable for early-stage local production

LCR Compliance

Localize procurement of glass, backsheet, EVA, etc., to meet local content policies

Risk Control

Lower technical and financial risks compared to cell or full-chain production

Foundation for Future Expansion

Prepares layout and infrastructure for future upstream development

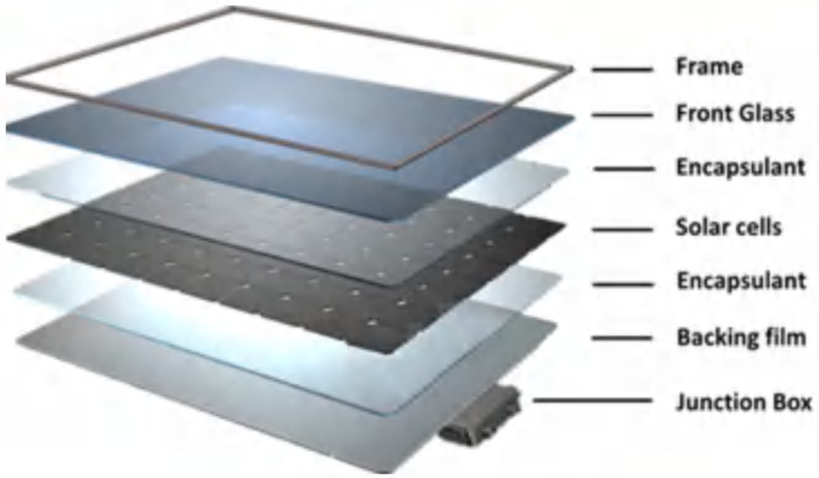
Foundation for Deep Localization

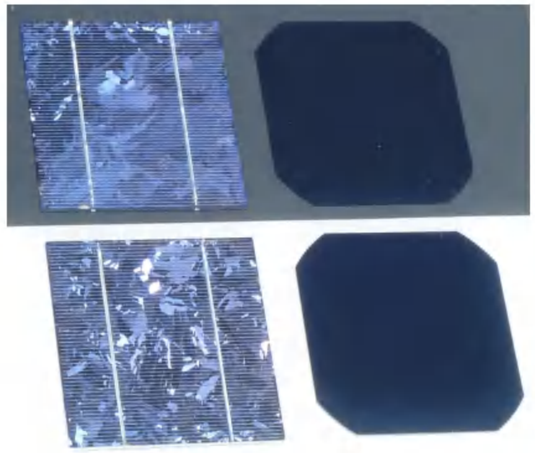
Talent Development
Train local teams starting from module factories

Tech Accumulation
Gain experience in PV manufacturing for future upgrades

Supply Chain Building
Promote local supply chain formation, enabling full-chain expansion later

Phased Execution Roadmap





0年 — 3年 — 6年 — 10年

Phase 1: Module Encapsulation Capacity Setup (Years 0–3)

- Market research and site selection
- Factory design and permitting
- Equipment procurement and installation
- Trial production and certification
- Module line production
- Local auxiliary supply chain development

Goal: Rapid launch of local production to meet LCR requirements

Phase 2: Solar Cell Production Line (Years 3–6)

- Technology assessment for solar cells
- Production line planning
- Equipment procurement and installation
- Pilot production and optimization
- Line commissioning
- Local workforce development

Goal: Enhance core competitiveness and value addition

Phase 3: Upstream Expansion and Industry Cluster (Years 6–10)

- R&D on silicon and wafer technologies
- Feasibility analysis of upstream sectors
- Cluster layout and planning
- Localization of auxiliary equipment
- Solar industry ecosystem formation

Goal: Full independence and maximum local value creation

Key Milestones

Module Line Commissioned → Cell Line Commissioned → Local Talent Pipeline Established → Industry Cluster Formed

Investment & Partnership Models

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This project offers flexible investment and cooperation models to match the strategic needs and risk preferences of different partners.

Equity Joint Venture

Model Features

Co-invest in a joint company; share profits and risks

Advantages

Strong alignment of interests in tech and market, Shared risk

Best for

Strategic partners seeking long-term joint development in Saudi Arabia

EPC+O&M

Model Features

Partner takes charge of Engineering, Procurement, Construction, and Operation & Maintenance

Advantages

Fast project delivery, Stable operations, Lower operational risk.

Best for

Partners who want quick execution and stable long-term service returns

Technology Licensing

Model Features

Provide core tech, IP, and know-how; earn licensing fees

Advantages

Light asset model, Quick market expansion, Technology monetization

Best for

Local partners with manufacturing capability seeking tech upgrade

Value Creation & Project Integration

- Tailored Solutions: Custom cooperation models based on each partner’s strengths and needs
- Risk Sharing: Clear structure for investment and return allocation
- Mutual Benefit: Fair value distribution for sustainable growth
- Phased Flexibility: Adjustable cooperation levels over time

Dual Value Proposition: Investor & Government Win-Win

Analyze Project Value from Both Investor and Saudi Government Perspectives to Highlight a Win-Win Value Proposition

Investor Perspective ⟷ Project Partnership ⟷ Government Perspective

Investor Value Points

- Expected gross margin: 20% – 40%, with attractive returns
- Long-term PPA contracts ensure predictable cash flow
- Payback period: 5 – 7 years, fast investment recovery
- Preferential tax & customs incentives
- SIDF financing support: up to 75% of project costs
- SEZs (Special Economic Zones) provide tax-free export opportunities

Saudi Government Value Points

- Supports Vision 2030 national energy strategy
- Creates large-scale local employment
- Helps reduce dependence on oil revenue
- Drives technology transfer and innovation
- Boosts local renewable energy capacity
- Fulfills local content targets: 40 – 45% by 2028

This project not only offers strong financial returns and cash flow stability for investors, but also helps the Saudi government achieve national goals in energy transition, economic diversification, and sustainable growth — making it a truly win-win opportunity.

Strategic Summary & Action Recommendations

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Three-Stage Strategic Plan

Phase 1 (Years 0–3)
Build module encapsulation production capacity

Phase 2 (Years 3–6)
Launch solar cell production line

Phase 3 (Years 6 – 10)
Expand upstream and form a full industrial cluster

This project is a key step in Saudi Arabia’s energy transition and local manufacturing strategy.
By leveraging local PV production, it fills a critical market gap, enhances energy security, and creates economic, social, and environmental value.

Next-Step Recommendations

Project Team Formation

Set up a joint working group with core members from both sides to clarify responsibilities and collaboration mechanisms.

JV Negotiation

Start equity structure and governance talks for a joint venture company.

Financing Landing

Engage with investors and financing channels, leverage SIDF programs to ensure smooth project funding.

Site Visit Planning

Organize visits to suitable Chinese manufacturing bases for technical exchange and knowledge sharing.

Project Value & Significance

This project will leverage Saudi localization policies and Chinese industrial capabilities,
form a cost-effective and differentiated production base, and help Saudi Arabia achieve its Vision 2030 goals while delivering economic and social impact.

Chinese Solar Industry Supply Chain Overview

Chinese solar industry collaboration in Saudi Arabia has evolved from a focus on single project contracting to a deeper integration across the entire supply chain.
This comprehensive approach covers everything from upstream silicon wafers to midstream cells, inverters, and downstream mounting systems and system integration.
The following is a breakdown of the key roles and development models of Chinese solar companies within the Saudi supply chain.

Silicon Wafers & Solar Cells:
TCL Zhonghuan and JinkoSolar are key players in this sector. They are shifting from a pure export model to establishing local production facilities in Saudi Arabia.

TCL Zhonghuan: In partnership with Saudi Arabia's Public Investment Fund (PIF) and other entities, the company plans to build a 20 GW solar wafer factory in Saudi Arabia, with an estimated investment of approximately $2.08 billion.

https://www.tcl.com/global/en/photovoltaic

JinkoSolar: The company formed a joint venture with RELC, a subsidiary of PIF, to construct a 10 GW high-efficiency solar cell and module project in Saudi Arabia, with an investment of nearly $1 billion.

https://www.jkosolar.com/Products.html?gad_source=1&gad_campaignid=22528462543&gbraid=0AAAAA_jTgAnPFmhlaEZHNTZO9O6yLmYwg&gclid=Cj0KCQjwndHEBhDVARIsAGh0g3CCGBdqBxrmQiTtyPq7j_q4oITX3yaH9U8xytW4znjaGjPD38Lq3RUaAv6BEALw_wcB

Chinese Solar Industry Supply Chain Overview

Solar Inverters:

Sungrow is a leader in this area, primarily providing high-efficiency inverters and energy storage solutions for large-scale projects in Saudi Arabia.

Project Case: In 2024, Sungrow signed a deal with Saudi company ALGIHAZ to provide a 7.8 GWh system solution for one of the world's largest energy storage projects.

https://en.sungrowpower.com/

Solar Mounting Systems:

Companies like Arctech and Zhenjiang are actively establishing local production lines in Saudi Arabia to enhance supply chain flexibility.

Project Cases: Arctech plans to invest in a 3 GW solar mounting system facility in Jeddah, while Zhenjiang has also announced plans to build a factory with an initial capacity of 3 GW.

https://en.arctechsolar.com/
https://www.arabnews.com/node/2579132/business-economy
https://www.pif.gov.sa/en/news-and-insights/newswire/2025/acwa-power-badeel-and-sapco-to-invest-approximately-8-3-billion-to-develop-15000-mw-of-renewable-energy-projects-in-saudi-arabia/

Chinese companies' collaboration models in Saudi Arabia primarily fall into two categories: Engineering, Procurement, and Construction (EPC) and Joint Development and Investment. The following are representative project cases showcasing recent progress in the Saudi market.

EPC Project: Shuaibah Solar Power Plant

Project Overview: Located in the Makkah Province, this project has a total capacity of 2.6 GW, making it one of the largest single-site solar power plants under construction globally.

Partners: Led by China Energy Engineering Group (CEEC) in collaboration with the local Saudi company ACWA Power.

Latest Developments: The project achieved full-capacity grid connection ahead of schedule on December 5, 2024, with project handover expected by the end of 2025.

http://en.ceec.net.cn/

Joint Development & Investment: Saudi REPDO Project

Project Overview: A consortium of State Power Investment Corporation's Yellow River Company and EDF Renewables won a 1.4 GW solar project in Saudi Arabia's fifth round of renewable energy tenders.

Latest Developments: The project has received domestic approval and has officially entered the execution phase. The MAS project is the Yellow River Company's first gigawatt-scale project secured in a global competitive bidding process.

Other Significant Projects

Power Construction Corporation of China (PowerChina): The first 799 MW phase of its Saad 2 solar power plant project has achieved commercial operation, demonstrating its continuous presence and commitment to the Saudi market.

https://en.powerchina.cn/

Key Chinese Companies in the Photovoltaic Industry Chain

Silicon Material / Wafer	Tongwei	https://en.tongwei.com/
Silicon Material / Wafer	GCL Technology	http://www.gcltech.com/en
Silicon Material / Wafer	Daqo New Energy	https://www.dqsolar.com/
Silicon Material / Wafer	TCL Zhonghuan	https://www.tcl.com/global/en/photovoltaic
Silicon Material / Wafer	LONGi Green Energy	https://www.longi.com
Cell / Module	JinkoSolar	https://www.jinkosolar.com
Cell / Module	Trina Solar	https://www.trinasolar.com
Cell / Module	Canadian Solar	https://www.canadiansolar.com
Cell / Module	JA Solar	https://www.jxajinko.com/
Cell / Module	Risen Energy	https://en.risen.com/
Cell / Module	Astronergy (Chint)	https://www.astronergy.com

Chinese Solar Industry Supply Chain Overview

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Inverter / Energy Storage	Sungrow	https://en.sungrowpower.com
Inverter / Energy Storage	Huawei Digital Power	https://digitalpower.huawei.com
Inverter / Energy Storage	Growatt	https://www.growatt.com
Inverter / Energy Storage	GoodWe	https://www.goodwe.com
Inverter / Energy Storage	Kstar	https://www.kstar.com
Mounting / Tracker	Arctech Solar	https://www.arctechsolar.com
Mounting / Tracker	Antaisolar	https://www.antaisolar.com
Mounting / Tracker	Versolsolar	http://www.versolsolar.com
EPC / System Integration	China Energy Engineering	http://en.ceec.net.cn/
EPC / System Integration	PowerChina	http://en.powerchina.cn
EPC / System Integration	State Power Investment Corporation (SPIC)	http://eng.spic.com.cn
EPC / System Integration	CGN New Energy	http://en.cgnp.com.cn/