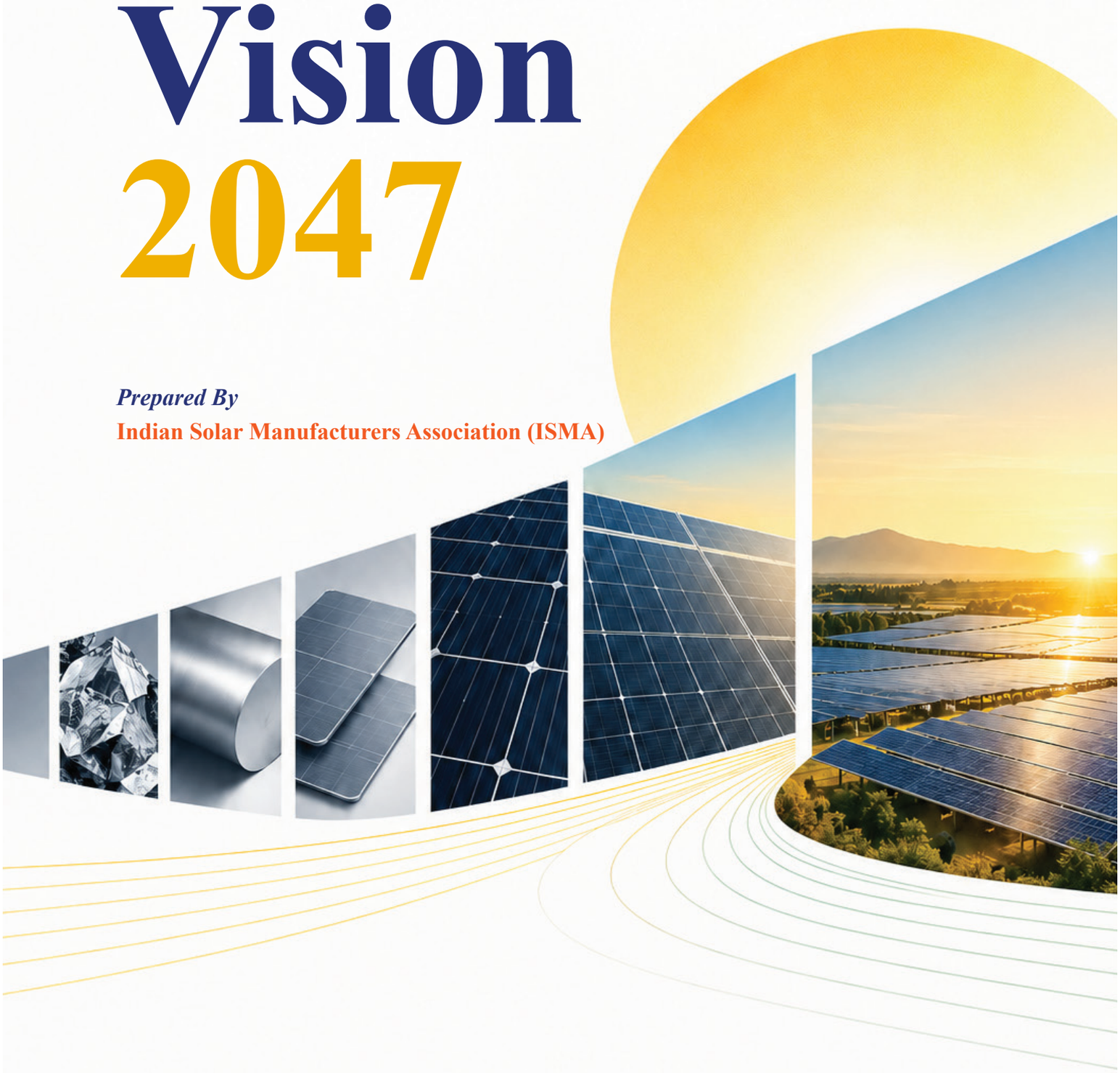
ISMA
INDIAN SOLAR MANUFACTURERS ASSOCIATION

India's Solar Manufacturing Vision 2047



Prepared By

Indian Solar Manufacturers Association (ISMA)

About ISMA

The Indian Solar Manufacturers Association (ISMA) is the apex industry body representing leading backward-integrated solar PV manufacturers in India, with strong representation from solar cell and upstream capacity manufacturing.

ISMA engages actively with policymakers, regulators, and industry stakeholders to enable policy frameworks that support domestic value addition, technology advancement, and long-term competitiveness of India's solar manufacturing ecosystem. ISMA's membership reflects significant cumulative capital investments in manufacturing capacity and supply chains, underscoring the industry's commitment to building a resilient and globally competitive solar manufacturing base in India.

Reviewed by

Amit Manohar, Secretary General, Indian Solar Manufacturers Association (ISMA)

Contributors

Varun Pandita, Senior Manager (Policy & Research), Indian Solar Manufacturers Association (ISMA)

Banani Kashyap, Indian Solar Manufacturers Association (ISMA)

How to Read This Document

Forecasts start from the same official figures for March 2026 and are shown on two pathways that differ only in how fully India's demand programmes are delivered.

- **Current Policy Scenario.** Existing programmes carry on at their current pace, following the Government's 2030 plan, the solar share of the 500 GW non-fossil target.
- **Vision 2047 Pathway.** Every demand programme, from green hydrogen and storage to transmission, electric vehicles, rooftops, and agriculture-based distributed renewable energy, is fully delivered beyond 2030, and Indian PV plants grow stage by stage to meet it.

Both are scenarios rather than targets. Financial years run from April to March; installed capacity is in GW AC, and manufacturing capacity is in GW DC. Sources marked † are intergovernmental or foreign official sources. Appendix B explains how each estimate is made.

India's Solar Manufacturing

VISION 2047



OUR MEMBERS

adani Solar

alpex POWER FOREVER

EMMVEE

First Solar

grew solar

JAKSON SOLAR

JUPITER TOWARDS A GREEN FUTURE

Premier Energies

Reliance Industries Limited

ReNew SOLAR PANELS

RenewSys let there be light

TATA TATA POWER SOLAR

From the Desk of President



Chiranjeev Singh Saluja
Managing Director. Premier Energies Limited

India stands at a defining moment in its solar manufacturing journey. As the apex industry body representing Indian solar manufacturers, ISMA is committed to working closely with the Government of India to build a globally competitive, resilient and self-reliant manufacturing ecosystem. The strong policy momentum created by Make in India and Atmanirbhar Bharat, together with the continued support of MNRE, is unlocking investment at unprecedented scale. Our collective priority now must be to deepen domestic capabilities across the value chain and establish India as a global leader in solar manufacturing.

From the desk of Secretary General



Amit Manohar
Secretary General, Indian Solar Manufacturers Association (ISMA)

Indian manufacturers have built strong capacity in modules, and the industry is now investing across the rest of the value chain, from polysilicon, ingots and wafers to cells, glass, frames, encapsulants and equipment. Building each of these stages at home will strengthen supply security, create skilled employment and keep more value within the country. ISMA will continue to work with the Government and our members to make this integrated value chain a reality.

Table of Contents

Executive Summary **1**

1. More Than a Decade of Policy-Led Growth in Solar PV Manufacturing **3**

Progress Across the Solar Value Chain 3

2. India's Solar Value Chain Today **4**

2.1 A Manufacturing Base Across the Solar PV Value Chain 4

2.2 Progress Under the PLI Scheme 4

2.3 Manufacturing Clusters by State 5

2.4 India in the Global Supply Chain 6

3. Policy Framework **7**

3.1 Building Manufacturing Capacity 8

4. Solar PV Demand Drivers **9**

4.1 National Programmes Driving Demand 9

4.2 Sources of Demand to 2047 10

5. Outlook to 2047 ..... **11**

5.1 Installed Solar Capacity 11

5.2 Manufacturing Capacity 12

5.3 Investment 14

5.4 Employment 15

5.5 Trade 17

6. Research and Technology **19**

6.1 Research Priorities 19

6.2 Cell Technology Outlook 19

6.3 Capital Equipment 20

7. Sustainability and Circularity **21**

8. India's Global Position **23**

9. The Way Forward **24**

Partnering for the Next Stage 25

Appendix A. Official Sources **26**

Appendix B. Methodology and Forecasting Approach **27**

Abbreviations

ALMM	Approved List of Models and Manufacturers: List-I modules, List-II cells, List-III ingots and wafers
BESS	Battery energy storage system
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
DGCI&S	Directorate General of Commercial Intelligence and Statistics (trade data)
DGTR	Directorate General of Trade Remedies
FY	Financial year, April to March
GEC	Green Energy Corridor, the transmission programme for renewable power
HJT	Heterojunction, a high-efficiency cell technology
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
ISMA	Indian Solar Manufacturers Association
MNRE	Ministry of New and Renewable Energy
NCPRE	National Centre for Photovoltaic Research and Education, IIT Bombay
NISE	National Institute of Solar Energy
NPL	CSIR–National Physical Laboratory, India's measurement standards body
PERC	Passivated emitter and rear cell, the previous cell technology
PIB	Press Information Bureau, the Government's news service
PLI	Production-linked incentive scheme for high-efficiency solar modules, with awards from polysilicon to the module
PM-KUSUM	Scheme for solar pumps and solar power on farms
PM Surya Ghar	PM Surya Ghar Muft Bijli Yojana, the rooftop solar scheme for households
RDI	Research Development and Innovation Scheme
RE-RTD	MNRE's Renewable Energy Research and Technology Development programme
TOPCon	Tunnel oxide passivated contact is today's mainstream cell technology.

Units

MW, GW	Megawatt, gigawatt = 1,000 MW. India installs tens of GW of solar a year
GW a year	Manufacturing capacity: gigawatts one stage of a solar PV manufacturing plant can make in a year
GW AC, GW DC	Installed capacity is counted in AC (power to the grid); panels in DC. Each GW AC carries about 1.25 GW DC of panels.
GWh	Gigawatt-hour, the unit for energy storage
GW-equivalent	Materials and equipment measured by the gigawatts they serve
tonne	1,000 kg; a gigawatt of modules uses about 1,900 tonnes of polysilicon today, falling to about 1,300 by 2047
lakh, crore	1 lakh = 100,000; 1 crore = 10 million; ₹1 lakh crore = ₹1 trillion (about USD 11.5 billion)

Executive Summary



India's solar industry is making excellent progress in integrating backwards, guided by steady and well-sequenced policy. One approved list at a time, cells, wafers, and polysilicon inside every solar panel are coming onto Indian soil, and the solar value chain is becoming deeper, more resilient, and increasingly India's own. Module makers already work at full scale, with 233+ GW of capacity. Cell lines now run at 50+ GW, the first ingot and wafer plant is ahead of the 2028 approved list for wafers, and the first polysilicon plants are on their way.

Recognised among the world's largest and fastest-growing solar manufacturers, India now has the market, the policy framework and the capital to build the full chain at home. This vision sets out what that will take by 2047, the centenary of Independence: the solar India will install, the solar PV manufacturing plants, capital and skills to supply it, and the policies that keep the build-out on track.

Figure ES1: Vision 2047 at a Glance

	TODAY	BY 2047, VISION 2047 PATHWAY
Solar installed	**171 GW**	**2,275 GW**
Modules	**233+ GW**	**3,484 GW**
Cells	**50+ GW**	**3,128 GW**
Ingots and wafers	**3+ GW**	**2,630 GW**
Polysilicon	**Coming up**	**2,200 GW**
Direct + indirect jobs	**4 lakh**	**32.3 lakh**
PV manufacturing investment	**USD 8.4 bn**	**USD 89 bn**
	Invested under PLI	

Source: *Ministry of New and Renewable Energy (MNRE); ISMA estimates.*

The foundation is built. Indian solar PV manufacturing plants supply the panels the country installs and a growing number of buyers abroad, and the chain behind them is filling in, with glass, frames and the other parts around each panel growing alongside. In ISMA's vision, cumulative output by 2030 reaches about **355 GW of modules, 205 GW of cells, 56 GW of ingots and wafers, and 20 GW of polysilicon**, and every part of the panel is made in India within the next decade as each stage comes home in turn. India's solar value chain will become fully integrated, from polysilicon to modules, by the middle of the next decade. By 2047, every stage from polysilicon to modules will run at about **260 to 372 GW a year**. Capital is moving at a pace. PLI plants have invested about USD 8.4 billion (₹73,400 crore) so far, and every dollar of incentive has drawn about four dollars of private investment. About 70% of the investment ahead goes into polysilicon, wafers and cells, starting with about USD 6 billion for cells in 2027. With research and recycling built in from the start, India is earning a growing place in the world as a trusted source of solar supply.

Firm ALMM dates and PLI plants completed on time have built each stage so far, and holding that sequence, with early clarity on polysilicon, will carry the industry to 2047.

1. More Than a Decade of Policy-Led Growth in Solar PV Manufacturing

India built a solar manufacturing industry of national scale in about a decade, and each step forward followed a clear policy decision.

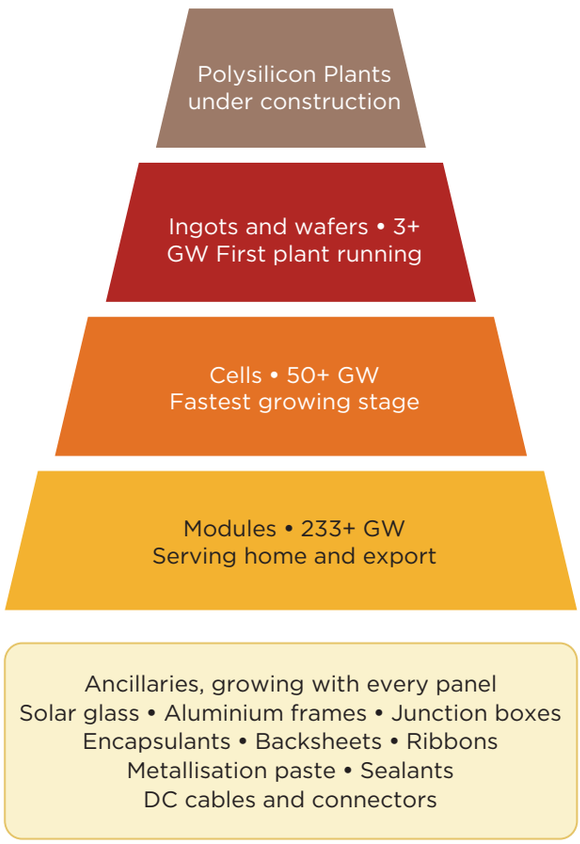
- **Foundation (to 2020):** Starting from about 2.3 GW of module capacity in 2014, early solar PV manufacturing plants learned the technology, trained their people, and set the quality standards that later growth was built on.
- **Scale (2021 to 2025):** A list of approved manufacturers, production incentives, and customs duties gave Indian-made panels a secure market, and capacity grew many times over.
- **Depth (from 2026):** Government-backed projects now use Indian-made cells, wafers are next, and cell capacity is rising fast.

Progress Across the Solar Value Chain

The earlier stages of the chain, polysilicon and wafers, need the most capital, power and specialised skills. India now has solar PV manufacturing plants at every stage. Cells, which turn wafers into the working part of the panel, are growing fastest (Figure 1.1).



Figure 1.1: Manufacturing Capacity at Each Stage of the Solar Value Chain



Source: *MNRE, ISMA Estimates*

Each time Government-backed projects have turned to Indian solar PV manufacturing plants for a stage, investors have built it and moved one step further up the chain. ISMA's vision takes that same approach all the way to polysilicon.

2. India's Solar Value Chain Today

India's solar industry now spans the entire solar value chain, from polysilicon to modules. Panel assembly runs at a national scale, cell manufacturing is the fastest-growing stage, the first wafer plants are producing, and polysilicon plants are being built. Policy support has created a base of solar PV manufacturing plants, workers and investment for the next phase.

2.1 A Manufacturing Base Across the Solar PV Value Chain

Indian manufacturers are adding one stage at a time, each building on the last, with makers of glass, frames, junction boxes and other parts growing around them. Panel capacity is already larger than what India installs each year, which leaves room to supply export markets.

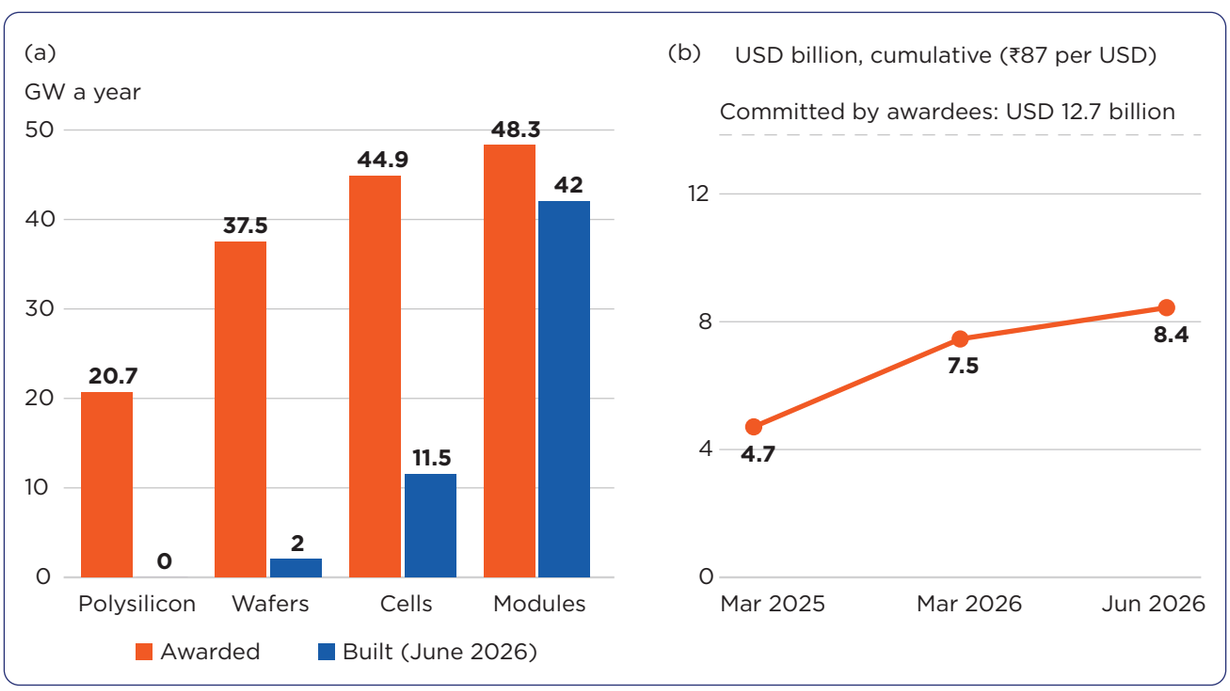
Many new plants manufacture cells and soon wafers under the same roof as the finished panel. This keeps more of the value in one plant, shortens supply lines and lets each new stage use the skills, power and suppliers already on site.

2.2 Progress Under the PLI Scheme

The Production Linked Incentive (PLI) scheme, which rewards manufacturers for what they produce and sell, has funded much of this expansion. Each stage is now moving from award to production (Figure 2.1).

- **Cells:** about a quarter of the awarded cell capacity is already in place, and the rest is under construction.
- **Wafers:** the first ingot and wafer plant are running.
- **Polysilicon:** the first polysilicon plants are coming up next.
- **Panels:** most of the awarded assembly capacity is built and serving the market.

Figure 2.1: PLI Plants, from Award to Production



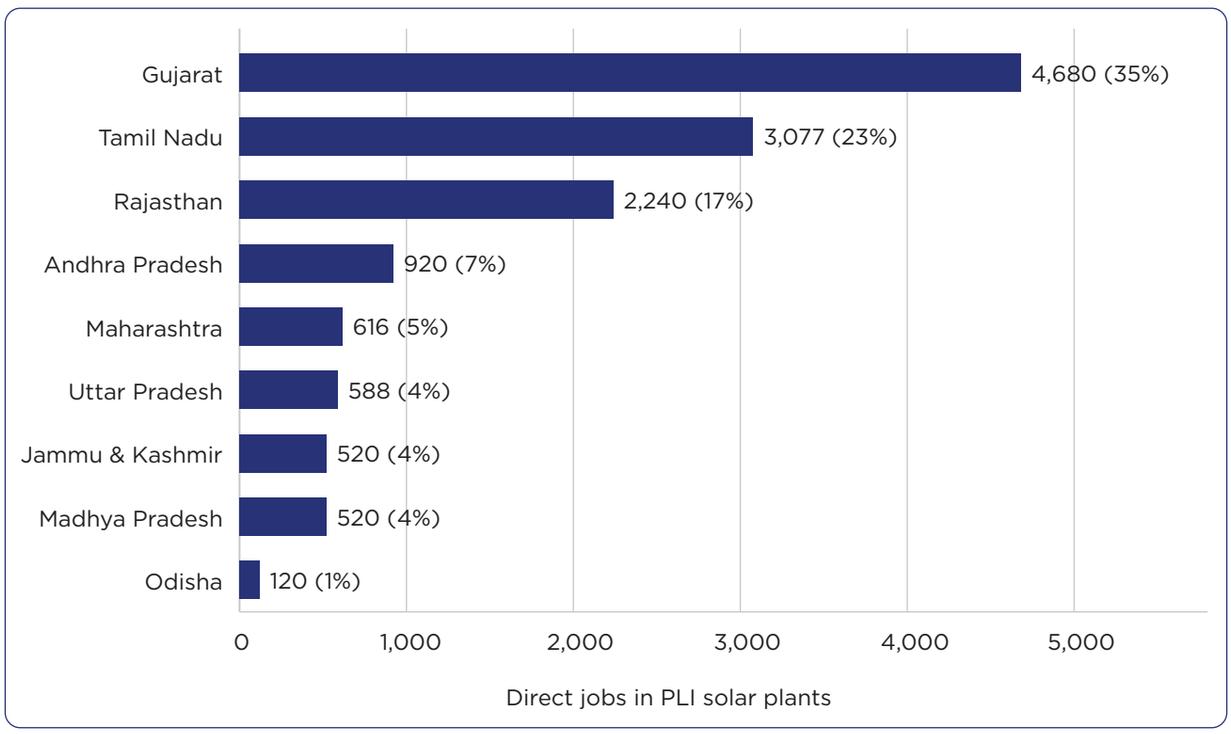
Source: *MNRE*



2.3 Manufacturing Clusters by State

Solar PV plants have clustered in states with ports, reliable power, and skilled workers. Gujarat, Tamil Nadu and Rajasthan together account for about three-quarters of direct jobs in PLI solar plants (Figure 2.2). These clusters already have suppliers and trained workers, which makes them the natural location for new wafer and polysilicon plants.

Figure 2.2: Solar Manufacturing Jobs by State



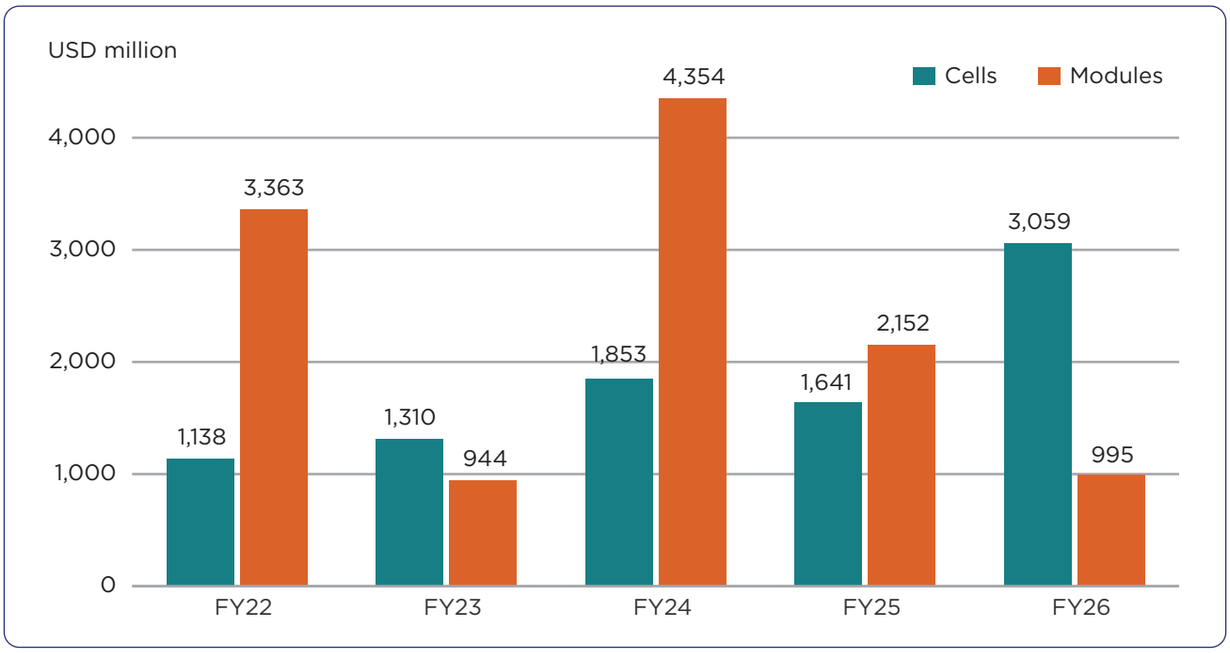
Source: *MNRE*

2.4 India in the Global Supply Chain

Buyers around the world want more than one reliable source of solar supply at every stage of the chain. India's scale, stable policy, and growing capacity in the earlier stages put it in a strong position to become that supplier (chapter 8).

Module imports have fallen sharply since their peak, as Indian plants now supply the panels the country installs. The rapid growth of module assembly has created strong demand for cells, and Indian cell lines are now stepping up to meet it as new capacity opens (Figure 2.3). In FY2026, India's module exports (USD 1.03 billion) already exceeded its module imports (USD 0.99 billion). With the first wafer plant running, a growing share of each panel is made in India.

Figure 2.3: Imports of Solar Cells and Modules



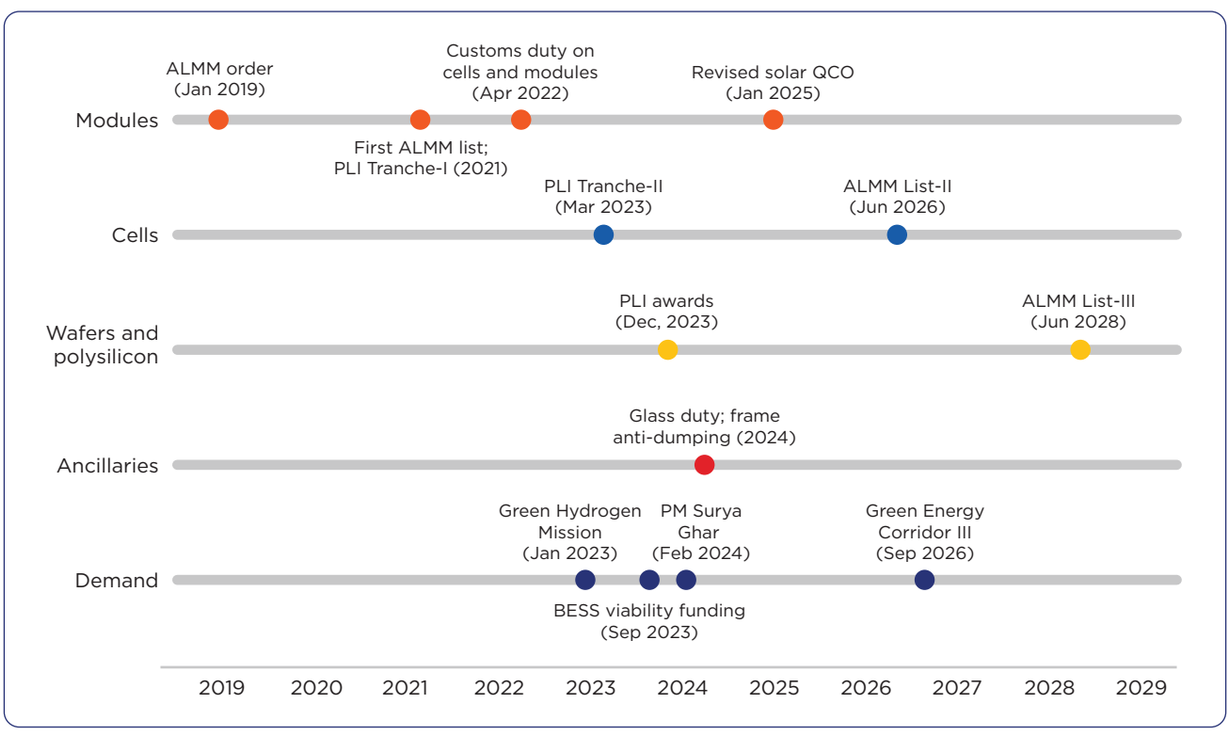
Source: *Ministry of Commerce and Industry*

3. Policy Framework



Indian solar policy works on two fronts. It gives manufacturers the confidence to invest, and it creates a large, predictable market for what they make. It has moved along the solar value chain one stage at a time, securing demand for each stage before moving to the next (Figure 3.1).

Figure 3.1: Policy Milestones for Solar Manufacturing and Demand

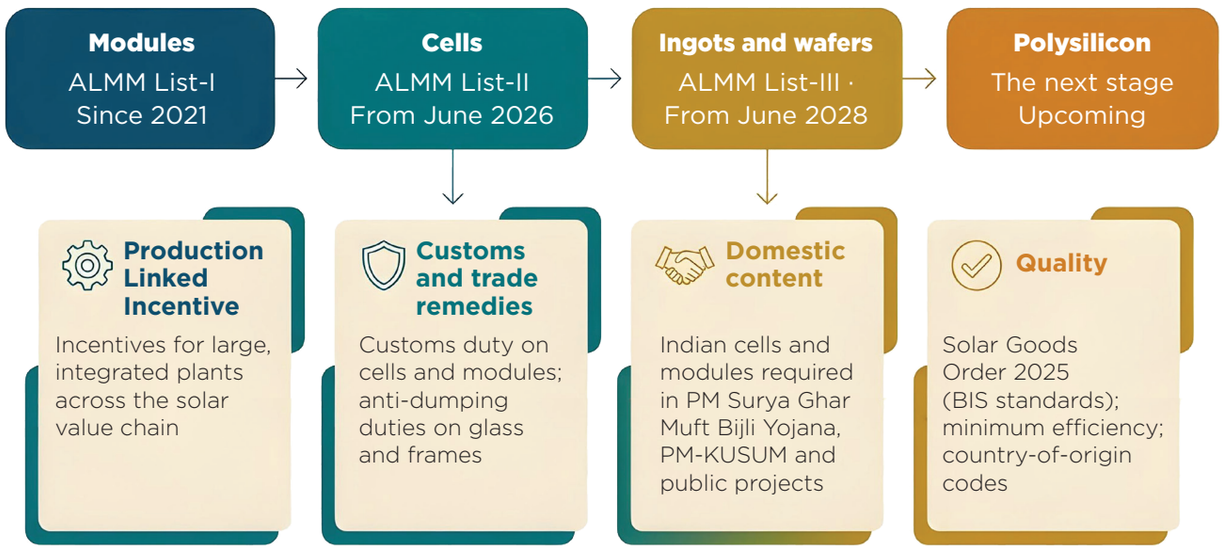


Source: *MNRE; Ministry of Power; Ministry of Finance; Gazette of India*

3.1 Building Manufacturing Capacity

The main policy instrument is the Approved List of Models and Manufacturers (ALMM). Government-backed projects must buy from solar PV manufacturing plants on this list, which are inspected before they are added. Each stage is added to the list with advance notice, so investors know when demand for their product will arrive. Four other policies support it (Figure 3.2).

Figure 3.2: The Approved List and Four Policy Pillars



Source: *MNRE; Ministry of Finance.*

Together, these measures have given the industry the scale and credibility to move from panels to cells and next to wafers and polysilicon.



4. Solar PV Demand Drivers

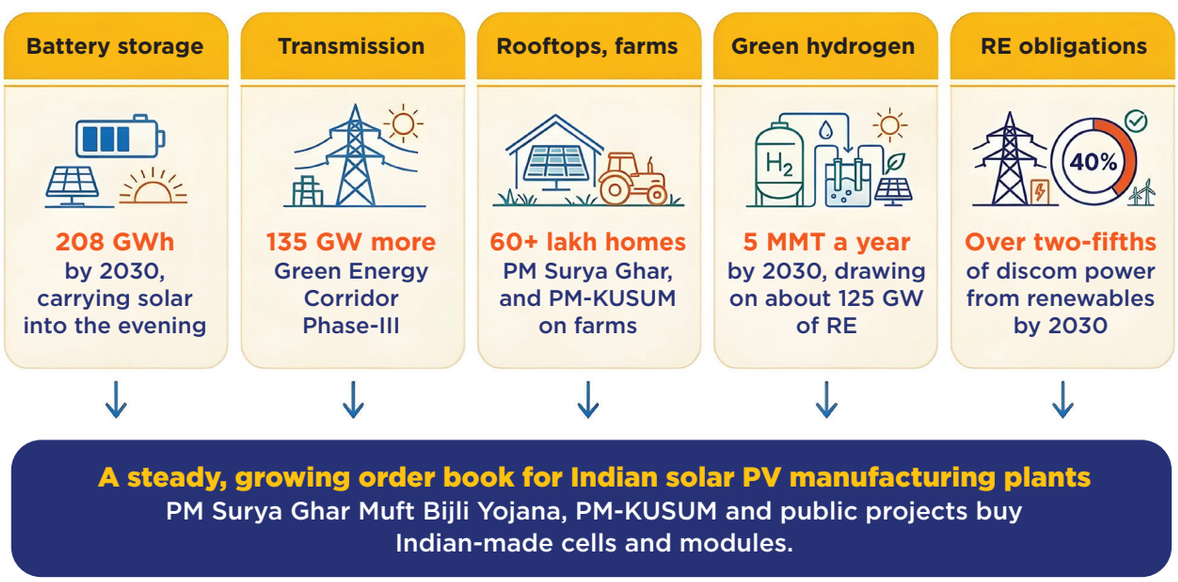


Every manufacturing plan starts with demand. How much solar India installs, and what that power is used for, sets how many cells, wafers and tonnes of polysilicon the country will make.

4.1 National Programmes Driving Demand

Five national programmes shape how many panels India will need each year (Figure 4.1). Green hydrogen turns clean power into an industrial raw material, battery storage carries solar into the evening, and new transmission corridors link renewable-rich regions to demand centres. PM Surya Ghar Muft Bijli Yojana and PM-KUSUM take solar to homes and farms, and renewable purchase obligations give clean power a rising share of the market.

Figure 4.1: Five National Programmes Driving Solar Demand

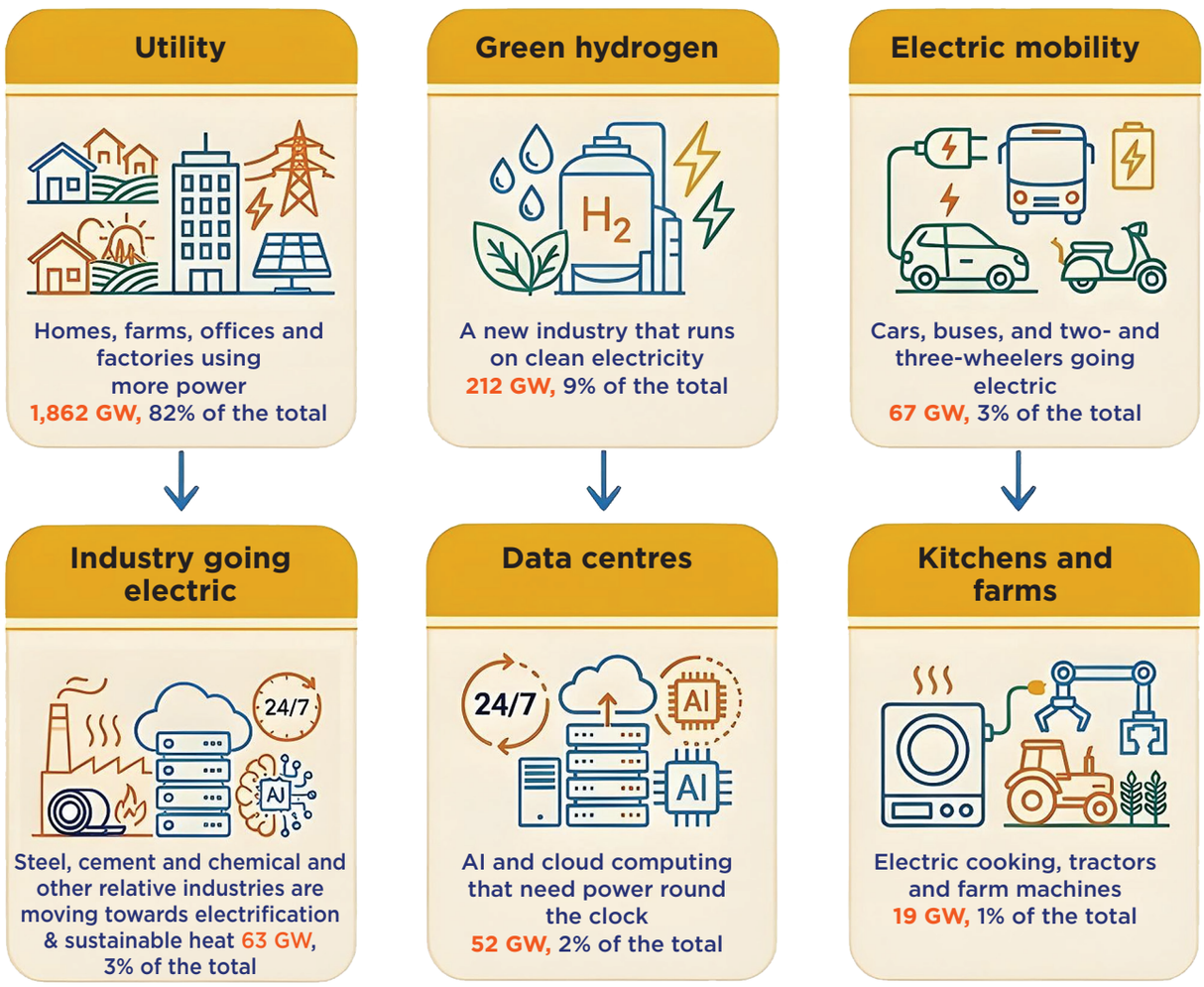


Source: *MNRE; Ministry of Power*

4.2 Sources of Demand to 2047

Most demand to 2047 will come from households, farms, and businesses using more electricity each year. New industries that are now taking shape will add the rest (Figure 4.2). Utility demand accounts for about four-fifths of the solar needed by 2047. Green hydrogen is the largest new use, at about 210 GW, followed by electric vehicles, industry and data centres.

Figure 4.2: Solar Demand by End Use, 2047



Making it work: storage and transmission
Battery storage and the Green Energy Corridors add no demand of their own but decide how much solar the grid can use.

Source: *ISMA estimates.*

Rising incomes and economic growth drive most of this demand. New uses, led by green hydrogen, are where policy has the most influence, and how fully they are delivered is the main difference between the two pathways in chapter 5.

5. Outlook to 2047

This chapter sets out what the Vision 2047 Pathway requires: how much solar India installs, the solar PV manufacturing plants needed to supply it, and the investment, jobs and trade that follow.

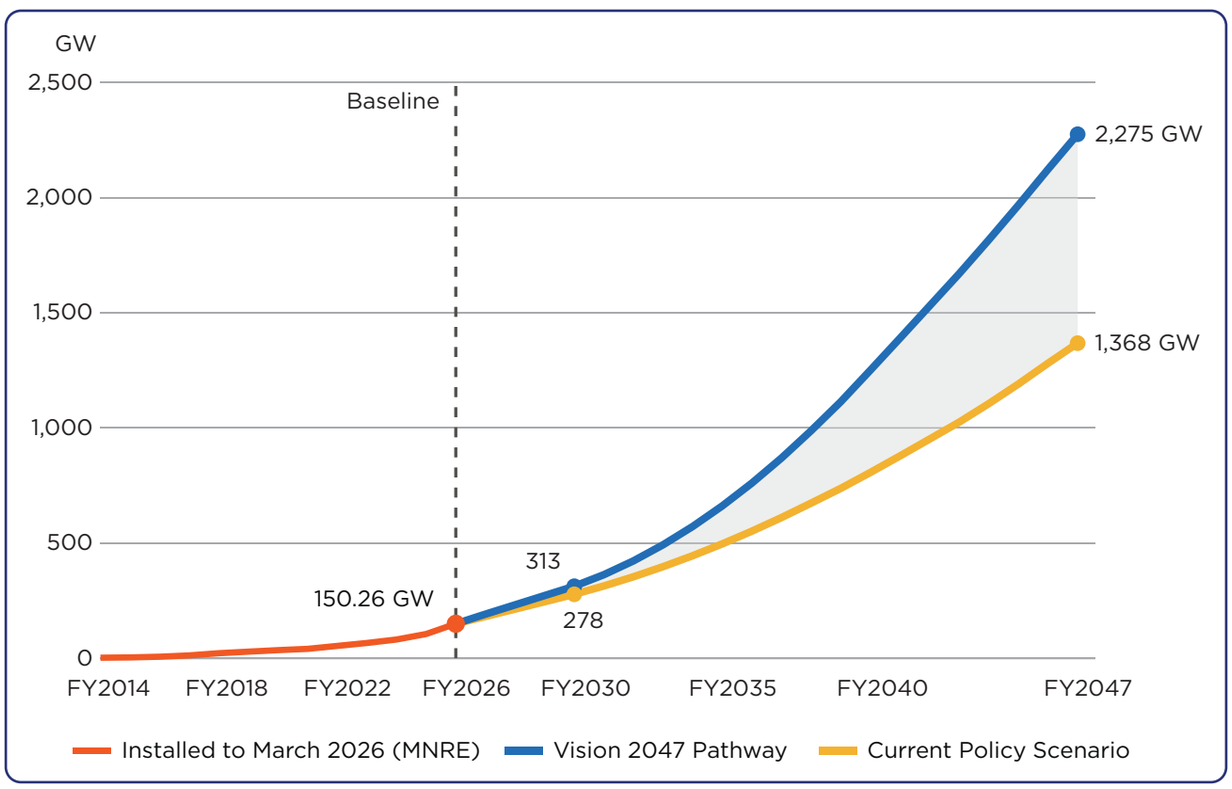
5.1 Installed Solar Capacity

Both pathways start from the same official base today. They also grow in the same ways: large solar parks, projects that pair solar with batteries so power is available round the clock, solar supplied directly to industry, and rooftop and farm solar under PM Surya Ghar Muft Bijli Yojana and PM-KUSUM (Figure 5.1).

If today's policies continue as they are, ISMA projects that India reaches about 278 GW by 2030, close to its 292 GW goal, and goes on to reach about **1,370 GW by 2047**. This sits just below NITI Aayog's current-policy range of 1,430 to 1,650 GW for 2050, as expected for a date three years earlier.

The Vision 2047 Pathway adds the extra demand that new industries and infrastructure will bring. If every programme is delivered in full, ISMA estimates that installed solar reaches **313 GW by 2030** and about **2,275 GW by 2047**, which would be enough to supply close to half of the electricity India uses.

Figure 5.1: Installed Solar on Both Pathways



Source: *MNRE; ISMA estimates*

Solar has grown at a compounding pace. India had about **2.8 GW** of solar in 2014 and has 171 GW today, and each year's additions are larger than the last. The curve in Figure 5.1 keeps steepening for the same reason: a larger base, economic panels, and more uses for clean power. Looking ahead, ISMA expects yearly additions to rise from about **42 GW in 2027** to about **165 GW in 2047**, an average of about **104 GW** every year.

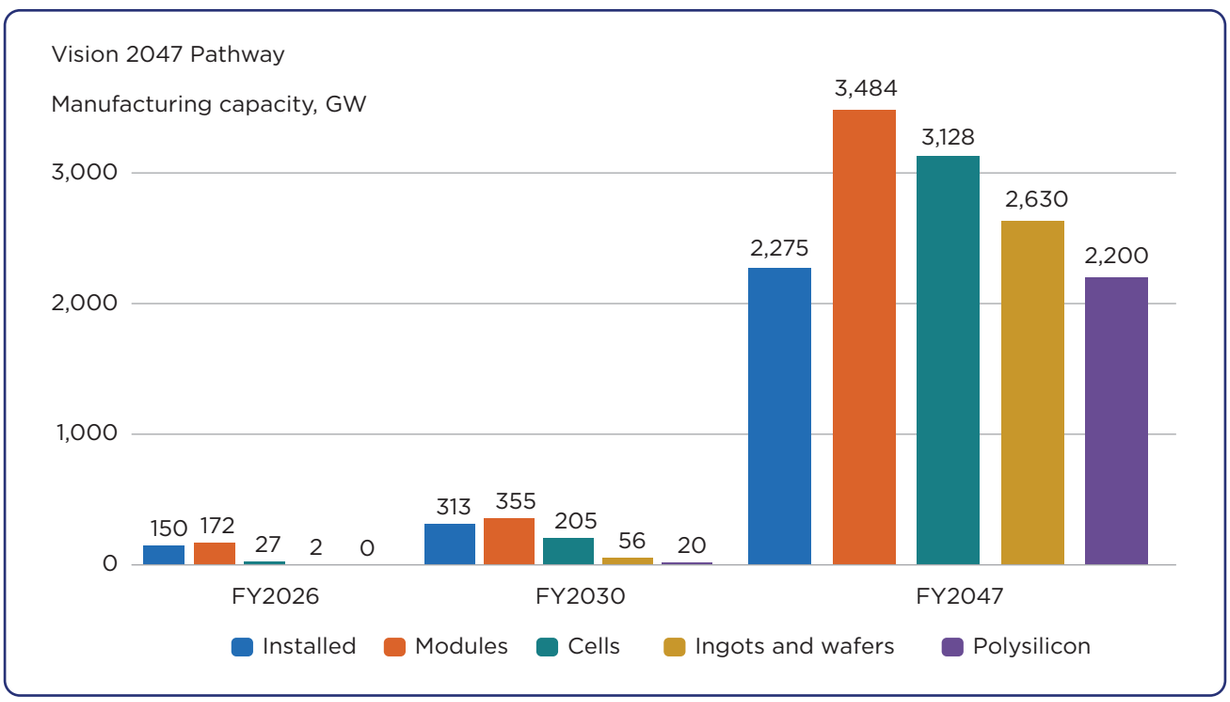
What drives the vision

1. **Start from today:** India's official electricity generation and solar capacity for FY2026.
2. **Grow today's demand:** electricity use rises every year, a little more slowly as India gets richer.
3. **Add what is new:** hydrogen, vehicles, industry, data centres, cooking and farm machines, each counted only once.
4. **Work out the solar:** solar's share of that electricity, including power stored for the evening, converted into panels.
5. **Build it year by year:** new capacity plus replacement of 25-year-old panels, at a pace industry can deliver.

5.2 Manufacturing Capacity

Most of the growth in manufacturing comes from the parts inside the panel. ISMA projects that cumulative output at every stage grows many times over with cells leading and wafers and polysilicon close behind (Figure 5.2). By 2030, cumulative output reaches about 355 GW of modules, 205 GW of cells, 56 GW of ingots and wafers and 20 GW of polysilicon. By 2047, Indian solar PV manufacturing plants would make about 3,480 GW of modules, 3,130 GW of cells, 2,630 GW of ingots and wafers and 2,200 GW of polysilicon in total.

Figure 5.2: Manufacturing Capacity at Every Stage of the Solar Value Chain

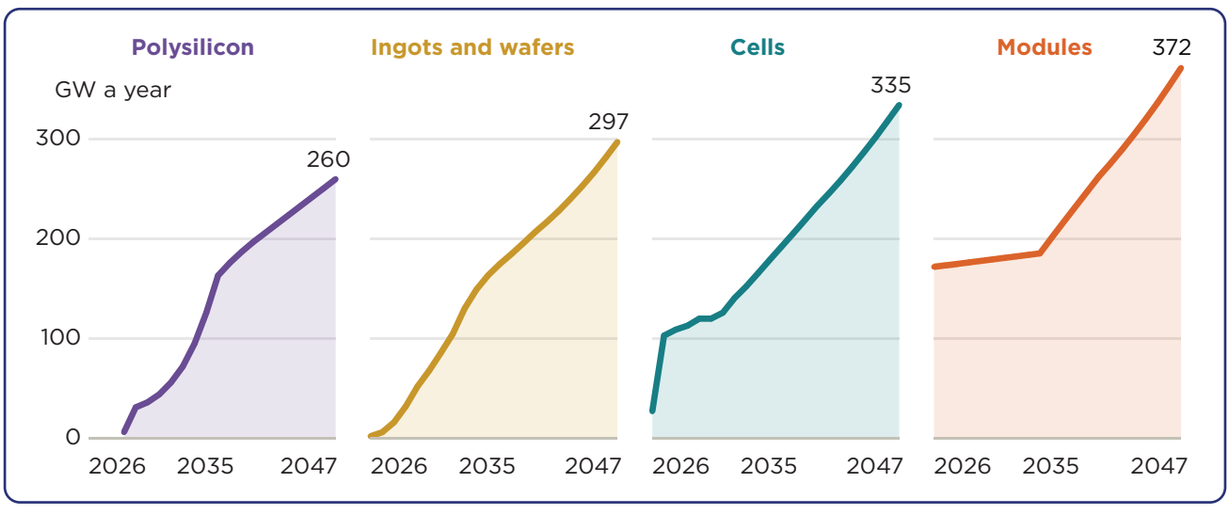


Source: *MNRE; ISMA estimates*

Each stage grows quickly once Government-backed projects are required to buy it from Indian plants (Figures 5.2 and 5.3):

- **Cells:** capacity passes the Government's 100 GW goal by 2027, well ahead of time, and cumulative output reaches about 205 GW by 2030, so Indian cells soon meet domestic demand.
- **Ingots and wafers:** cumulative output reaches about 56 GW by 2030 as the approved list for wafers takes effect, and Indian wafers meet domestic demand by the mid-2030s.
- **Polysilicon:** the first PLI plants start production in 2029, and cumulative output reaches about 20 GW by 2030. Building then speeds up through the 2030s, so Indian polysilicon meets domestic demand within the next decade.

Figure 5.3: Manufacturing Capacity at Each Stage



Source: MNRE; ISMA estimates.

The stages grow in step, each one following the stage it supplies. Module assembly expands in line with installations and exports, and cell, wafer, and polysilicon capacity rises behind it until each stage can supply the next from within India. By 2047, every stage runs at about **260 to 372** a year. With steady policy, the whole chain, from polysilicon to modules, will meet India's own demand within the next decade.

What drives the vision

1. **Start from installations:** the solar added each year on each pathway, plus panels replaced after 25 years.
2. **Turn it into panels:** allowing for the extra panels each plant carries, spares and exports.
3. **Work back up the chain:** modules to cells, wafers and polysilicon, allowing for thin-film panels and normal plant utilisation.

5.3 Investment

India's solar manufacturers are already investing steadily in new capacity across the solar value chain. What is needed is a steady flow of investment rather than a sudden jump, with each new stage drawing its share as its approved list takes effect (Figure 5.4). In the current policy scenario, the need is about half, at USD 45 billion.

Figure 5.4: Solar PV Manufacturing Investment at a Glance

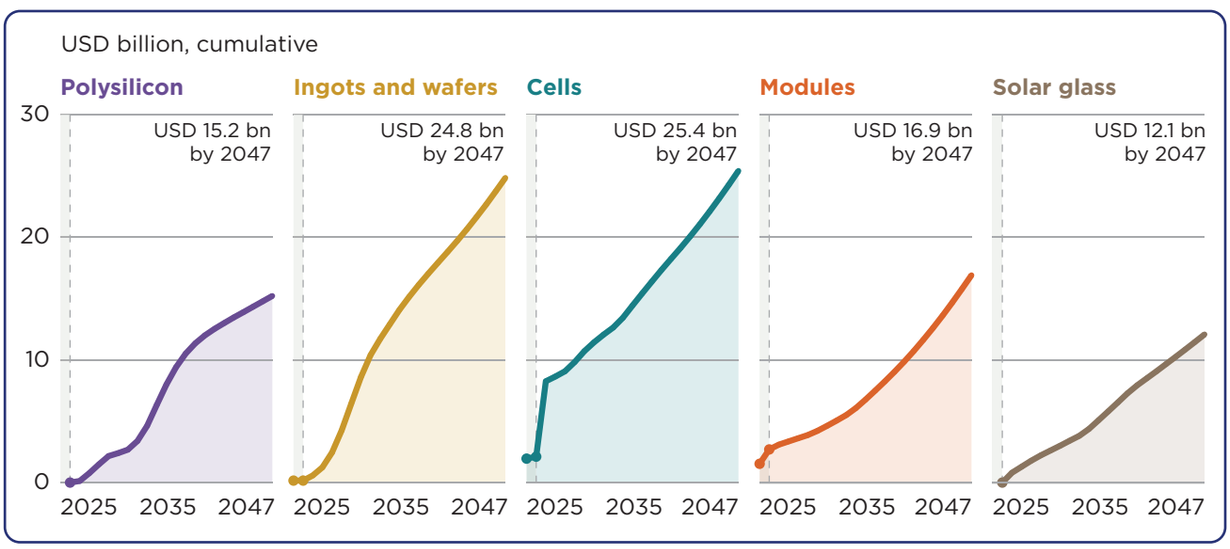


Source: *MNRE; ISMA estimates.*

The PLI scheme has attracted strong investment. PLI plants have invested about USD 8.4 billion (₹73,400 crore) so far, and every dollar of incentive has drawn about four dollars of private investment. Most of the next round goes into cell and wafer plants.

In ISMA's vision, investment builds up at every stage, each in its own time (Figure 5.5). Cell plants draw the largest share of investment first, as lines already under way are completed. Investment in wafers then rises through the early 2030s and in polysilicon through the mid-2030s, as each stage is built to supply the one after it. Investment in modules and solar glass grows steadily, in step with demand. By the middle of the next decade, every stage from polysilicon to module is manufactured in India.

Figure 5.5: Cumulative Solar PV Manufacturing Investment by Stage



Source: *MNRE; Lok Sabha; ISMA estimates*

Policy sets this order. MNRE's approved lists give Indian cells assured demand from June 2026 and Indian wafers from June 2028, while the PLI scheme backs the first polysilicon plants. Setting clear dates early for each list will help investors keep pace.

What drives the vision

1. **Start from capacity:** the new capacity each stage adds every year on each pathway, as set out in section 5.2. Plants already running in March 2026 are not counted again.
2. **Price each gigawatt:** US Department of Energy plant costs†, adjusted to India with IEA cost ratios†, and checked against the PLI Tranche-II awards.
3. **Keep prices constant:** all figures are in USD at FY2026 prices (₹87 per USD). Land, working capital, captive power and ancillaries other than glass are not included.

5.4 Employment

Employment at a Glance

4 lakh
jobs today
direct + indirect

→

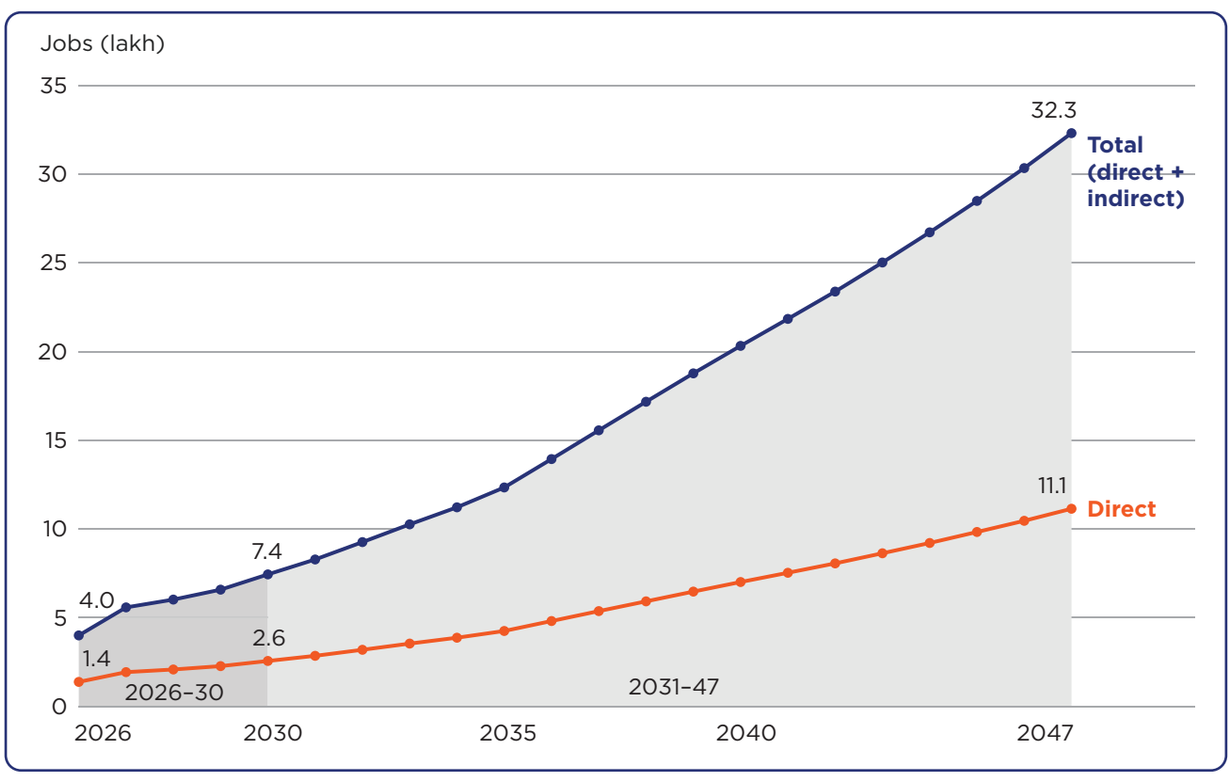
7.4 lakh
jobs by 2030
direct + indirect

→

32.3 lakh
jobs by 2047
Vision 2047 Pathway

Solar manufacturing is set to become one of India's major industrial employers. ISMA estimates that jobs grow from about 4 lakh today to about 7.4 lakh by 2030 and 32 lakh by 2047 as each new stage is built (Figure 5.6). Direct jobs inside solar PV manufacturing plants rise from about 1.4 lakh to about 11 lakh.

Figure 5.6: Solar Manufacturing Jobs, 2026 to 2047



Source: *MNRE; ISMA estimates*

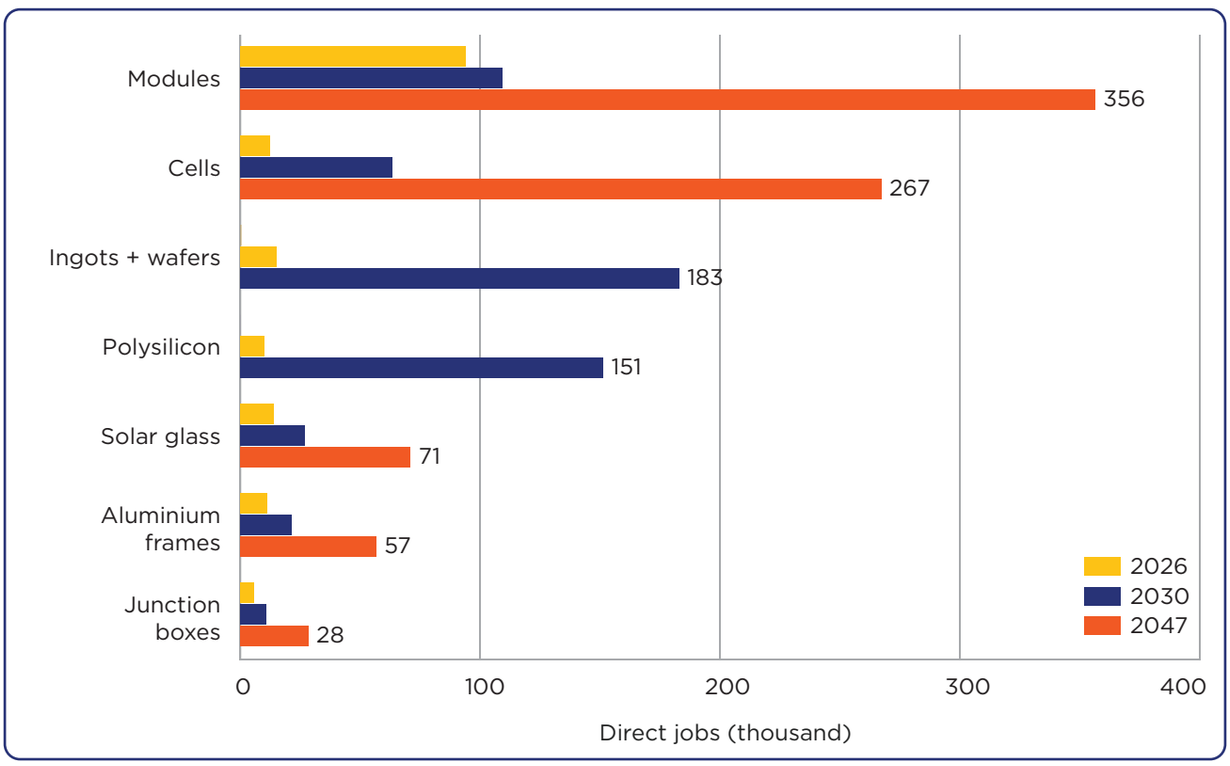
About two in three of these jobs are outside the manufacturing plant, with suppliers, transport firms, and service providers. Growth in solar PV manufacturing output benefits communities well beyond the manufacturing clusters.

How the estimate is built. Jobs are estimated for each gigawatt of capacity at each Staffing starts at today's level and rises steadily to about 2,930 direct jobs per GW for fully integrated plants by 2047, close to the PLI Tranche-I benchmark of 3,000. Jobs in glass, frames, and junction boxes are added for every panel made, and indirect jobs follow the PLI Tranche-II ratio.

Jobs Across the Solar Value Chain

Panel assembly remains the largest employer, followed by cells, while the fastest job growth comes from wafers, and polysilicon. (Figure 5.7).

Figure 5.7: Direct Jobs at Each Stage of the Solar Value Chain



Source: *MNRE; ISMA estimates.*

The share of direct jobs in cells, wafers and polysilicon rises from about one in ten today to about a third by 2030 and more than half by 2047 (Figure 5.8). These are skilled jobs for technicians, engineers and chemists.

Figure 5.8: Share of Direct Jobs in the Upstream Stages



Source: *ISMA estimates*

Jobs in the Ancillary Industry

Glass, aluminium frames and junction boxes are needed for every panel, which makes them some of the most stable jobs in solar (Figure 5.7). Including indirect work, these suppliers support about 4.5 lakh jobs by 2047.

Other components, such as encapsulant films, backsheets, cables and connectors, offer further room for growth. Extending the approved list to them would give these suppliers the same assured demand that cell and panel makers have and bring more of those suppliers into India.

Skills for the full solar value chain. Cell, wafer and polysilicon plants need a new tier of technical skills. The industry will work with the government on training programmes and on publishing employment data by stage.

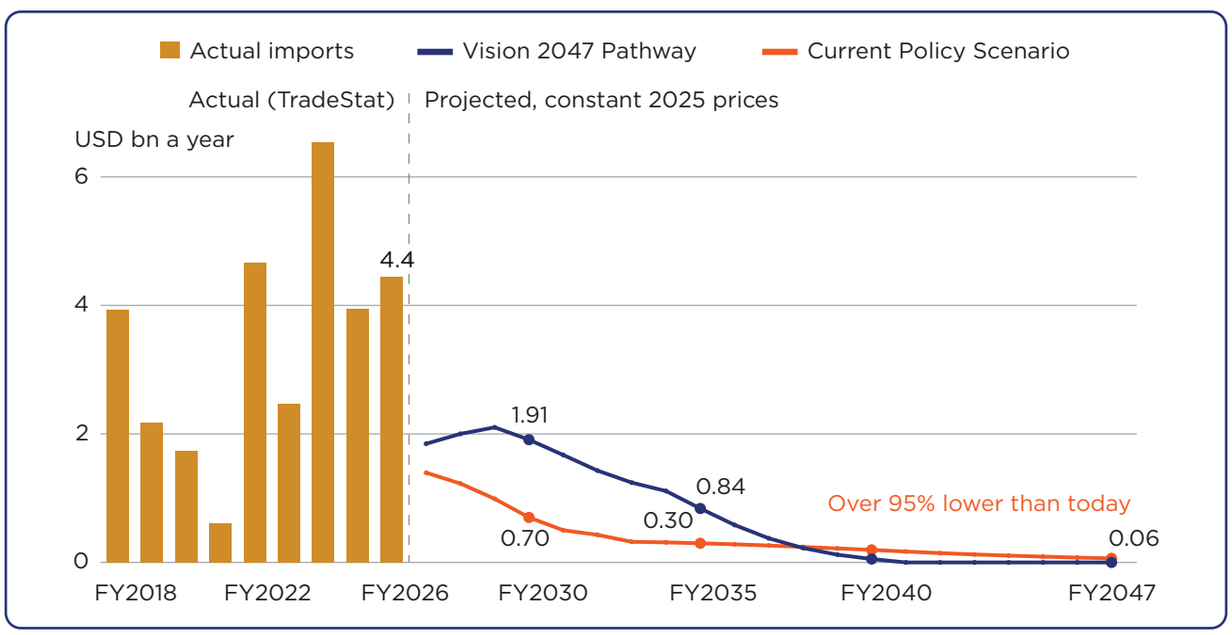
What drives the vision

1. **Start from capacity:** the solar PV manufacturing plants running at each stage every year (section 5.2), with the ancillary industry sized on module output.
2. **Count jobs per gigawatt:** starting at today's staffing and rising to close to the PLI Tranche-I figure of 3,000 direct jobs per integrated GW by 2047.
3. **Add the wider economy:** 1.9 indirect jobs for every direct job, the ratio in the PLI Tranche-II awards.

5.5 Trade

Every stage made in India keeps more of the value of each panel in the country. Panels are already made at home; cells are next, followed by wafers and polysilicon. In ISMA's vision, India's solar import bill of about USD 4.4 billion today falls by more than 95% by the early 2040s, and current policy brings a similar fall by 2047 (Figure 5.9). Cells, which made up 69% of today's bill, are largely made at home from 2027.

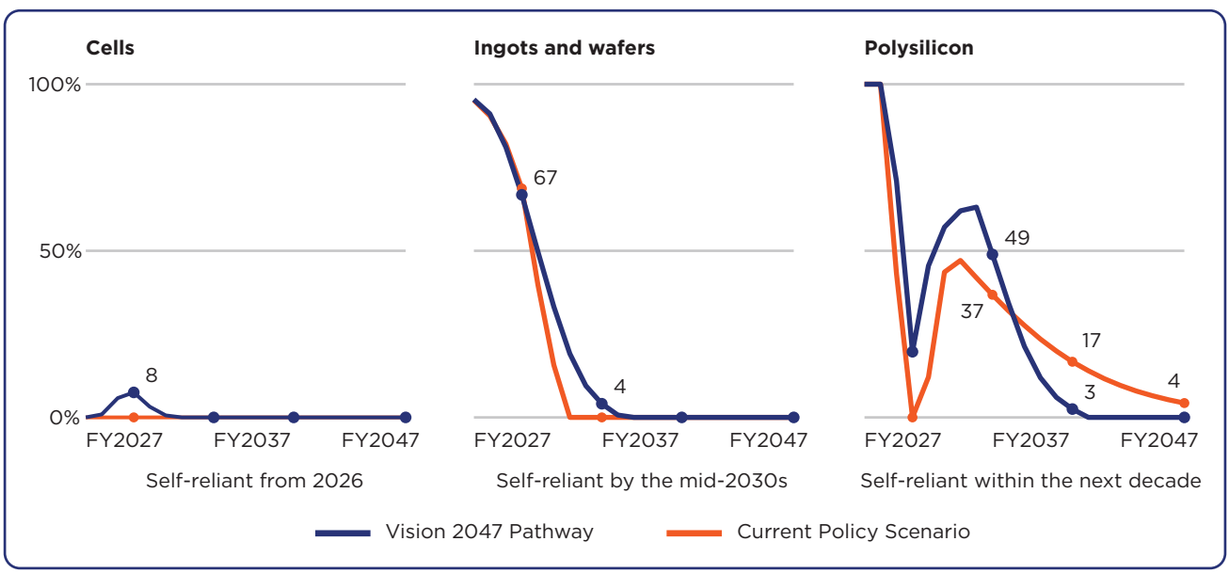
Figure 5.9: India's Solar Import Bill Falls as Indian Plants Grow



Source: *Ministry of Commerce and Industry; IRENA†; ISMA estimates*

Indian plants meet a rising share of each stage's needs once they are built and Government-backed projects are required to buy from them (Figure 5.10). India makes more than 95% of the wafers it needs by the mid-2030s, and polysilicon reaches the same mark within the next decade. Keeping polysilicon in step with the wafer build-out after 2030 is the main lever for keeping more value in India.

Figure 5.10: Imported Share of Inputs at Each Stage



Source: *Ministry of Commerce and Industry; ISMA estimates.*

Exports: India's solar PV manufacturing plants are built first for a fast-growing home market, with a share set aside for the world. The vision is for exports to grow to about 10% of India's output by 2047, with cells moving abroad alongside the modules, while wafer and polysilicon plants are sized first to meet India's own needs. Many countries want a reliable alternative supplier, and each new stage made in India gives them one more reason to buy Indian.

What drives the vision

1. **Start from need:** what Indian solar PV manufacturing plants use at each stage, plus exports.
2. **Set it against home output:** whatever India does not yet make at a stage is imported.
3. **Price the gap:** landed costs to India from IRENA†, held at constant 2025 prices.

6. Research and Technology

Technology keeps Indian solar PV manufacturing plants competitive. MNRE's renewable energy research programme has been renewed, and the new Research Development and Innovation (RDI) Scheme, with a corpus of about USD 11.5 billion (₹1 lakh crore), offers long-term finance for projects close to commercial use. Solar manufacturers can draw on both.

6.1 Research Priorities

India's research base is strongest in testing, which already supports the approved list and the PLI scheme. The first public pilot line for next-generation tandem cells is running at IIT Bombay, and the next step is a clear route from pilot line to commercial PV manufacturing plant. Beyond crystalline silicon, thin-film panels, led by cadmium telluride (CdTe) and followed by copper indium gallium selenide (CIGS), take a growing share of the market, reaching about 18% of modules by 2047 (ISMA estimate, based on NITI Aayog). Back-contact cells and perovskite-silicon tandems are the other technologies to watch, and each will need pilot lines and testing capacity in India. Wafers, polysilicon and production equipment are where research can add the most (Figure 6.1).

Figure 6.1: Research Strengths and Priorities by Stage

	Polysilicon	Ingots and wafers	Cells	Modules
Public research	Next priority	Next priority	NCPRE; RE-RTD	NISE reliability work
Pilot lines	Next priority	Next priority	1 tandem line, IITB	Mature, not needed
Testing, certification	Follows new plants	Follows new plants	NISE; NPL standard	NISE, ISO/ IEC 17025
Production equipment	Make in India next	Make in India next	Make in India next	Make in India next
PV plants today	Plants upcoming	About 3 GW	List-II from 2026	233+ GW (Sep 2026)
Key	Established	Developing	Next priority	Not applicable

Source: *MNRE; ISMA assessment.*

6.2 Cell Technology Outlook

Solar cells keep getting more efficient, and each new design changes the wafer and the machines needed to make it. Industry has already moved to a newer, more efficient cell type, and the next generations are being tested (Figure 6.2).

Figure 6.2: Solar Cell Technology Outlook

PERC, p-type	TOPCon, n-type	HJT, back-contact	Perovskite tandem
Earlier generation	*Mainstream now*	*Next step*	*Pilot now*
Most of the world's installed base until recently	About four-fifths of wafers made in 2025 were n-type (IEA PVPS)†	Higher efficiency on the same n-type wafers, with new processes	Perovskite layer on a silicon cell; pilot at IIT Bombay; early commercialisation by 2035
What it needs	**What it needs**	**What it needs**	**What it needs**
Lines are now moving to n-type.	Indian n-type wafers from 2028 (List-III)	New tools and trained engineers	Shared pilot lines and RDI funding

Solid border: in place today. *Dashed border: industry direction, not a Government target.*

Source: *IEA PVPS†; MNRE*

The industry's aim is to adopt each new cell design early, bring tandem cells into early production, and by 2047 design and build both cells and the core equipment in India.

6.3 Capital Equipment

Every stage of the solar value chain runs on specialised machines: wafer saws and crystal pullers, diffusion furnaces and cell printing lines, laminators and stringers. Most of this equipment still comes from abroad, which opens a large opportunity for Indian makers. As India builds cell, wafer and polysilicon plants at scale, it becomes worthwhile to design and make these machines at home, as every large solar manufacturing country has done before.

Indian-made equipment would shorten delivery times, lower the cost of each new plant and keep know-how in the country as cell technology changes. The first step is a dedicated programme for cell and wafer production tools, built with the equipment industry and the research institutes, which ISMA sets out in the partnering section.

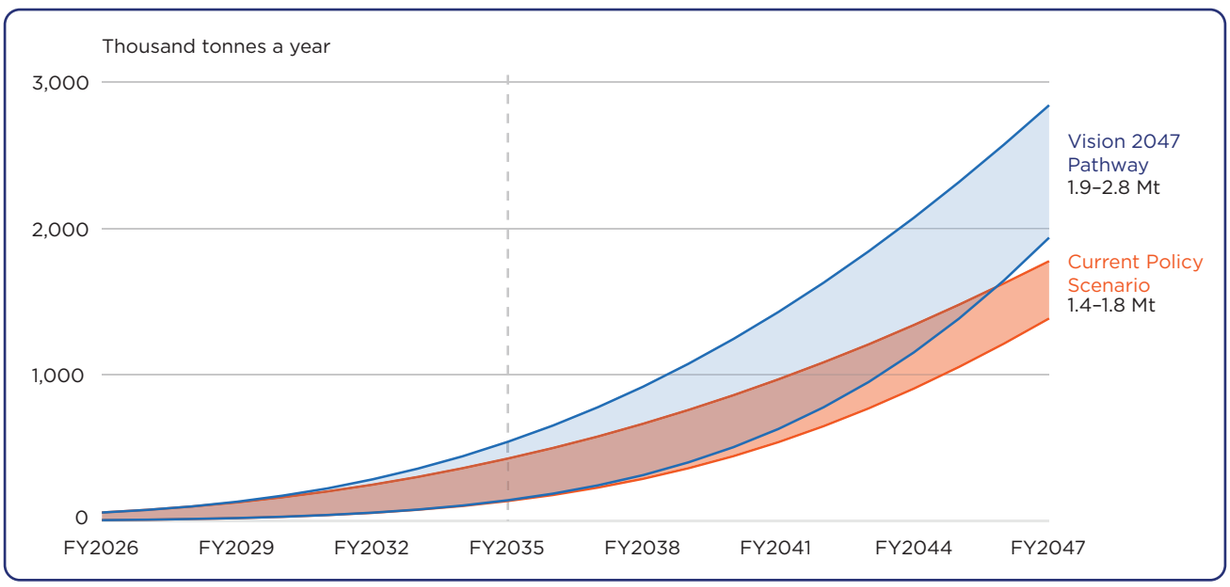
7. Sustainability and Circularity

A solar industry built for 2047 should be clean in how it makes panels and responsible for them at the end of their life. Because most of the solar value chain is still being built, now is the time to build it in.

Clean power for solar PV manufacturing plants. Polysilicon uses more energy than any other stage. Many Indian solar manufacturers already run their plants partly on renewable power. Extending this to energy-intensive polysilicon, wafer and cell plants, supported by easier access to green power through open access, captive plants and round-the-clock renewable supply, will give Indian panels a much lower carbon footprint, which buyers at home and abroad increasingly value.

A new source of materials. As panels reach the end of their life, ISMA estimates that the volume retired each year will reach about 1.4 to 2.8 million tonnes by 2047 (Figure 7.1). Manufacturers already register and store retired panels under the E-Waste (Management) Rules, and the recycling rules that follow will shape a new industry.

Figure 7.1: Solar Panels Retired Each Year

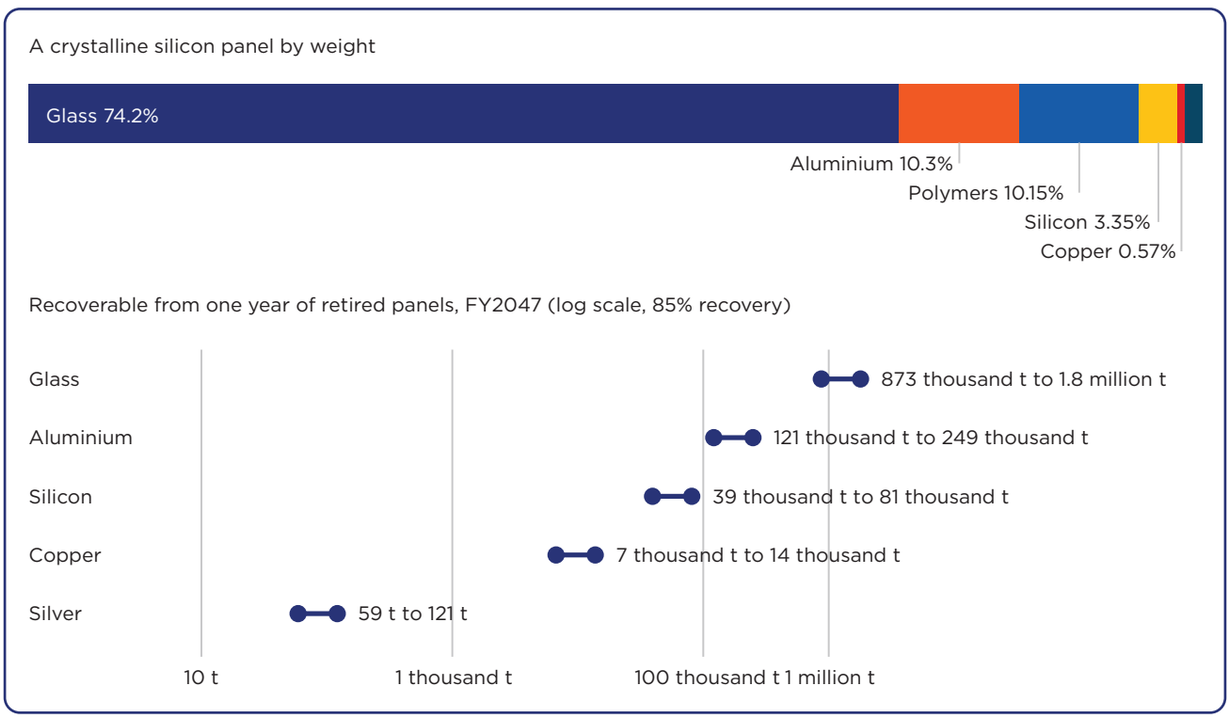


Source: MNRE; ISMA estimates.



Old panels, new materials. Glass and aluminium make up most of a panel's weight, while silicon and silver are small in volume but valuable. Recovered well, retired panels can return up to about 1.8 million tonnes of glass and 80,000 tonnes of silicon in 2047 alone, all of which can go back to Indian solar PV manufacturing plants (Figure 7.2).

Figure 7.2: Materials Recoverable from Retired Panels



Source: *MNRE; IEA†; ISMA estimates.*



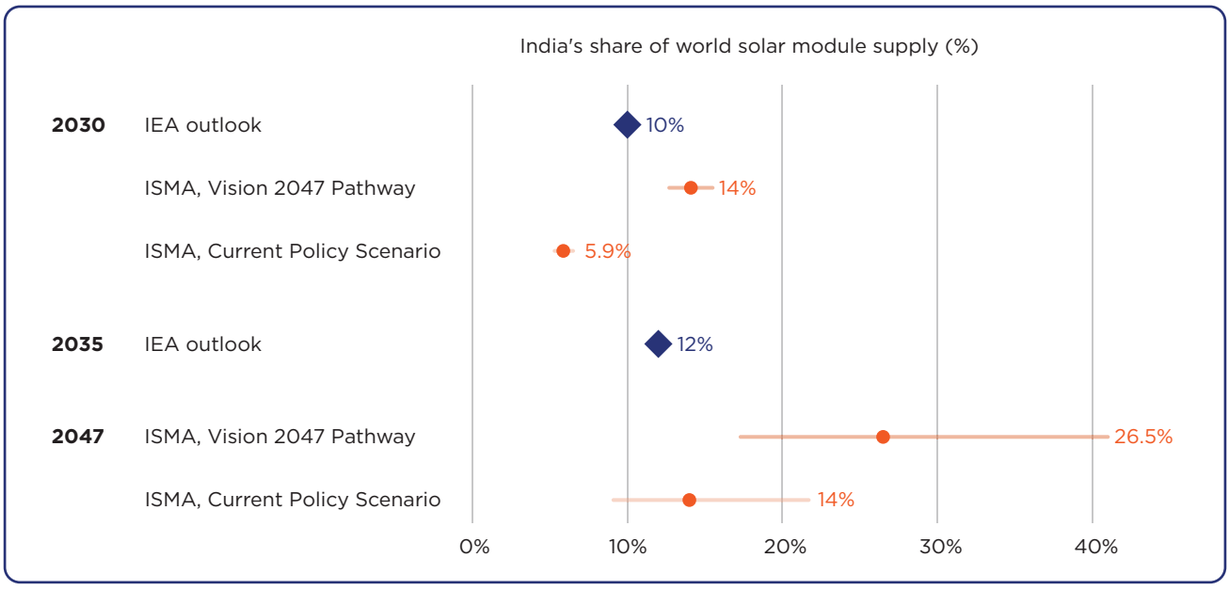
8. India's Global Position

India is one of the world's largest and fastest-growing solar markets, and the Government counts it among the world's leading solar manufacturers (MNRE). Each new stage India adds increases its weight in the global solar value chain.

A large home market. India is among the world's biggest and fastest-growing markets for new solar, adding about 54 GW DC in 2025 (IEA PVPS†). ISMA estimates that if the programmes behind this vision are delivered in full, India would add about 200 GW DC a year by 2047, nearly four times its 2025 level. Demand on this scale gives Indian solar PV manufacturing plants a large, steady market at home to build on, before a single panel is sold abroad.

A trusted, growing supplier. The IEA expects India's share of world module supply to keep rising, with India becoming a net exporter of modules. ISMA expects, India's share to run ahead of that outlook and reach about a quarter of the world supply by 2047 (Figure 8.1). As cells, wafers and polysilicon come home, India becomes a reliable supplier at those stages too, with about a tenth of output at every stage finding buyers abroad by 2047 (section 5.5).

Figure 8.1: India's Share of World Solar Module Supply



Source: *IEA†; IEA PVPS†; ISMA estimates*

9. The Way Forward

India built a solar manufacturing industry of national scale in under a decade. The next phase is about depth: making the cell, the wafer and the polysilicon inside every Indian panel, while demand for those panels keeps rising.

Table 9.1: Key Indicators, Today and 2047

	Today	2047, Vision 2047 Pathway
Solar installed	171 GW	2,275 GW
Modules	233+ GW	3,484 GW
Cells	50+ GW	3,128 GW
Ingots and wafers	3+ GW	2,630 GW
Polysilicon	Plants under construction	2,200 GW
Manufacturing jobs (direct + indirect)	4.0 lakh	32.3 lakh
Stages made at scale	Modules and cells	All four, from polysilicon to module

On this pathway, India installs many times more solar; its solar PV manufacturing plants employ many more people, and almost all of the value of each panel stays in the country. Six priorities stand out:

1. **Keep dates steady.** Clear dates on the approved list have given investors the confidence to build. Holding them and setting a path for polysilicon early sends the strongest signal.
2. **Deliver demand in full.** Delivering green hydrogen, storage, transmission, and the rooftop and farm schemes in full is what separates the two pathways. Steady programmes turn new solar PV manufacturing plants into a lasting industry.
3. **Keep polysilicon in step.** Polysilicon completes the chain. Building it in step with the wafer plants after 2030 brings every stage home by the middle of the next decade.
4. **Connect research to solar PV manufacturing plants.** India is already strong in testing. Public pilot lines and engineers trained for wafer and polysilicon plants would keep Indian PV manufacturing plants competitive as technology changes.
5. **Build clean and circular.** Renewable power for solar PV manufacturing plants gives Indian panels a lower carbon footprint, and early recycling rules turn retired panels into a source of materials.
6. **Open new markets.** Indian panels have earned a place with buyers abroad, but exports have fallen sharply after trade and geopolitical shocks in India's key export markets. A wider and more diverse base of overseas customers would give Indian plants steadier earnings, larger scale and less exposure to any single market.

The approach that built the first stages, assured demand first and solar PV manufacturing plants after, will complete the chain. With continuity in policy, India will make every part of the panels it installs within the next decade and be among the world's most trusted solar suppliers by 2047.

Partnering for the Next Stage

Industry and Government built the foundation of the chain together, with policy setting the direction and solar PV manufacturing plants following. The same partnership can complete it. ISMA proposes ten areas for joint work:

- **Polysilicon:** A dedicated support scheme with an indicative ALMM date.
- **ALMM sequencing:** Hold the List-II and List-III dates, and publish installed manufacturing capacity at every stage on a regular basis.
- **Power for upstream plants:** Support for round-the-clock renewable power for polysilicon, wafer and cell plants through green open access, transmission-charge relief and banking.
- **Duty structure:** Concessional duty on capital goods, spares and process inputs not yet made in India, and a review of duties on upstream inputs.
- **Ancillaries:** Bring glass, frames, encapsulants, backsheets and junction boxes under the same assured demand and quality orders as cells and panels.
- **Indian-made equipment:** A programme to design and build production tools for cell and wafer lines in India.
- **Skills:** Process-technician courses for cell, wafer and polysilicon plants, built with industry and certified to industry standards.
- **Markets:** Export credit, traceability and certification support, and market access through trade agreements.
- **Recycling:** Practical recycling and recovery guidelines for retired panels under the E-Waste Rules, ready before the storage period ends in 2034-35.

Industry brings its part: Industry is ready to do its part: building plants on schedule, investing in each new stage as its approved list takes effect, training young Indians through shop-floor apprenticeships, and sharing data openly with Government so progress can be tracked together. ISMA looks forward to working hand in hand with Government to turn these proposals into a shared plan, and to building, together, a solar manufacturing ecosystem complimenting the vision of Viksit Bharat by 2047.

Appendix A. Official Sources

Government of India

- Press Information Bureau (PIB)
- Ministry of New and Renewable Energy (MNRE)
- Lok Sabha and Rajya Sabha
- Union Cabinet
- Ministry of Finance
- Ministry of Power
- Ministry of Environment, Forest and Climate Change (MoEFCC)
- Directorate General of Commercial Intelligence and Statistics (DGCI&S)
- Directorate General of Trade Remedies (DGTR)
- Gazette of India
- NITI Aayog
- Central Electricity Authority (CEA)
- Central Pollution Control Board (CPCB)
- National Institute of Solar Energy (NISE)
- Solar Energy Corporation of India (SECI)

International official sources

- International Energy Agency (IEA) and its PV Power Systems Programme (IEA PVPS)†
- International Renewable Energy Agency (IRENA)†
- European Commission Joint Research Centre (EC JRC)†
- US Department of Energy (DOE)†
- US International Trade Administration and US International Trade Commission†
- US Geological Survey (USGS)†

Estimates and projections are by ISMA; the methods are set out in Appendix B. Each figure caption names the sources it draws on.

† Intergovernmental or foreign official source.

Appendix B. Methodology and Forecasting Approach

B1. Scope, Conventions and Methods

This appendix sets out how each forecast and estimate in the report was produced. Four kinds of numbers appear in the report. Official reported data come directly from Government or intergovernmental sources, such as installed capacity and listed manufacturing capacity. Calculated values follow from those data through a stated equation. Modelled estimates come from ISMA's model under stated assumptions. Scenario outcomes describe what happens on the Current Policy Scenario or the Vision 2047 Pathway; they are not targets or predictions. Financial years run April to March. Installed capacity is in GW AC; manufacturing capacity is in GW DC; polysilicon is in the GW-equivalent of wafers or in tonnes.

The forecasts use standard, transparent methods. Installed solar comes from a demand-driven stock-flow model: electricity demand grows from the FY2026 official base, new uses are added once each, solar's share of that electricity is converted into panels, and capacity is built year by year with 25-year replacements. Manufacturing capacity follows a stage-by-stage material balance from modules back to cells, wafers and polysilicon, with upstream build-up following a logistic S-curve set to international build times and checked against the Government's 2030 goals. Investment is new capacity multiplied by official unit plant costs (US DOE†, adjusted with IEA† cost ratios and checked against PLI Tranche-II awards). Jobs are jobs per gigawatt at each stage, anchored to the PLI benchmark of 3,000 direct jobs per integrated GW, with 1.9 indirect jobs for each direct job. The import bill is a net material balance at each stage priced at IRENA† landed costs. Retired panels follow a Weibull failure model by installation year, and recoverable materials apply panel composition and an 85% recovery rate.

B2. Key Assumptions

- **DC/AC ratio and utilisation.** The ratio of 1.25 and the plant utilisation rates are ISMA assumptions, not official figures. They drive every manufacturing estimate.
- **Exports.** The manufacturing, investment, and jobs estimates use the model's export share.
- **Annual paths.** The trade and waste estimates use straight lines between the installation model's milestone years.
- **Jobs.** Jobs per GW rise in a straight line from today's staffing in FY2026 to about 2,930 direct jobs per integrated GW in 2047, close to the PLI Tranche-I figure of 3,000; indirect jobs use the PLI Tranche-II ratio of 1.9 for every direct job. Jobs in the current policy scenario are not estimated.
- **Prices.** Investment is at constant FY2026 prices, at ₹87 per USD. Projected trade is at constant 2025 prices; past trade uses the USD values published by DGCI&S, which convert each year at that year's exchange rate.
- **Data.** Official series by stage are not yet published for production, for jobs in encapsulants, backsheets, cables and connectors, or for plant energy, water and scrap; the estimates will be refreshed as they become available.
- **Global shares.** No official source gives world module production after 2025, so India's 2030 and 2047 shares rest on an assumed growth in world demand and are illustrations, not forecasts.




Designed by : Madre Designing (www.madredesigning.com)



Office Address: 2nd Floor, We Work Eldeco Centre, New Delhi - 110017
Email: sg@isma.solar | www.isma.solar

adani Solar | alpex POWER FOREVER | EMMVEE | First Solar. | Grew solar | JAKSON SOLAR

JUPITER | Premier Energies | Reliance Industries Limited | ReNew SOLAR PANELS | RenewSys let there be light | TATA POWER SOLAR