

Solar Business Opportunities in India

A Value Chain Perspective

September 2014



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1. Executive Summary

The explosive growth of the solar sector in India has had many large and small businesses consider entering the solar space.

Key decision makers in companies large and small have been exploring the best ways for their businesses to enter the solar energy sector.

Utility scale power generation has seen a great deal of interest but is increasingly perceived as a purely financial venture. With emphasis shifting beyond power plants, other parts of the solar PV value chain are coming into focus.

This whitepaper from EAI examines the different segments of the solar PV value chain and evaluates the opportunities and risks present in each.

This white paper is perhaps the first attempt anywhere to analyse solar business opportunities from a value chain perspective.

The objective is to provide decision makers the framework and supporting data to enable them analyse the sector better and make wiser investment decisions. We have structured the white paper such that a range of businesses – from large to small – can derive insights from it.

Sub-sectors within solar analysed in this white paper include:

Manufacturing	Services
<ul style="list-style-type: none">• Raw material<ul style="list-style-type: none">○ Polysilicon○ Ingots & Wafers○ PV Cells• Intermediates<ul style="list-style-type: none">○ Solar glass• Finished products<ul style="list-style-type: none">○ Crystalline Modules○ Thin-film Modules○ Inverters○ Monitoring Systems○ Mounting Structures○ Balance of System○ Other Solar Products	<ul style="list-style-type: none">• Utility Scale Solar Plants<ul style="list-style-type: none">○ Engineering, Procurement, and Construction○ Independent Power Production• Rooftop Solar Plants<ul style="list-style-type: none">○ System Integration

Each of the value chain component/sector is analysed on the following parameters:

- Competitive landscape
- Investment
- Payback
- Margin
- Risk

In the end, we provide our recommendations for specific business segments – from large businesses with significant investment appetite to small businesses looking for low-capital or innovative opportunities.

We hope that this white paper enables decision makers to take better and more effective decisions in their diversification efforts into solar PV.

2. Introduction

The growth story of the solar sector in India is well known. From about 54 MW of solar power in 2010, India has 2,632 MW of installed solar capacity as of March 2014. This explosive growth has been led by favourable government policies and the large energy deficit faced by the nation (the peak power deficit stood at 5.4% in April 2014).

With the power deficit likely to continue and perhaps even increase for the foreseeable future, solar will continue to witness strong growth in the country. With an increased push for indigenisation of content, many entrepreneurs are considering investments in this sector.

There are many solar business opportunities along the solar value chain, both in manufacturing and in services; however, not all opportunities suit all entrepreneurs. An analysis of the various segments of the solar PV value chain is recommended, with emphasis on competition, financial returns, and risks before deciding on entering a segment. The diagram below provides an overview of the solar PV value chain:

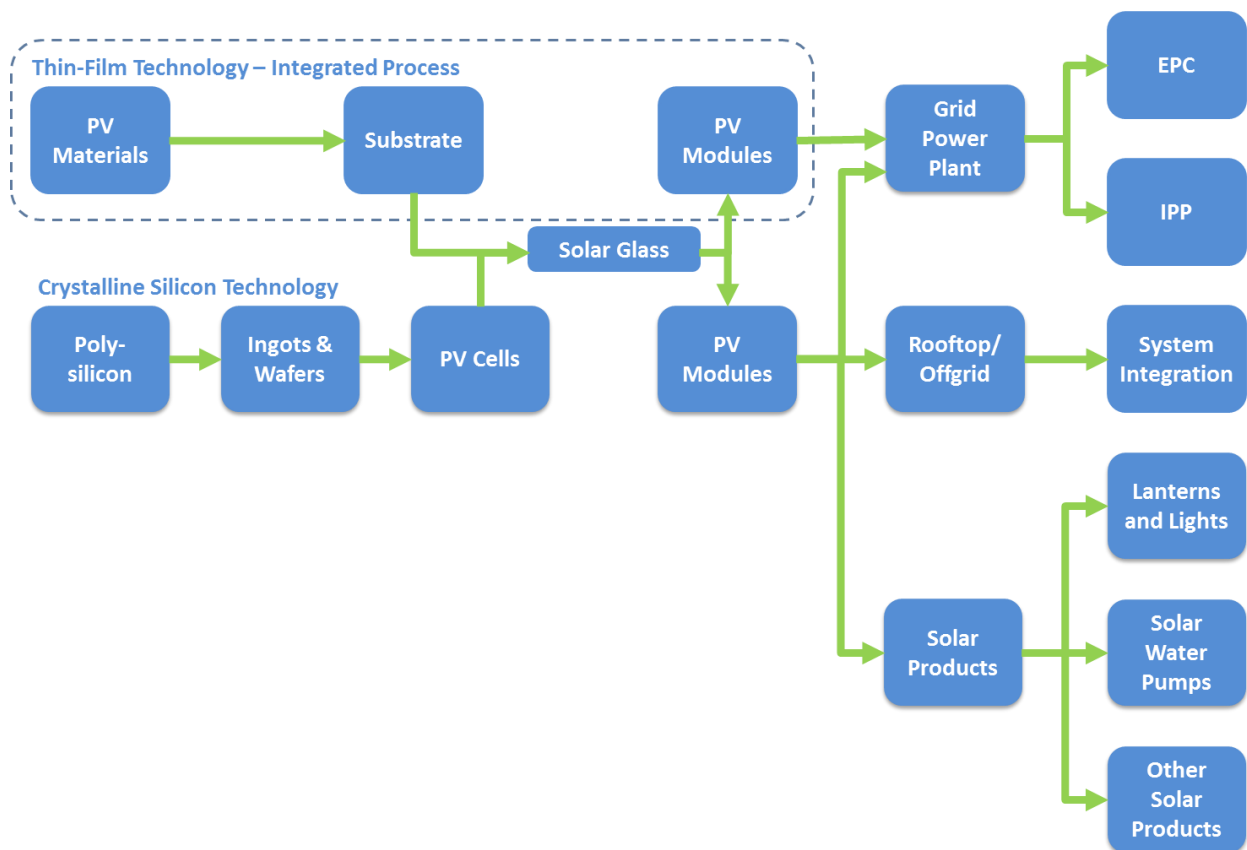


Figure 1: Solar PV Value Chain

The Solar PV value chain represents all the stages, processes, and products involved in the solar PV sector, including manufacturing of materials, system integration, solar products manufacture, etc. As mentioned earlier, based on your business profile, some value chain components will be far more suitable to you than others. The table below gives an overview of the opportunities available to different kinds of businesses:

Your Organisation	EAI Suggests	Key Drivers	Risk Assessment
<i>Large enterprise capable of significant investment</i>	Polysilicon	<ul style="list-style-type: none"> • Policy support/incentives • Reliable low-cost power • Scale to achieve production economies 	High Risk - Low competition but high investments and long payback periods
	Ingots & Wafers	<ul style="list-style-type: none"> • Policy support/incentives • Reliable low-cost power • Scale to achieve production economies 	High Risk -Low competition but high investments and long payback periods
	Solar Cell	<ul style="list-style-type: none"> • Policy support • Scale and technology to achieve production economies 	Medium-High Risk- Medium competition with high investment and long payback periods
<i>Large enterprise considering medium initial investment</i>	Solar Glass	<ul style="list-style-type: none"> • Technology • Price 	Medium Risk: Low-medium competition with medium investments and medium payback period
	Solar Module (Thin-Film)	<ul style="list-style-type: none"> • Policy support • Increased efficiency • Scale and technology to achieve production economies 	Medium-High Risk - Medium competition, technology risk present, medium-high investments and medium payback periods
	Solar Inverter	<ul style="list-style-type: none"> • Price • Technology suited to Indian needs & conditions • Alliances with EPCs and system integrators 	Medium Risk - High competition with medium-high investment and medium payback periods
	EPC (utility scale)	<ul style="list-style-type: none"> • Cost-effective procurement • Administrative expertise in getting approvals etc. • Subcontracting network 	Low-Medium Risk - High competition with low investment and short payback periods
	Developer/IPP	<ul style="list-style-type: none"> • Policy support 	Low Risk - High competition

Your Organisation	EAI Suggests	Key Drivers	Risk Assessment
		<ul style="list-style-type: none"> • Low-cost funding • Optimal power purchase tariff 	with higher investment and payback period but good long term revenue prospects for specific projects
<i>SME seeking low investment business opportunities</i>	Mounting Structures	<ul style="list-style-type: none"> • Design/customization suited to India • Alliances with EPCs and system integrators 	Medium Risk -Low- Medium competition with low-medium investment and medium payback periods
	System Integration for rooftop solar	<ul style="list-style-type: none"> • Cost-effective procurement • Marketing/promotion • Differentiation of product/service 	Low-Medium Risk - High competition with low investment and short payback period, but low margins
	EPC (smaller projects)	<ul style="list-style-type: none"> • Cost-effective procurement • Differentiation of product/service • Marketing/promotions 	Low Risk - High competition with low investment and short payback periods
<i>SME looking for innovative opportunities</i>	Balance of System	<ul style="list-style-type: none"> • Product differentiation • Alliances with EPCs and system integrators 	Medium Risk - High competition with medium investment and medium payback periods
	Solar Products	<ul style="list-style-type: none"> • Product differentiation • Government incentives, for certain product categories • Access to retail channels 	Medium Risk (depends on the product) - Medium competition with medium investment and medium payback periods
	Solar Module (Crystalline)	<ul style="list-style-type: none"> • Policy support • Increased efficiency • Scale and technology to achieve production economies 	Medium Risk - High competition with medium investment and medium payback periods
<i>Start up seeking low-risk, minimal investment opportunity</i>	EPC Subcontracting	<ul style="list-style-type: none"> • Cost-effective procurement • Alliances with EPCs 	Low Risk - High competition with low investment and short payback periods

Table 1: Opportunities for Different Businesses

2.1 Solar PV Technologies

Current Solar PV technology mainly comprises two types: Crystalline Silicon and Thin-Film

- **Crystalline Silicon** – The value chain involves reducing sand to raw silicon followed by purification, wafer cutting, doping, cleaning, and coating. This forms cells which are subsequently connected and laminated to form a solar module (panel), which can then be assembled in arrays and combined with electrical components to form a solar system
- **Thin-Film** – The value chain is much shorter, as the modules are manufactured in one single step from raw silicon and other compounds by depositing the photovoltaic material and other chemicals on glass or transparent film

2.2 Manufacturing and Service Components

The solar PV value chain for Crystalline Silicon and Thin-Film technology can be classified into

2.2.1 Manufacturing

Raw materials manufacturing (Crystalline Silicon)

- Polysilicon
- Ingots & Wafers
- PV Cells

Intermediates (Crystalline Silicon & Thin-Film)

- Glass

Finished products (Crystalline Silicon & Thin-Film)

- PV Modules
- Inverters
- Monitoring Systems
- Mounting Structures
- Balance of System
- Other Solar Products

2.2.2 Services (Crystalline and Thin-Film)

Services are predominantly related to the construction of solar PV power plants

- For ground-mounted grid-feeding solar plants
 - Engineering Procurement and Construction

- Independent Power Production
- For rooftop plants
 - System Integration

Takeaways

- Solar installations in India have grown from 54 MW to 2,632 MW in just 4 years
- There are multiple products and services in the solar PV value chain, with opportunities for both large and small enterprises with varying levels of capital commitment
- The Crystalline-Silicon value chain offers a wider variety of opportunities than Thin-Film, as the manufacturing process can be divided into sub-products that can be supplied by different vendors

3. Manufacturing Opportunities

Manufacturing opportunities cover both raw material processing as well as finished products usable by consumers.

Raw Material Processing (Crystalline Silicon)

- Polysilicon
- Ingots & Wafers
- PV Cells

Intermediates (Crystalline Silicon & Thin-Film)

- Glass

Finished Products (Crystalline Silicon & Thin-Film)

- PV Modules
- Mounting Structures
- Balance of System
- Other Solar Products

3.1 Raw Material Processing (Crystalline Silicon)

3.1.1 Polysilicon

The basic raw material for manufacturing polysilicon is silicon, which is available in plenty in the form of silicon di-oxide in sand.

- Silicon oxide sand (quartz) is processed at high temperature to separate oxygen and silicon
- The silicon obtained is purified by various technologies such as coke reduction, distillation and Siemen's process

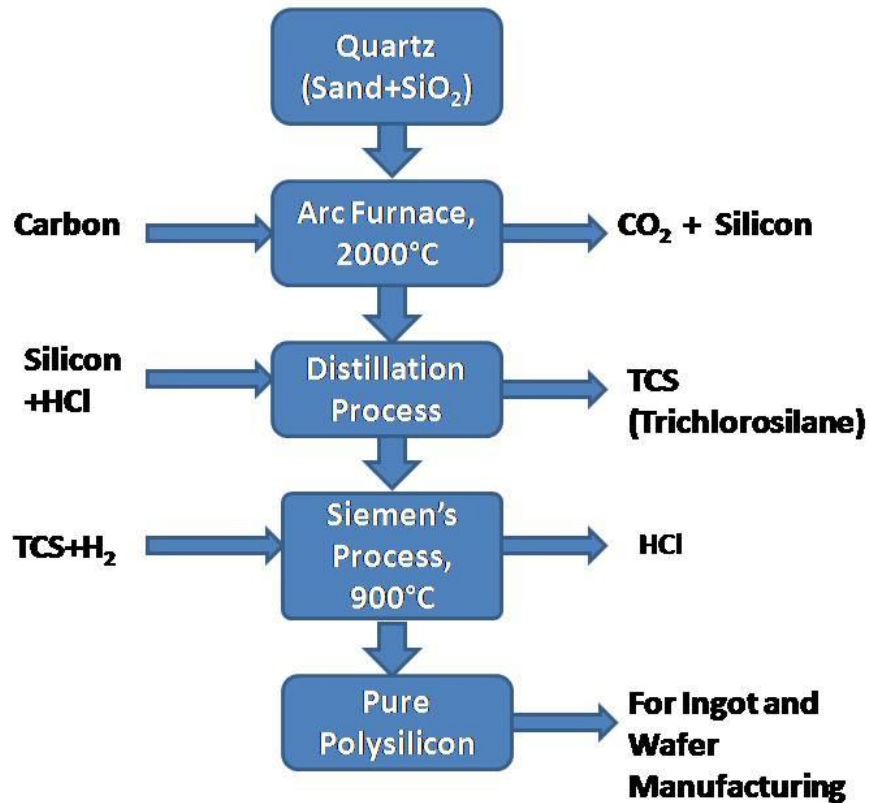


Figure 2: Polysilicon Manufacturing Process

Polysilicon manufacturing is the fundamental process in the solar PV value chain, as well as the most intricate. Investments required are high due to extensive land and equipment requirements.

EAI Analysis

Competitive Landscape	<u>Domestic</u> No polysilicon manufacturing plant is currently found in India. Lanco Solar and BHEL will be the first to build such plants in the country ¹ <u>International</u> About 7 Tier 1 (GCL, Hemlock, SunEdison, REC Silicon, Tokuyama, Wacker, and OCI) and many Tier 2 Chinese manufacturers are found globally. These companies are well established, making it difficult for new entrants to compete.
Investment Required	High Equipment requirement is high technology and requires considerable investment.

¹<http://www.fluor.com/india/projects/projectinfopage.aspx?prjid=246>, <http://www.energynext.in/bhel-may-set-up-silicon-wafer-manufacturing-plant/>

Payback Period	High New entrants will find it difficult to establish themselves and build sales.
Margin Potential	Linked to the price of modules. Is currently rising slowly along with module prices.
Risk Assessment	High Lack of domestic competition is countered by well-established international players. Risk of changes in technology.
Key Drivers	<ul style="list-style-type: none"> • Policy support/incentives • Reliable low-cost power • Scale to achieve production economies

EAI recommends polysilicon manufacturing only for large, well established industries with sufficient financial resources to compete against international players and who can wait for the market to come to them.

3.1.2 Ingots & Wafers

The next step is ingot manufacturing where the polysilicon is melted and cast into ingots. The ingots are in different shapes and sizes; these ingots are further cut into ultrathin wafers. Wafer shaping involves a series of precise mechanical and chemical processes that are necessary to turn the ingot into a wafer.



Figure 3: Ingots and Wafers Manufacturing Process

EAI Analysis

Competitive Landscape	<u>Domestic</u> There are a few small-scale ingot/wafer manufacturers currently in India (Maharishi Solar). <u>International</u> About 5 wafer companies (Shin Etsu, Handotai, Sun Edison [then MEMC], LG Siltron, Sumco Corp), held 90% market share in 2012. These companies are leading manufacturers and it will be difficult to compete against them. Most wafers used by Indian module manufacturers are imported.
Investment Required	High Expensive technologies, such as metal crystallisation and diamond cutting tools, are required.
Payback Period	High
Margin Potential	Linked to the price of modules. Is currently rising slowly along with module prices.

Risk Assessment	High Primarily risk of newer, cheaper technologies emerging.
Key Drivers	<ul style="list-style-type: none"> • Policy support/incentives • Reliable low-cost power • Scale to achieve production economies

EAI recommends ingot/wafer manufacturing only for large, well established industries with sufficient financial resources to compete against international players and who can wait for the market to come to them.

3.1.3 Solar Cells

The PV cells convert sunlight to electricity which is the first step in solar power generation. Solar cells form the base for the PV module and are manufactured from the wafer. The solar cell has two layers of silicon; doping is performed to form the p-n junction layer which is the basis of power generation. A layer of silicon nitride is deposited on the cell surface to reduce reflection. Electrodes and aluminium layers are added.

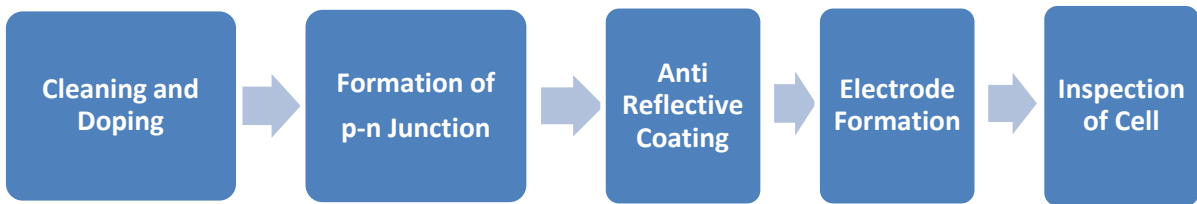


Figure 4: PV Cell Manufacturing Process (Crystalline Silicon)

Crystalline cells are of two types

- Monocrystalline
- Polycrystalline

3.1.3.1 Monocrystalline Cells

The characteristic feature of monocrystalline cells are

- Higher efficiency (suitable for limited rooftop space)
- Higher cost
- Complex manufacturing process
- Requires rigid mounting to avoid cracks in the crystals during transport, handling, and installation as cells are fragile
- Uniform appearance when installed as all cells have the same dark colour

3.1.3.2 Polycrystalline Cells

The characteristic feature of polycrystalline cells are

- Lower efficiency than monocrystalline cells
 - These can still be used in rooftop plants, depending on the capacity required and the extent of rooftop space available

- Relatively low cost
- Simpler manufacturing process
- Not uniform in appearance after installation

EAI Analysis

Competitive Landscape	Several cell manufacturers are already present in India (UPV Solar, Central Electronics Ltd, Maharishi Solar).
Investment Required	High High technology equipment investment is required.
Payback Period	High
Margin Potential	Linked to the price of modules. Is currently rising slowly along with module prices.
Risk Assessment	Medium-High Primarily risk of newer, cheaper manufacturing technologies emerging.
Key Drivers	<ul style="list-style-type: none"> • Policy support • Scale and technology to achieve production economies

EAI recommends cell manufacturing only for large, well established module manufacturers who wish to commence vertical integration.

3.2 Intermediate (Crystalline & Thin-Film)

3.2.1 Glass

Glass has an important role to play in the solar energy sector. Glass is used as a top cover for all types of photovoltaic panels that include Crystalline and Thin-Film technology. The glass is typically low-iron glass to maximise transmission of light. In thin-film panels the substrate used for deposition will typically be glass (polymer is also used in some cases).

EAI Analysis

Competitive Landscape	A handful of Tier I glass manufacturers are already present in India (Allied Glasses, Borosil Glass Works, GSC glass, EMMVEE solar)
Investment Required	Medium
Payback Period	Medium
Margin Potential	Medium
Risk Assessment	Medium There are many smaller glass manufacturers who could enter this sector.
Key Drivers	<ul style="list-style-type: none"> • Technology • Price

EAI recommends solar glass manufacturing for medium and large scale businesses.

3.3 Finished Products

3.3.1 Solar Modules

3.3.1.1 Crystalline Silicon

Crystalline silicon solar module (or panel) is the collection of solar cells soldered together under a glass pane surrounded by aluminium frame. The cells are soldered as per the required wattage. Panels are manufactured in separate plants.

EAI Analysis

Competitive Landscape	Tier 1 manufacturers are already present in India. Market is crowded and cost-competitive, with scale and backward-integration crucial to cost-competitiveness.
Investment Required	Medium Investment required is less compared to cell or ingot/wafer manufacturing.
Payback Period	Medium
Margin Potential	Linked to the price of modules. Is currently rising slowly along with module prices.
Risk Assessment	Medium Many domestic competitors exist, but new entrants can gather market share if they differentiate themselves.
Key Drivers	<ul style="list-style-type: none"> • Policy support • Increased efficiency • Scale and technology to achieve production economies

EAI recommends crystalline module manufacturing for large enterprises as well as medium scale businesses that can gather resources to vertically integrate later.

3.3.1.2 Thin Film

The Thin Film solar modules are categorized based on the photovoltaic material deposited on the substrate as

- Amorphous Silicon (a-Si)
- Cadmium Telluride (CdTe)
- Copper Indium (Gallium) di-selenide (CIS or CIGS)

The organic photovoltaic cells are growing technology. The most commonly used semiconductor materials are CdTe and CIGS. The advantages and disadvantages for using these thin-film panels are

PV Material	Advantages	Disadvantages
Amorphous Silicon	Mature manufacturing technology	High equipment cost, low efficiency
Cadmium Telluride	Low manufacturing cost	Rigid substrate is required; considerable efficiency; toxic; less available
Copper Indium Gallium Selenide	High efficiency, any substrate	High manufacturing cost

Table 2: Comparison of PV Material (Thin Film)

Thin-Film solar cells are formed by depositing several layers of photovoltaic material on a substrate which is generally glass or transparent film. Module manufacture is an integrated process that cannot be segregated. Thin-film modules are currently of lower efficiency than crystalline modules, limiting them to ground-mounted plants where space is not a constraint.



Figure 5: PV Cell Manufacturing Process (Thin-Film)

EAI Analysis

Competitive Landscape	Only a few Indian manufacturers(Moser Baer Solar,Shurjo Energy,Vorks Energy).
Investment Required	Medium-High Complex manufacturing process.
Payback Period	Medium
Margin Potential	Linked to the price of modules. Is currently rising slowly along with module prices.
Risk Assessment	Medium-High Risk of change in technology (high-efficiency thin-film).
Key Drivers	<ul style="list-style-type: none"> • Policy support • Increased efficiency • Scale and technology to achieve production economies

EAI recommends Thin-Film manufacturing only for large industries that have the ability to quickly adapt to technology shifts.

3.3.2 Inverters

Solar inverters convert the DC power generated by the panels into the AC power that can be injected into the utility/facility grid. Inverters are becoming increasingly complex, incorporating charge controllers for battery charging regulation and remote monitoring systems.

Solar Inverters typically serve two different user segments

- **Utility scale grid-tied inverters** – These inverters only sync with grid power and are designed to shut down the solar plant in the event of grid failure
- **Rooftop/hybrid inverters** – These inverters are smaller in capacity and can integrate with multiple sources of power (EB, diesel, battery) and may incorporate battery charging as well

Small, rooftop-scale grid-tied inverters are available, but they do not function during power outage or integrate with diesel generators, limiting their utility in India.

EAI Analysis

Competitive Landscape	<p><u>Utility scale grid-tied inverters</u> Many international and domestic manufacturers are already operating in the Indian market (SMA, Bonfiglioli, ABB, ReGen)</p> <p><u>Rooftop/Hybrid inverters</u> Domestic and International players operating in India include Mahindra Solar, SMA, Schneider, Studer, OPS.</p>
Investment Required	<p>Medium-high R&D investment and highly-skilled manpower with technology expertise are required for manufacturing.</p>
Payback Period	Medium
Margin Potential	Medium-High
Risk Assessment	<p>Medium Many manufacturers, including well-established international manufacturers, are active in this space, but opportunities exist for products tailored to Indian conditions in the off-grid/rooftop segment. Inverter replacement is a must in any plant consequently there exists continuous demand.</p>
Key Drivers	<ul style="list-style-type: none"> • Price • Technology suited to Indian needs & conditions • Alliances with EPCs and system integrators

EAI recommends solar inverter manufacturing for enterprises that are active in the Indian power sector and can develop products for Indian conditions.

3.3.2.1 Monitoring Systems

Solar monitoring systems are gaining importance as they assist the generator to instantly know the amount of solar energy generated. They help in reducing maintenance cost and time taken for fault detection, and maximise energy generation. They can be wired (suitable for medium and large plants) and wireless (suitable for small and medium sized plants). Nowadays monitoring systems are increasingly integrated with solar inverters.

EAI Analysis

Competitive Landscape	Many inverter manufacturers offer solar inverters with inbuilt monitoring system.
Investment Required	<p>Low-Medium Technically skilled personnel are required.</p>
Payback Period	Low
Margin Potential	Medium
Risk Assessment	<p>High (for stand-alone systems) Monitoring solutions bundled with inverters limit the market for stand-alone solutions.</p>
Key Drivers	<ul style="list-style-type: none"> • Policy support for monitoring and forecasting of solar plants • Developer demand for vendor neutral monitoring solutions that can integrate data from different technologies • Advanced fault detection and diagnosis support

EAI recommends monitoring solutions development primarily for inverter manufacturers, and recommends careful market analysis of partnerships if offered as a stand-alone solution.

3.3.3 Mounting Structures

Mounting structures are necessary for any kind of solar PV installation (rooftop or ground mounted) to support the PV panels. Mounting structures are designed to enable the panels be optimally oriented to the sun for maximum energy generation. Mounting structures are typically made of galvanized iron and can be elevated structures, as well as either penetrating or non-penetrating.

EAI Analysis

Competitive Landscape	A few domestic and international players are currently operating in the Indian market.
Investment Required	Low-Medium But skilled resources are required for design which is the high value part.
Payback Period	Medium
Margin Potential	Medium
Risk Assessment	Medium. Customers do not emphasise mounting structures as much as they do panels or inverters, making brand building a bit difficult.
Key Drivers	<ul style="list-style-type: none"> • Design/customization suited to India • Alliances with EPCs and system integrators

EAI recommends mounting structure manufacturing for small and medium-sized businesses, especially those that have design and manufacturing expertise for the engineering sector.

3.3.4 Balance of System

Energy acquired from solar PV system is not only reliant on the efficiency of PV module but also on other components like cables, transformers, surge protection, panel connectors, junction boxes, etc., collectively termed balance of system. Balance of system comprises all the components required for the PV System installation other than PV panels and inverters. Each component is separately manufactured or imported for the plant.

EAI Analysis

Competitive Landscape	Very competitive marketplace as there are already many manufacturers for some products, especially from companies already operating in the electrical domain. Differentiation is critical to acquire market share.
Investment Required	Medium
Payback Period	Medium
Margin Potential	Low-medium
Risk Assessment	Medium

	These are commodity products with many manufacturers already present in the market, but the market is not limited to the solar sector.
Key Drivers	<ul style="list-style-type: none"> • Product differentiation • Alliances with EPCs and system integrators

EAI recommends manufacturing balance of system products where competition is still emerging for small and medium-sized businesses.

3.3.5 Solar Products

Solar products refers to manufacture of off-grid products utilizing solar power such as solar light, solar water heater, solar air heater, solar dryer, solar cooker, solar air conditioner, solar water pump, solar charger, solar refrigerator, solar water purifier, etc.

EAI Analysis

Competitive Landscape	Some products like solar water heaters and solar cookers have many established players while other products are still emerging.
Investment Required	Medium
Payback Period	Medium
Margin Potential	Low-Medium
Risk Assessment	Depends on the product. Most solar products are still in the emergent stage and strong promotion and branding efforts will be required, with uncertain payoff.
Key Drivers	<ul style="list-style-type: none"> • Product differentiation • Government incentives, for certain product categories • Access to retail channels

EAI recommends solar products manufacturing for small and medium enterprises, but suggests selecting products that can leverage existing distribution network and customer base.

Takeaways

- Production of raw materials is better suited for large enterprises who have the resources to compete with few, well-established, international players
- Many opportunities exist for small and medium sized enterprises in balance of systems and other solar products, but extensive promotional activities may be required
- Risk of change in technology (such as high efficiency modules) should be carefully evaluated before entering module manufacturing

4. Service Opportunities

Services that can be provided to the solar PV sector are primarily linked to the design and construction of solar PV power plants. Based on plant capacity and function we find two kinds of services

For ground-mounted grid-feeding solar plants

- Engineering Procurement Construction(EPC) services
- Independent Power Producers (IPPs)

For rooftop solar plants

- System Integration services

4.1 Engineering Procurement Construction (EPC)

Engineering, Procurement and Construction (EPC) contracts are the most common form of contract used to undertake construction works by the private sector, usually on large scale projects. They are generally appointed by the project developer. EPCs deliver turnkey services for the entire project, including engineering and design; selecting the suppliers of solar modules, inverters, and other key items of equipment; plant construction; and finalising and underwriting the final design and output projections for the plant.

EAI Analysis

Competitive Landscape	Large, branded players are already operating in this market.
Investment Required	Low
Payback Period	Low
Margin Potential	Low-Medium
Risk Assessment	Low-Medium Cyclical business that is dependent on government policies. The industry is in the consolidation stage with many exits. Large projects are few and far between.
Key Drivers	<u>Utility scale</u> <ul style="list-style-type: none"> • Cost-effective procurement • Administrative expertise in getting approvals etc. • Subcontracting network <u>Smaller Projects</u> <ul style="list-style-type: none"> • Cost-effective procurement • Differentiation of product/service • Marketing/promotions

EAI recommends EPC services for medium and large enterprises that are already active in the infrastructure and construction sectors. Small and medium enterprises may consider EPC services if they are willing to undertake subcontract work while establishing themselves.

4.2 Independent Power Producers (IPPs)

IPPs invest in solar plants, generate solar power, and sell this power to the government or to the private sector under a Power Purchase Agreement (PPA).

EAI Analysis

Competitive Landscape	While there are many players in this sector, many PPAs are signed through competitive bidding which allows opportunities for new entrants. As the capital requirement is high, the ability to raise low cost finance is a critical differentiating factor.
Investment Required	High
Payback Period	High
Margin Potential	Medium-High
Risk Assessment	Low Many PPAs are signed with the government, giving greater payment security. 3 rd Party PPAs may carry greater risk of non-payment.
Key Drivers	<ul style="list-style-type: none"> • Policy support • Low-cost funding • Optimal power purchase tariff

EAI recommends the IPP opportunity only for large enterprises with access to significant financial resources.

4.3 System Integration

System integrators perform similar functions to EPC contractors for smaller, rooftop plants.

Competitive Landscape	Very competitive sector with few large players and a large number of small players.
Investment Required	Low
Payback Period	Low
Margin Potential	Low
Risk Assessment	Low-Medium Entry barriers are low but success depends on winning assignments from very price conscious customers. Advertising and marketing intensive.
Key Drivers	<ul style="list-style-type: none"> • Cost-effective procurement • Marketing/promotion • Differentiation of product/service

EAI recommends System Integration for businesses of any size, but owing to the low margins, points out that scaling is necessary for sustainability and growth.

4.3.1 Build Own Operate (Transfer)

Rooftop system integrators are increasingly offering the BOO(T) model where the customer pays only for the solar generation rather than paying for the solar plant upfront. As the investment in the plant is now borne by the system integrator, this is a very capital-intensive business model. Evaluating customer's credit worthiness over the long-term is critical for achieving payback.

Takeaways

- Services in the solar PV field are predominantly related to power generation
- This sector favours larger players due to high investment/manpower requirements. Subcontracting opportunities are available for smaller players
- Smaller players may find opportunities in rooftop system integration but face intense competition and margin pressure

5. Solar PV – Opportunities Summary

Value chain component	Competition	Investment required	Payback period	Margin Potential	Risk assessment	Suitable for
Polysilicon	Low	High	High	Slowly rising with module prices	High	Large enterprise
Ingots & Wafers	Low	High	High	Slowly rising with module prices	High	Large enterprise
Solar Cells	Medium	High	High	Slowly rising with module prices	Medium-High	Large enterprise
Glass	Low-Medium	Medium	Medium	Medium	Medium	Large enterprise
Solar Module(Crystalline)	High	Medium	Medium	Slowly rising with module prices	Medium	Small and Medium scale business looking for innovative opportunities
Solar Module(Thin Film)	Medium	Medium-High	Medium	Slowly rising with module prices	Medium-High	Large enterprise
Solar Inverter	High	Medium-High	Medium	Medium-High	Medium	Large enterprise
Monitoring System	High	Low-Medium	Low	Medium	High	Large enterprise & inverter manufacturers
Mounting Structure	Low-Medium	Low-Medium	Medium	Medium	Medium	Small and Medium scale business
Balance of System	High	Medium	Medium	Low-Medium	Medium	Small and Medium scale business looking for innovative opportunities
Solar Products	Medium	Medium-High	Medium-High	Low-Medium	Medium	Small and Medium scale business looking for innovative opportunities
EPC	High	Low	Low	Low-Medium	Low-Medium	Large enterprise (utility scale), Small & Medium scale (smaller projects), Start Up with low risk & minimum investment (subcontract)
Independent Power Producers (IPP)	High	High	High	Medium-High	Low	Large enterprise
System Integration	High	Low	Low	Low	Low-Medium	Small and Medium scale business

Table 3: Solar PV Opportunities Summary

From the above table we can see that the raw material stage and the utility-scale power generation opportunities favour large scale enterprises, while many finished products and system integration services are suitable for small and medium scale businesses.

Takeaways

- The sectors most suitable for small and medium scale businesses are
 - System Integration
 - Mounting Structures
 - Thin-Film Modules
 - Balance of System
 - Solar Products
 - EPC subcontracting
- Polysilicon, Ingot and Wafer, and Cell manufacturing; Monitoring Systems; and IPP can be considered by large enterprises
- Opportunities in Solar Products and Balance of System depend on the specific products to be manufactured
- Some sectors, such as Solar Inverter manufacturing, are better suited to large companies already operating in the electrical sector

6. Conclusion

There are many opportunities along the solar PV value chain in India that can be broadly divided into

- Manufacturing
- Services

Based on our analysis of opportunities and risks in each sector, we suggest that small businesses can explore

- System Integration (services)
- EPC Subcontracting (services)

Medium scale businesses can consider

- Solar PV Mounting Structures (manufacturing)
- Balance of System (manufacturing)
- Solar Products (manufacturing)
- EPC (smaller projects, services)

And large enterprises can examine

- Polysilicon (manufacturing)
- Ingots & Wafers (manufacturing)
- Solar Cell (manufacturing)
- Solar Glass (manufacturing)
- Thin-FilmModule (manufacturing)
- EPC (utility scale, services)
- IPP (services)
- Solar Inverter(manufacturing)

7. About EAI

EAI is a boutique research and consulting firm in renewable energy technologies. Our expertise ranges from Solar PV and Wind Energy to Algae fuels and Jatrophabiodiesel. Our work has been sought after by some of the largest corporate and multilateral organizations in the world such as The Bill and Melinda Gates Foundation, Reliance Industries, World Bank, PepsiCo, iPLON, Vedanta Group, Accenture, Boston Consulting Group, [and more](#).

Our services for clients seeking to diversify into the solar sector include

- Market potential analysis
- Financial feasibility analysis
- Competitor analysis
- Identification of key success drivers
- Evaluation of policy and regulatory barriers
- Formulation of marketing/sales strategies
- Identification of technology and marketing partners

EAI provides a range of services for various stakeholders in the Renewable Energy and Cleantech space, covering

- Developer/IPP Assistance
- Assisting Industrial consumers go green
- Diversification into/within renewable energy
- Market entry for international firms
- Research and Publications
- Renewable energy catalysis

EAI has assisted a number of companies benefit from the solar power sector – through assistance in diversification strategy, go-to-market strategy, and market research.

To hear more on how we can assist you in unlocking value from solar business, write to us at consult@eai.in.

To know more about EAI's overall consulting services, please visit – www.consult.eai.in.