सत्यमेव जयते

NITI Aayog

Report on Key Sectors to Position India as a GLOBAL MANUFACTURING HUB

Volume-1

AUGUST 2026

GMH Report

Volume - I

Crisil has received financial assistance under the Research Scheme of NITI Aayog (RSNA) to prepare this report. While due care has been exercised to prepare this report using data from various sources, NITI Aayog does not confirm the authenticity of data and accuracy of the methodology to prepare the report. NITI Aayog shall not be held responsible for findings or opinions expressed in the document.
That responsibility rests completely with Crisil.

Message from the Vice Chairman

Ashok Kumar Lahiri

Vice Chairman, NITI Aayog

"India stands at a defining moment in its economic and industrial journey. As the nation moves forward with the vision of Viksit Bharat @2047, manufacturing will play a central role in shaping the country's future growth trajectory. Across the world, the experience of every major industrial economy has demonstrated that sustained economic transformation is built on a strong and globally competitive manufacturing base. Manufacturing not only drives investment, innovation and exports, but also creates quality employment, raises productivity and strengthens linkages across multiple sectors of the economy. For a country like India, with a young workforce and a median age of around 28 years, a vibrant manufacturing sector offers the most effective pathway to harnessing its demographic dividend and translating it into broad-based and inclusive prosperity.

At the same time, the experience of recent decades reminds us that considerable work remains ahead. India's manufacturing sector today accounts for nearly 17 percent of Gross Value Added, a share that has remained broadly stable over the past two decades. During the same period, several economies have significantly expanded their manufacturing capabilities and strengthened their integration with global value chains. China's share in global manufacturing value added increased from about 5 percent in 1995 to nearly 32 percent in 2023, while India's share increased from about 1.5 percent to 3.2 percent. Likewise, countries such as the Republic of Korea and Vietnam have demonstrated how sustained policy support, technological advancement, investment in industrial capabilities and deeper integration with global production networks can transform national competitiveness. These experiences should not be viewed as a measure of India's limitations, but rather as a reminder of the scale of opportunity before us and the importance of pursuing long-term, coordinated and consistent reforms.

This report, prepared in collaboration with Crisil Intelligence, represents a structured endeavour to convert national ambition into a disciplined, evidence-based roadmap. From an initial universe of 62 sectors, a transparent relative-attractiveness methodology has identified twelve in which India can realistically aspire to global leadership: Electronics, Telecom Equipment, Solar PV, Pharmaceuticals, Chemicals, Automobiles, Defence and Drones, Steel, Capital Goods, Textiles, Food Processing, and Leather and Footwear. Each has been examined through the lenses of strategic alignment, financial viability, and value-chain positioning, and benchmarked against the nations that have achieved demonstrable excellence in the respective domain. The intent throughout has been to ground aspiration in analytical rigor, so that the choices before us rest on evidence rather than on assertion.

The common thread running through all twelve sectors is the recognition that India's manufacturing ambitions must extend beyond expanding production alone. The country must progressively move up the value chain, build globally competitive enterprises, strengthen domestic capabilities in advanced manufacturing, and integrate more deeply into global production networks. Self-reliance, export competitiveness, technological leadership and employment generation are not competing priorities; rather, they reinforce one another and together form the foundation of a resilient, competitive and future-ready manufacturing economy.

Realising this vision will require sustained collaboration between the Union and State Governments, industry, academia, financial institutions and the wider innovation ecosystem. It will also require policy continuity, institutional coordination and a shared commitment to strengthening India's manufacturing capabilities over the long term. I am confident that this study will serve as a valuable resource for policymakers, industry leaders, investors and researchers, and will contribute meaningfully to informed policy formulation and effective decision-making. I trust that the analysis and recommendations presented in this report will support informed policymaking and contribute to strengthening India's manufacturing competitiveness and enhancing its participation in global value chains."

Message from the CEO

Nidhi Chhibber

CEO, NITI Aayog

"A strategic roadmap is meaningful only if it provides a basis for informed decision-making and effective implementation. This report has therefore been prepared not merely as an assessment of India's manufacturing landscape, but as a framework for identifying the sectors that should receive strategic attention and the interventions required to strengthen their competitiveness. It examines each sector through the lens of India's comparative advantages, emerging global opportunities and existing structural constraints. The objective is to support evidence-based prioritisation, so that policy efforts, public investment and private capital are directed towards areas that offer the greatest potential for enhancing productivity, expanding manufacturing capabilities, creating employment and increasing India's participation in global value chains. In doing so, the report seeks to move the discussion from broad strategic intent to a more focused and implementable sectoral roadmap.

The report is underpinned by a rigorous and evidence-based methodology. Rather than beginning with a predetermined set of priority sectors, it adopts a systematic approach to sectoral assessment, evaluating a broad universe of manufacturing sectors before identifying those with the greatest strategic potential. The shortlisted sectors are subsequently examined through the lens of strategic relevance, competitiveness and value chain opportunities, with the findings further validated through benchmarking against global best practices and extensive stakeholder consultations. This integrated approach ensures that the recommendations are grounded in robust analysis, informed by international experience and aligned with industry realities.

The report also recognizes that India's manufacturing ambitions will depend not only on leveraging its strengths but also on addressing persistent structural constraints. High logistics costs, gaps in infrastructure and power reliability, the predominance of MSMEs with limited access to technology and finance, and an export basket concentrated in relatively low value-added products continue to affect the competitiveness of Indian manufacturing. While significant progress has been made through initiatives such as the Goods and Services Tax (GST), Make in India, the Production Linked Incentive (PLI) Schemes, PM Gati Shakti and the India Semiconductor Mission, the next phase of reforms will require more targeted, sector-specific interventions. This report seeks to identify those priorities and provide a roadmap for the actions needed across different sectors.

Given the breadth and diversity of India's manufacturing landscape, the study has been structured as a series of sectoral volumes to allow for a more detailed examination of each priority area. The present volume marks the beginning of this effort. I would like to place on record my appreciation for the team at NITI Aayog and our knowledge partner, Crisil Intelligence, for the analytical rigor and commitment that have gone into the preparation of this report. I hope that the analysis and recommendations presented here will contribute meaningfully to informed policy discussions and support the decisions needed to strengthen India's manufacturing competitiveness in the years ahead."

Message from the Programme Director

Ishtiyaque Ahmed

Programme Director – Industry and Foreign Investment, NITI Aayog

"The global manufacturing landscape is undergoing a period of rapid transformation as firms diversify their supply chains, reduce dependence on any single geography, and seek stable and competitive manufacturing locations to serve global markets. These developments have created a significant opportunity for countries that are able to strengthen their manufacturing capabilities and integrate more deeply into global value chains. For India, this opportunity coincides with a period of strong policy momentum, a maturing industrial base, and a demographic profile well suited to expanding manufacturing employment.

A study of this nature is therefore both timely and necessary. This report is the outcome of extensive work by NITI Aayog, in collaboration with Crisil Intelligence, to identify the manufacturing sectors that offer the maximum potential to drive India's manufacturing growth, strengthen its participation in global value chains, and generate employment. It seeks to support informed policy choices by identifying sectors where focused interventions can have the significant impact.

The study followed a structured four-phase approach. Phase 1 narrowed the field from an initial 62 sectors to twelve through a four-parameter relative attractiveness framework comprising domestic and global market size, together with domestic and global growth projections up to FY30, mapped on a market size-growth matrix. Phase 2 involved a detailed assessment of each shortlisted sector across three dimensions: strategic alignment, operational and financial viability, and value chain play. The analysis examined raw material dependencies, geopolitical considerations, profitability, capital intensity, and India's current position within global value chains. Phase 3 benchmarked each sector against two leading manufacturing nations to identify relevant lessons on policy, technology and industrial development. Phase 4 integrated these findings with extensive industry consultations, combining insights from secondary research, international best practices and stakeholder feedback to develop recommendations centred on identified challenges, targeted interventions and implementation strategies.

Twelve sectors have been identified. The analysis has been tailored to reflect the specific requirements and growth drivers of each sector. For every sector, the objective has remained consistent: to move beyond assessing the current situation and develop practical, evidence-based recommendations for strengthening India's manufacturing competitiveness. The recommendations seek to address the underlying structural constraints affecting each sector while identifying the policy measures, institutional reforms, infrastructure requirements and investment incentives necessary to unlock future growth.

The report will be released in three volumes. This volume presents a sectoral analysis along with detailed reports on the Chemicals, Textiles, Solar PV Manufacturing, and Telecom & Networking Products sectors.

I hope that the depth of analysis presented in this report will serve as a valuable resource for policymakers, industry leaders, researchers, and other stakeholders working towards advancing India's manufacturing ambitions."

Acknowledgements

The Report on Key Sectors to Position India as a Global Manufacturing Hub represents the culmination of a collaborative effort involving CRISIL, the knowledge partner, and the team of the Industry & Foreign Investment Division, NITI Aayog. The report has been shaped through extensive research, stakeholder consultations and deliberations, with the objective of identifying opportunities and addressing key constraints to strengthen India's manufacturing capabilities and global competitiveness.

I express my sincere gratitude to the Hon'ble Vice Chairman, NITI Aayog, for his leadership and valuable guidance, and to Dr. Arvind Virmani, Hon'ble former Member, NITI Aayog, for his insightful suggestions. I also acknowledge the valuable guidance and direction provided by the CEO, NITI Aayog, throughout the course of this exercise.

The report has drawn considerably from the expertise and active engagement of the concerned Ministries and Departments of the Government of India. I gratefully acknowledge the valuable inputs received from the Ministry of Textiles, Ministry of Steel, Ministry of New and Renewable Energy, Ministry of Heavy Industries, Ministry of Electronics and Information Technology, Ministry of Defence, Ministry of Communications, Ministry of Chemicals and Fertilizers, Department of Pharmaceuticals, Department for Promotion of Industry and Internal Trade (DPIIT), and Ministry of Food Processing Industries. Their sectoral perspectives and constructive feedback have been important in strengthening the analysis and ensuring that the recommendations remain relevant to the evolving needs of Indian industry.

I also place on record my appreciation for the industry representatives, experts and practitioners who participated in the consultations undertaken as part of this exercise. Their first-hand understanding of market developments, global trends, emerging opportunities and implementation challenges has added significant depth to the report and helped bring an industry perspective to the recommendations.

I would particularly like to acknowledge the contribution of the CRISIL team, especially Mr. Pushan Sharma, Mr. Mohit Adnani, Mr. Jyotish Menon, and the sectoral experts associated with the study. Their analytical rigour and technical expertise have been valuable in undertaking the sectoral assessment and developing a comprehensive understanding of the opportunities for India to strengthen its presence across global manufacturing value chains.

I sincerely appreciate the dedicated efforts of the Industry & Foreign Investment Division, NITI Aayog. The team led by Shri Upendra Kumar Gupta, Deputy Adviser, comprising Shri Abhishek Mukherjee, Research Officer, and Ms. Pragya Bajpai, Young Professional, has contributed through sustained research, analysis, stakeholder coordination and consultations throughout the project.

For Volume I, covering the Chemicals, Textiles, Solar PV and Telecom sectors, I would also like to acknowledge the valuable contributions of Ms. Vamakshi, Shri Bhadraksh Bhargava and Ms. Vrushali Lokhande, young professionals of the Division. Their sector-specific research, analytical inputs and sustained efforts have played an important role in shaping this volume and bringing together the insights and recommendations presented herein.

I hope that this Report will serve as a useful reference for policymakers, industry and other stakeholders in strengthening India's manufacturing ecosystem, enhancing competitiveness and enabling greater integration with global value chains.

Ishtiyaque Ahmed
Programme Director (Industry & Foreign Investment)
NITI Aayog

List of abbreviations

ADD	Anti-Dumping Duty
API	Active Pharmaceutical Ingredient
ASEAN	Association of Southeast Asian Nations
BCD	Basic Customs Duty
BIS	Bureau of Indian Standards
BOM	Bill of Materials
CAGR	Compound Annual Growth Rate
CEPA	Comprehensive Economic Partnership Agreement
CPDS	Chemical Promotion Development Scheme
CPVC	Chlorinated Polyvinyl Chloride
DGFT	Directorate General of Foreign Trade
DoT	Department of Telecommunications
EBITDA	Earnings Before Interest, Tax, Depreciation and Amortisation
EPZ	Export Processing Zone
FDI	Foreign Direct Investment
FTA	Free Trade Agreement
GDP	Gross Domestic Product
GPON	Gigabit Passive Optical Network
GVA	Gross Value Added
GVC	Global Value Chain
HJT	Heterojunction Technology
HSN	Harmonised System of Nomenclature
IC	Integrated Circuit
IoT	Internet of Things
KTPA	Kilo Tonnes Per Annum
MEG	Mono Ethylene Glycol
MMF	Man-Made Fibre
MMTA	Million Metric Tonnes Per Annum
MSME	Micro, Small and Medium Enterprise
OEM	Original Equipment Manufacturer
OFC	Optical Fibre Cable
PCPIR	Petroleum, Chemicals and Petrochemicals Investment Region
PE	Polyethylene
PET	Polyethylene Terephthalate
PLI	Production Linked Incentive
PP	Polypropylene

PTA	Purified Terephthalic Acid
PVC	Polyvinyl Chloride
PV	Photovoltaic
QCO	Quality Control Order
R&D	Research and Development
RAN	Radio Access Network
RCEP	Regional Comprehensive Economic Partnership
RMG	Ready-Made Garments
ROCE	Return on Capital Employed
SEZ	Special Economic Zone
SME	Small and Medium Enterprise
SPV	Special Purpose Vehicle
T&A	Textile and Apparel
TANE	Telecom and Network Equipment
TOPCon	Tunnel Oxide Passivated Contact
VGF	Viability Gap Funding
WTO	World Trade Organization

List of tables

Contents

Objective of the study

India's journey towards becoming a USD 30 trillion economy by 2047 will require the manufacturing sector to play a critical role in this transformation. Currently, manufacturing accounts for 17.5% of the country's gross value added (GVA), with the Indian government having set out a target to increase this share. As a major employment generator, the sector supported 1.85 crore jobs in fiscal 2022, making it crucial for a youthful India where the average age is currently ~28 years. To translate this demographic profile into broad-based prosperity, the share of manufacturing in gross domestic product (GDP) needs to rise. Manufacturing can absorb labour at scale across diverse skill levels, create stable and formal jobs, and lift productivity through better processes and technologies.

Manufacturing expands employment by establishing large, formal operations and deep supplier networks that create roles across production, quality, maintenance, logistics, and business services; capacity additions bring structured hiring and skilling pathways that move workers into higher-productivity positions. By standardizing processes, investing in equipment and automation, and achieving scale efficiencies, firms raise value added per worker—broadening income through export participation and stronger domestic linkages, and thereby supporting gains in per capita GDP. Continuous product and process development on the shop floor—underpinned by advances in design, tooling, and digital and advanced manufacturing technologies—and supplier development within clusters foster R&D and innovation, accelerating technology diffusion and capability building across the ecosystem. In India, a robust manufacturing sector is essential for enhancing the country's competitiveness in global markets. It plays a vital role in increasing exports and reducing reliance on imports, thereby contributing to a favorable trade balance. The Indian government has recognized the importance of manufacturing and aimed to improve India's manufacturing competitiveness with a host of measures outlined in the later section, with the aim to transform the country into a global manufacturing hub. By strengthening manufacturing capabilities, India can achieve sustainable economic growth and improve its position in the global supply chain.

This study aimed to identify key sectors that can elevate India to the status of a global manufacturing hub by 2047, focusing on domestic and global market opportunities, future growth outlook, as well as competitiveness and employment intensity, all in alignment with national growth priorities. The objective of the analysis was to provide a strategic roadmap, offering actionable recommendations to position India at the forefront of global manufacturing in the identified sectors. Before delving into the shortlisted 12 manufacturing sectors, it is essential to understand the evolution of manufacturing through the ages. The first industrial revolution marked a significant shift with the introduction of mechanization and steam power, fundamentally changing production processes. This was followed by the second industrial revolution, characterized by mass production and the advent of electricity, which further transformed manufacturing capabilities. While the third and fourth industrial revolutions have introduced digital technologies and automation, respectively, it is crucial to analyze how these historical developments have shaped contemporary manufacturing landscapes. Additionally, we will examine case studies of manufacturing booms in countries like Vietnam, China, and Japan, which provide valuable insights into successful strategies and practices that can inform India's potential as a global manufacturing hub.

Manufacturing through the ages – a global perspective

The First Industrial Revolution

The First Industrial Revolution, which began in Great Britain around 1760, marked a fundamental turning point in the history of manufacturing. It represented the shift from small-scale, manual craftsmanship to mechanized, factory-based production. For the first time, goods could be produced on a mass scale, drastically reducing costs and increasing availability. This also led to a reorganization of labor: skilled artisans gave way to a growing workforce of semi-skilled factory workers, laying the foundation for the modern factory system. Importantly, this era established key principles—like mechanization, centralized production, and specialization of labor—that still define manufacturing processes today. This process began in Britain in the 18th century and from there spread to other parts of the world.

The technological advancements included the following:

- The introduction of new raw materials, primarily iron and steel
- The utilization of novel energy sources, including coal and steam power
- The development of innovative machinery, such as the spinning jenny and power loom, which enhanced productivity while reducing manual labor
- The establishment of the factory system, marked by increased division of labor and specialization
- The growing application of scientific principles to industrial practices.

The period also witnessed significant developments in the non-industrial sphere**:**

- Improved agricultural techniques increased food production, supporting a larger non-agricultural population
- Industrial production overtook landownership as the primary source of wealth, leading to a broader distribution of wealth and growth in international trade
- Shifts in economic power led to political changes and new state policies suited to an industrialized society
- Urbanization accelerated, working-class movements emerged, and new social structures and power dynamics developed
- Workers transitioned from skilled handcraft to machine operation, adapting to the discipline and routines of factory life

A new psychological outlook took hold, marked by growing confidence in the ability to utilize resources efficiently.

The Second Industrial Revolution

Although there was significant overlap with earlier industrial developments, the late 19th and 20th centuries marked the emergence of a distinctly new phase of the Industrial Revolution. The innovations of the Second Industrial Revolution brought about profound changes in manufacturing, transportation, communications, and ways of life and leisure. Some of the most significant inventions include:

Internal combustion engine: Developed by German engineer Nicolaus Otto in 1876, this engine utilized gasoline fuel derived from petroleum, leading to the invention of automobiles and airplanes.

Automobile: Karl Benz incorporated the internal combustion engine into the first automobile in 1886. This innovation was further perfected by Henry Ford with the launch of the Ford Model T in 1908, making automobiles accessible to the masses.

Airplane: The Wright brothers achieved the first sustained flight with a powered aircraft in 1903, revolutionizing air travel and transportation.

Telegraph: Although invented earlier, the telegraph became widely used for transmitting coded messages over long distances, thanks to Samuel Morse's system, which gained popularity in the late 19th century.

Radio: The discovery of electromagnetic waves by Heinrich Hertz in 1887 led to the wireless telegraph and the development of radio by Guillermo Marconi in the early 20th century.

Telephone: Patented by Alexander Graham Bell in 1876, the telephone revolutionized communication and became widely used in the 20th century.

Electric light bulb: Thomas Edison invented a carbon-filament incandescent lamp in 1879, which proved essential for public and domestic lighting, replacing kerosene lamps.

There was a significant shift in the ownership of means of production. Initially, ownership was concentrated among a small elite in the 19th century, but later, it became more dispersed as individuals and institutions, such as insurance companies, began to purchase common stocks. In the first half of the 20th century, many European countries nationalized key sectors of their economies. Additionally, there was a change in political ideologies, with governments moving away from *laissez-faire* policies (free market policy) and becoming more involved in addressing the social and economic needs of their increasingly complex industrial societies. However, this trend was reversed in the US and UK starting in the 1980s, with a shift back towards more free-market oriented policies.

Japan’s miraculous industrial boom

Since World War II, Japan's economic growth has been characterized by the remarkable development of its manufacturing sector, marked by significant advancements in quantity, quality, variety, and efficiency. The country's industrial focus has shifted from light to heavy industries, with a greater emphasis on processing, leading to a decline in the relative importance of traditional industries such as lumber and wood processing, textiles, and food.

Japan has established itself as a leading global manufacturer, with a strong presence in shipbuilding and automotive production, as well as the production of essential materials like crude steel, synthetic rubber, aluminium, and plastics. The country is home to some of the world's most advanced and largest industrial facilities and has experienced rapid growth in the production of motor vehicles, iron and steel, machinery, and precision equipment, including cameras. In recent decades, Japan has also become renowned for its production of advanced electronic products, including computers, microelectronics, telecommunications equipment, and consumer goods.

The driving force behind Japan's post-war industrial success has been the high level of capital investment, particularly during the 1960s and 1970s. A surge in equipment investment created a rapidly expanding domestic market for the iron and steel, and machine-building industries, enabling a significant increase in productive capacity and scale of operations. This, in turn, led to the rapid replacement of outdated machinery, resulting in substantial improvements in productivity across the economy. Despite facing challenges such as a shortage of skilled labor and rising wages, Japan's manufacturing sector has continued to thrive, thanks in part to the widespread adoption of technological innovations and superior production systems. The country's exports have experienced significant growth, and the establishment of overseas facilities in Asia, North America, and Europe has helped to reduce trade friction and cut costs, particularly for manufacturers of automobiles and advanced electronic products.

China’s manufacturing surge

China's remarkable rise as a global manufacturing leader has been swift and unprecedented. Having ranked seventh in the world, behind Italy, as recently as 1980, China surpassed the United States in 2011 to become the world's largest manufacturer of goods. This significant growth has had a profound impact on the country's economy, with GDP per capita doubling over the decade from 2000-2010, a feat that took the UK 150 years to achieve during its own industrialization process.

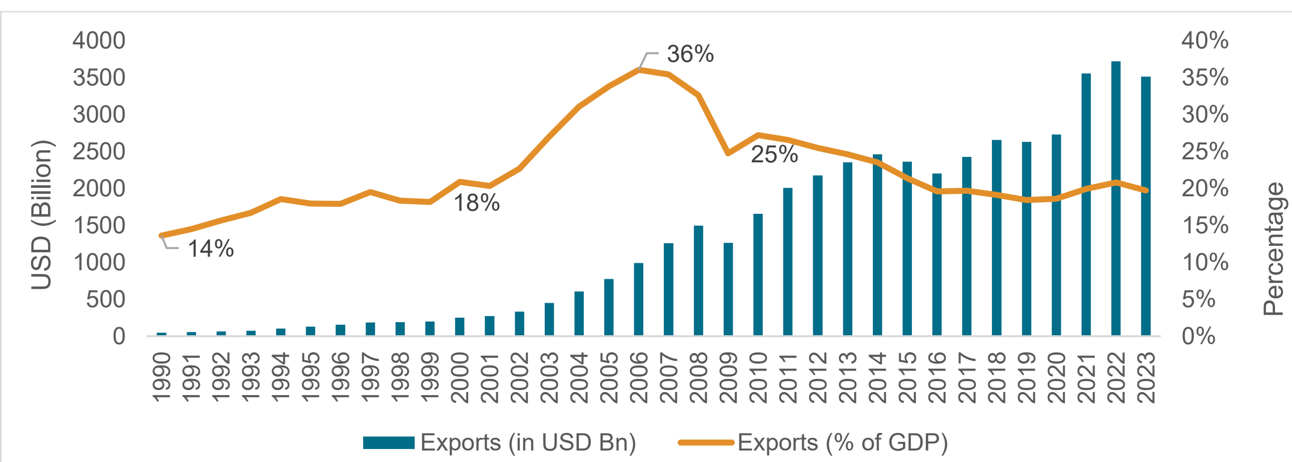
Between 2000 and 2007, China's export sector experienced rapid growth, with the value of exports increasing more than fourfold. As a result, exports as a percentage of GDP rose significantly, from 20% to 35%. As China transformed into a factory for the world, the Chinese economy was aided by its export-driven focus. This strong focus on manufacturing driven exports is reflected in the current account surplus, which surged from less than 2% of GDP to a peak of 10%, closely mirroring the expansion of the trade surplus.

A number of policies and incentives with a focus on state-owned enterprises (SOEs) and labour specific policies drove China’s manufacturing boom in the 2000s. The government provided subsidies to manufacturing firms, especially for entry into new capacity, for production, and for investment. Further, governments (central + provincial) provided indirect subsidies (e.g., cheap land, favorable financing) that reduced the cost of setting up manufacturing capacity.

The Chinese government did not privatize all SOEs; rather, it followed a strategy of “grasping the large, letting go of the small” — keeping big SOEs in strategic sectors but letting small uncompetitive SOEs go or be privatized. SOEs received direct fiscal support: many loss-making SOEs continued to get budgetary transfers, particularly during the early 2000s. There was a shift from requiring SOEs to hand over all profits (“profits remittance”) to a more profit- and tax-based regime: SOEs started to pay income tax instead of just being forced to remit profits to the state (“substituting taxes for profits”). On the financing side, SOEs benefited from low-cost capital via state-owned banks, subsidized lending, and preferred access to credit. (Implicit in broader SOE-state relationship.) SOEs were also used by the state as “national champions” in strategic industries (heavy manufacturing, infrastructure, energy), leveraging their scale and access to finance to build capacity.

As a testament to its manufacturing prowess, China currently accounts for over 50% of global manufacturing output in many sectors. This dominance in various sectors underscores China's critical role in global supply chains and its status as a leading manufacturing hub.

Figure 1: China’s exports over the years



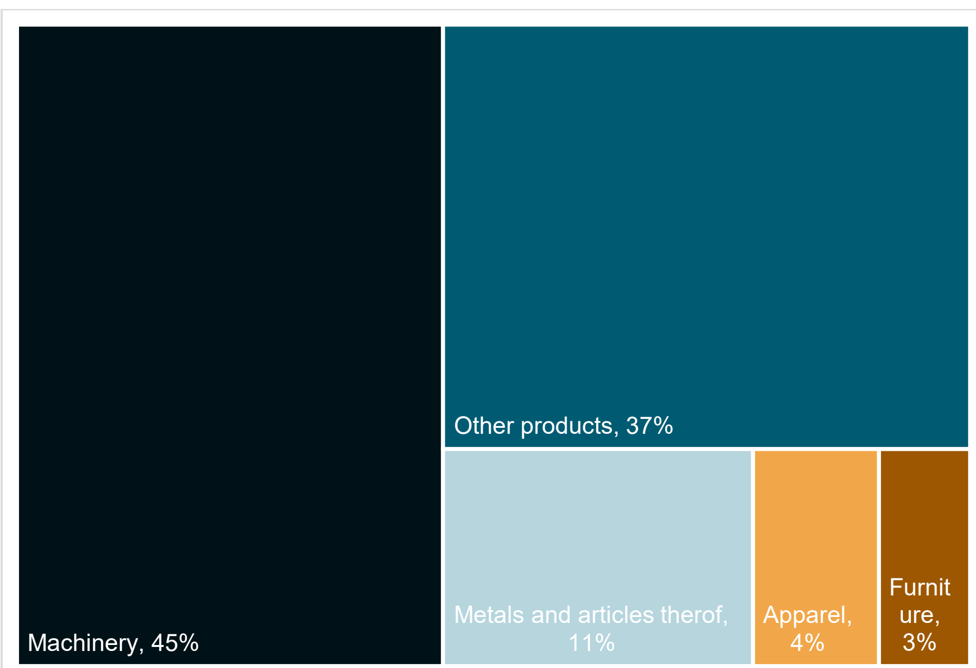
Source: World Bank

During the period from 2000 to 2010, China's exports as a percentage of GDP peaked at around 36%. However, in the following years, this percentage began to decline gradually driven by the Chinese government shifting its focus towards promoting domestic consumption and sustainable economic growth, aiming to reduce reliance on exports. Rising per capita incomes in China also led to a consumption boom improving the share of domestic consumption in China. Additionally, rising labor costs, increasing competition from other emerging markets, and trade tensions with key partners led to a reevaluation of China's export-driven model. As a result, the economy began to transition towards a more balanced approach, emphasizing domestic demand and innovation while still maintaining a significant role in global trade.

The surge in exports was driven by the country's rapid integration into the global economy, competitive manufacturing capabilities, and a strong focus on export-oriented growth. The increase in exports significantly benefited China's local economy by driving job creation and increasing income levels, which, in turn, fueled domestic consumption. Higher exports also contributed to the country's trade surplus, providing the government with additional resources for infrastructure development and social programs.

Since its liberalization in 1978, China has experienced an extraordinary period of sustained economic growth, with its real GDP increasing 23-fold since 1977. However, the drivers of this growth have undergone significant changes over time. Notably, the contribution of household consumption to GDP has decreased, falling from approximately 50% in the early 1980s to around 35% by the mid-2000s. This decline was accompanied by a surge in investment and a growing reliance on exports. The early 2000s marked a significant acceleration of this trend, with China's exports expanding rapidly to become the largest in the world by 2009, surpassing those of the United States, Japan, and Germany. By 2009, China's export growth was largely concentrated in a few key sectors. The machinery sector was the primary driver, accounting for approximately 45% of total exports. The textiles and apparel and furniture sectors together contributed around 7% to total exports.

Figure 2: Sector-wise contribution to China's exports, CY2009 (%)



Source: ITC Trade Map

This section delves into the underlying factors that contributed to China's remarkable export growth over the past decade. While an undervalued exchange rate may have played a role, the concentration of export growth in select industries suggests that other factors were also at play. The apparel, textiles, and furniture industries benefited significantly from China's accession to the World Trade Organization (WTO), as well as the expiration of multilateral agreements that had previously limited China's exports. The elimination of quotas under the Multifiber Arrangement (MFA) allowed Chinese textile products to flood international markets without restrictions, resulting in a dramatic increase in exports. Similarly, the furniture industry benefited from enhanced market access, enabling manufacturers to reach global consumers more effectively. The influx of foreign investment in both sectors modernized production processes and improved product quality through the adoption of advanced technologies. Additionally, increased production capacity allowed for economies of scale, further reducing costs and enhancing competitiveness. Together, these developments positioned China as a leading supplier in both the textile and furniture industries on the global stage.

Capital and energy-intensive industries such as iron and steel benefited from government subsidies and reforms that led to increased profitability of state-owned enterprises (SOEs). The retained profits of these SOEs were then reinvested in expanding capacity and production, which ultimately exceeded domestic demand. Key initiatives included providing substantial energy and capital subsidies to boost production capabilities. These reforms allowed SOEs to operate more efficiently and compete effectively in global markets. Additionally, labor policies were introduced to ensure a steady supply of skilled workers, including vocational training programs and incentives for companies to invest in employee development.

However, a significant portion of China's export growth can be attributed to the "machinery" categories, indicating that a deeper assessment is required to fully understand this aspect of its economic expansion. A more detailed analysis of Chinese trade data reveals that this growth was heavily concentrated in a few specific high-tech products, including cell phones, laptops, liquid crystal displays, and integrated electronic circuits. China's ability to rapidly increase exports of these products can be attributed to a combination of factors, including:

1. Strong FDI inflows from global tech majors (e.g., Intel, Motorola, HP), turning China into the world’s electronics assembly hub and rapidly transferring technology and production know-how
2. Rising global demand for consumer electronics, fueled by technological advancements and increased connectivity created a robust market for these products.
3. Large-scale investment in industrial parks and SEZs dedicated to electronics, telecom equipment, semiconductors packaging/testing, and ICT manufacturing.
4. Government-led subsidies and incentives for R&D, high-tech zones, export rebates, and credit support that lowered production costs and scaled capabilities fast.
5. Aggressive technology acquisition—both formal and informal—through JVs, licensing, MNC partnerships, and global talent return programs (like Thousand Talents Program).
6. A decline in U.S. high-tech fixed investment, which created an opportunity for China to dominate these new technologies.

Vietnam: Asia's new manufacturing powerhouse

Vietnam's manufacturing sector lies at the heart of its economy, serving as the primary driver of national growth. In 2023, it accounted for 24% of the country's GDP. Looking ahead, Vietnam aims to increase this contribution to 30% by 2030, with high-tech products expected to make up a majority of the sector's output.

Figure 3: Manufacturing as a % of Vietnam's GDP

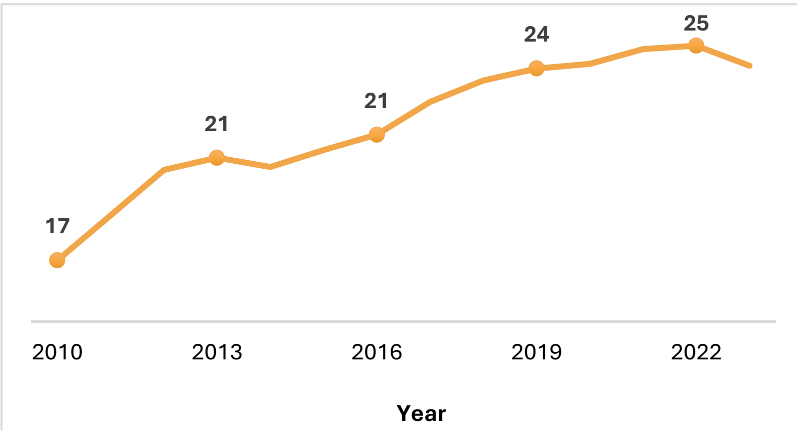
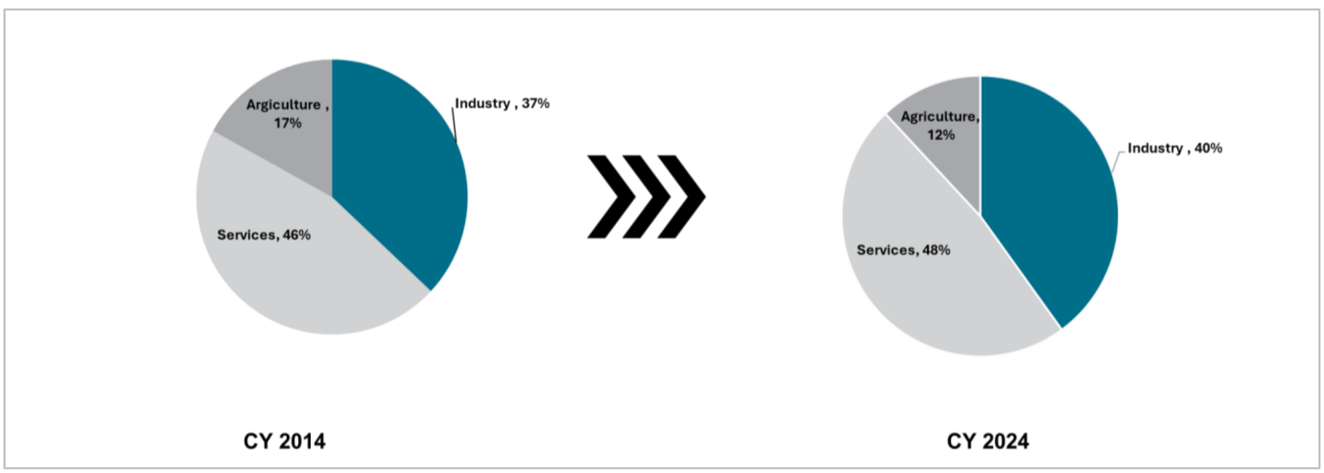


Figure 4: Sectoral contribution to Vietnam's GDP, CY 2014 vs CY2024 (%)



Source: World Bank

In Vietnam, the distribution of economic contributions from industry, services, and agriculture has undergone notable changes in the last decade (2014-2024). The share of industry, increased from 37% to 40%, reflecting the country's ongoing industrialization and significant growth in manufacturing sectors. Similarly, the services sector saw a rise from 46% to 48%, highlighting the expansion of service-oriented industries such as finance, tourism, and technology. In contrast, agriculture's contribution to GDP decreased from 17% to 12%, indicating a shift away from traditional farming practices as the economy diversifies and urbanizes. This transition illustrates Vietnam's evolving economic landscape, with a growing emphasis on manufacturing and industrial activities as key drivers of economic growth.

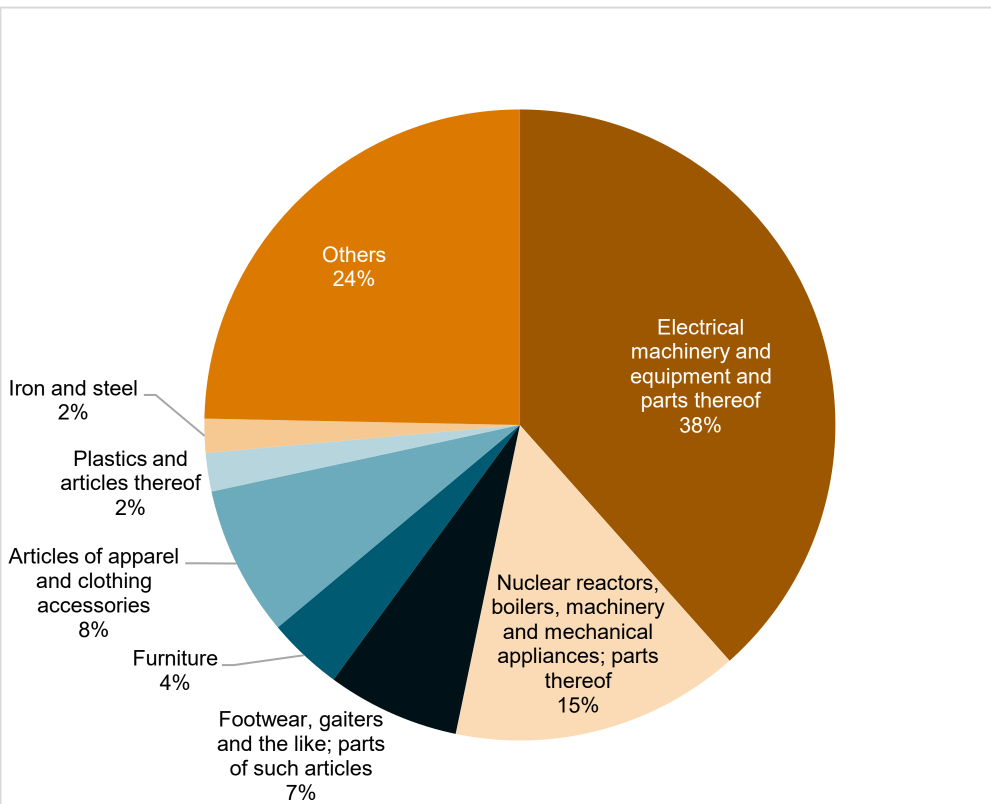
The manufacturing sector has significantly benefited from the global shift triggered by the China Plus One strategy, which gained momentum following the Covid-19 pandemic. As part of its growing strategic alignment with the United States, Vietnam recently entered into a partnership aimed at developing a strong semiconductor supply chain to support U.S. industry needs.

Vietnam's cost-competitive labor market has also been a key advantage. The labour cost per month in Vietnam is approximately USD 188, compared to USD 521 in China—making it one of the most affordable manufacturing destinations in Southeast Asia.

In addition, Vietnam's extensive network of free trade agreements (FTAs) has played a critical role in bolstering industrial growth. As a member of the World Trade Organization (WTO) and the Association of Southeast Asian Nations (ASEAN), Vietnam has signed 15 FTAs with partners across multiple continents. These agreements provide domestic and foreign enterprises operating in the country with preferential tariff access and lower operational costs, reinforcing Vietnam's position as a key global manufacturing hub.

Another reason for this surge in manufacturing is due to several government initiatives that have been promulgated to boost industrial growth, digital transformation, and sustainability, namely the National Industrial Development Policy (2030-2045), the Socio-Economic Development Plan (2021-2025), and the National Green Growth Strategy (2021-2030, Vision 2050). Additionally, the government has implemented vocational education and training programs aimed at upskilling the workforce.

Figure 5: Composition of Vietnam's merchandise exports by product category, CY2024 (%)



Source: ITC Trade Map

Thriving manufacturing sectors

Some of Vietnam's key manufacturing sectors:

a) Electrical machinery and equipment & parts thereof

This sector is the cornerstone of Vietnam's export economy, driven by global electronics giants like Samsung, Foxconn, and LG, who have made Vietnam their regional manufacturing base. The country is now a critical player in assembling smartphones, components, and consumer electronics for export. Over the years, this industry has also been gradually upgrading its capabilities from basic assembly to higher-value activities such as chip packaging, testing, and smart device integration. The strong FDI inflows and supply chain realignments post-China Plus One have further solidified its position

b) Nuclear reactors, boilers, machinery & mechanical appliances

This broad category reflects Vietnam's growing capabilities in industrial equipment, engines, and mechanical components. This category includes machinery for agriculture, manufacturing lines, and construction. The growth of this sector ties in closely with Vietnam's broader industrialization strategy—enabling local businesses to scale up productivity and supporting the needs of other domestic industries. Investment from Japan, South Korea, and Germany has brought in technology transfer and machinery upgrades.

c) Footwear/ Gaiters

Footwear manufacturing is a long-established strength of Vietnam, employing millions and contributing heavily to both exports and rural employment. Vietnam is a leading global supplier of shoes, particularly for brands like Nike, Adidas, and Puma. The sector thrives due to low labor costs, skilled craftsmanship, and robust production clusters around the southern provinces. In recent years, there's also been a push to integrate sustainability and move up the value chain with design and branding efforts

d) Furniture

Vietnam has emerged as one of the world's top furniture exporters, especially for wooden indoor and outdoor furniture. The industry benefits from abundant timber resources (both local and imported), skilled labor, and modern processing facilities. Vietnam's rise has been accelerated by global buyers shifting orders from China due to tariffs and rising costs. Most of the production is based in southern provinces like Binh Duong and Dong Nai. The sector is increasingly moving toward green certifications and eco-friendly manufacturing to meet Western market demands.

e) Apparel and clothing articles

The textile and garment industry is one of Vietnam's oldest and largest manufacturing employers. It caters to global fast-fashion and sportswear brands, offering cost-efficient production and a skilled workforce. The country has benefited significantly from free trade agreements, which allow tariff-free access to key markets like the EU and Japan. There is also growing investment in sustainable textiles and automation, helping factories meet global ESG standards and rising labor challenges.

India's manufacturing journey

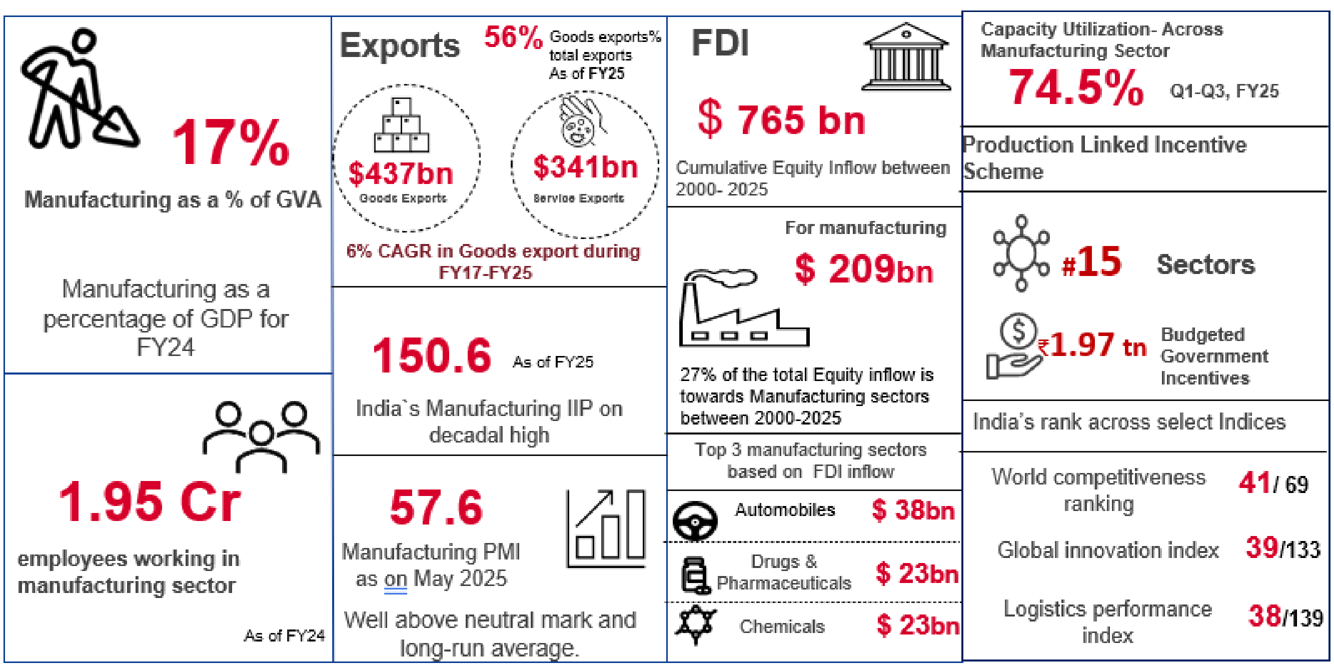
The manufacturing sector in India has a few success stories and a lot of runway for improvement as its share of GDP has been stagnant between 15-17% over the past two decades. The importance of the manufacturing sector as explained above was recognized by the Government and a host of initiatives have been taken to improve the share of manufacturing in India's GDP. The sector is also a significant source of employment, providing 11.4% of jobs in India, helping to absorb the growing workforce.

In contrast, agriculture, while employing the largest share of the population at 46.1%, contributes only about 14.7% to GVA, highlighting a disparity in productivity. This situation underscores the need to transition workers from agriculture to more productive avenues in manufacturing and services, thereby enhancing overall economic output and improving living standards. By focusing on increasing the share of manufacturing in GDP, India can create more sustainable employment opportunities and drive inclusive growth.

A robust manufacturing base is essential for promoting self-reliance, reducing import dependence, and increasing value addition, particularly in critical sectors such as electronics, defense, and renewable energy. As India strives to become a USD 30 trillion economy by 2047, the manufacturing sector is expected to play a pivotal role in achieving this vision, driving both industrial growth and social progress.

As the Indian manufacturing sector continues to evolve, it is increasingly adopting automated and process-driven manufacturing practices, which are expected to yield significant improvements in efficiency and productivity. The shift towards Industry 4.0 has the potential to enhance the sector by allowing manufacturers to optimize their operations, manage costs more effectively, and improve product quality, which could contribute to their competitiveness in the global market.

Figure 6: An overview of manufacturing in India



Source: DPIIT, RBI, MoSPI, Crisil Intelligence

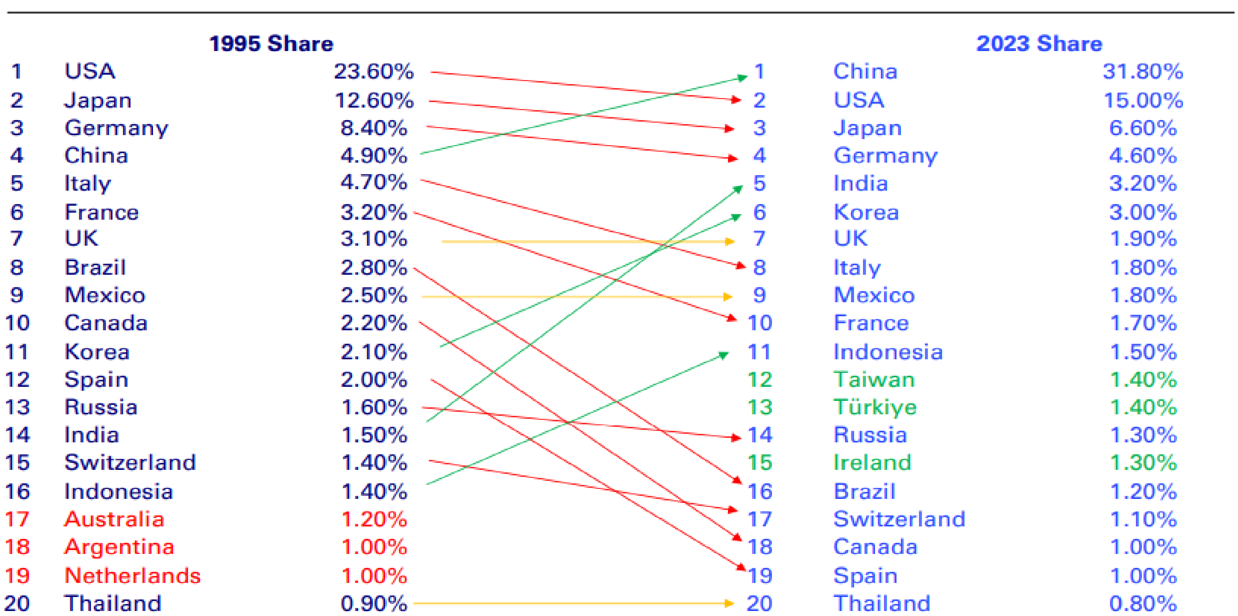
Peer benchmarking

Among Asian economies, China boasts the highest share of manufacturing in its GDP, standing at 26.7% as of 2019. The country's manufacturing sector has experienced robust growth, driven by strategic policy initiatives such as trade liberalization and the establishment of Special Economic Zones (SEZs). These measures have not only improved the incomes of the Chinese population but also propelled the country to become a dominant global exporter, significantly contributing to its GDP growth. Additionally, China's status as a dominant economic force globally provides it with substantial leverage in trade negotiations and enhances its geopolitical influence.

In recent years, Vietnam has made notable strides in its manufacturing sector, with government-led policy initiatives playing a pivotal role in driving this growth. In contrast, India's manufacturing sector, although growing, lags behind its Asian peers (Japan, South Korea, China and Vietnam), in terms of its contribution to GDP.

The chart below outlines the top 20 countries by percentage share of global manufacturing value added. Of the top 20 countries contributing to manufacturing as of 1995, only 4, China, India, South Korea and Indonesia have managed to gain share as of 2023 while 3 have dropped off the top 20 list. The USA that accounted for nearly a quarter of the world manufacturing GVA in 1995 is down to about one sixth as of 2023 with a shift away from manufacturing to a service and technology driven economy. This is in contrast with China which accounted for only 5% of the manufacturing GVA share in 1995 accounted for ~32% in 2023 while India has improved from 1.5% to 3.2%.

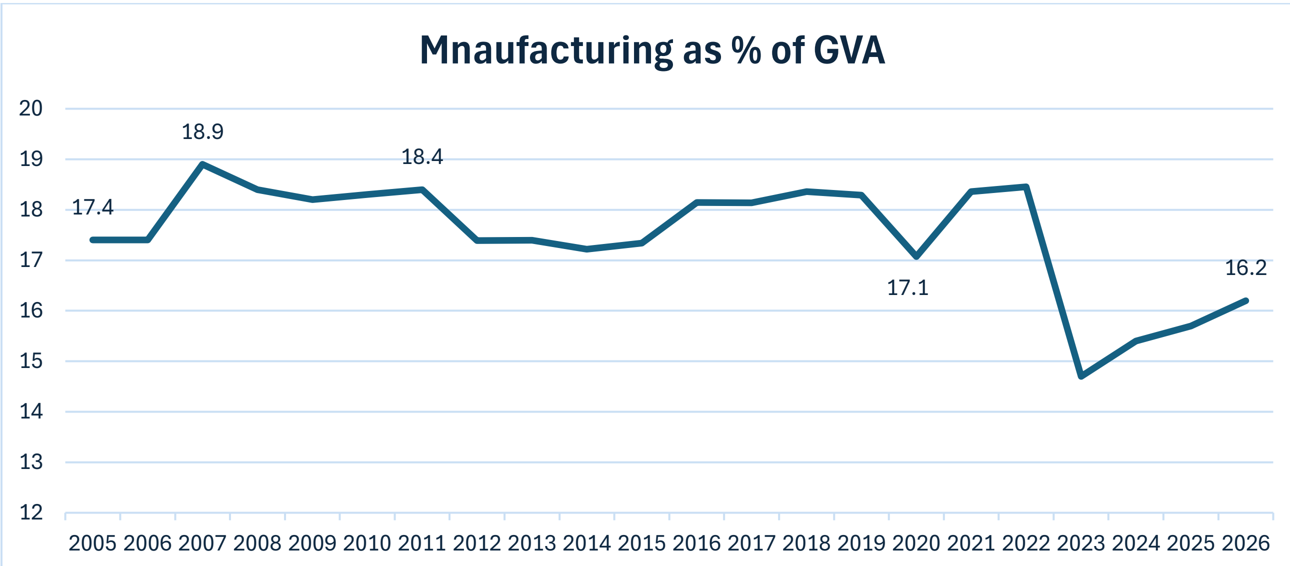
Figure 7: Top 20 countries by share of global manufacturing value added, 1995 vs 2023 (%)



Note: Green text denotes the new entrants to the list and the red text represents countries that no longer appear in the list
Source: Deutsche Bank, UNIDO

Trends in India's manufacturing GDP contribution

Figure 8: Manufacturing as a share of India's GVA, fiscals 2005–2024 (%)



Source: MoSPI

India's Manufacturing as a % of GVA has **been rangebound over the past two decades.** India's manufacturing sector has long been seen as a potential engine for job creation and economic growth, yet its share in GVA has remained stubbornly stagnant, hovering around 16-18% over the two decades. Few of the factors that are contributing to this stagnation are as follows:

Structural focus on services over manufacturing

India leapfrogged from an agrarian economy to a service-dominated economy, skipping the typical industrialization phase that countries like China followed.

- IT, finance, and telecom grew rapidly and attracted talent, capital, and policy focus.
- This shift meant that manufacturing didn't receive the optimal amount of attention and investment it needed.

Complex regulatory environment (before reforms)

Prior to the economic reforms, India operated within a regulatory framework that was often perceived as complex and challenging for businesses. This environment, characterized by stringent regulations and approvals, sometimes hindered the growth and dynamism of the manufacturing sector.

Underdeveloped supply chains and infrastructure

India's manufacturing potential remained under-realised largely due to persistent infrastructure bottlenecks—both in logistics and in power supply—that raise operating costs and limit competitiveness. India's logistics costs estimated at around 8% of GDP – continue to weigh on supply chain efficiency and constrain manufacturing competitiveness. Freight movement is still dominated by slower, costlier road transport, while gaps in multimodal connectivity, warehousing quality and port efficiency increase transit times and inventory costs for manufacturers. Equally important, India's power infrastructure continues to face reliability issues: firms and households experience far more frequent outages and voltage fluctuations compared to developed manufacturing economies, where annual interruptions are typically limited to just a few hours. This forces Indian factories to invest in costly backup power systems and build higher contingency buffers, pushing up production costs. Together, these transport and power constraints weaken India's ability to support large-scale, time-sensitive, and globally competitive manufacturing, preventing the country from fully realising its industrial potential.

Lack of global scale in exports

India has not built globally dominant manufacturing clusters the way China has with electronics or Vietnam with garments. Export baskets are still dominated by low-value added products (e.g., textiles, gems & jewelry), India has only recently made headway in electronics, defense manufacturing, and semiconductors—and scale is still emerging.

Fragmented MSME sector

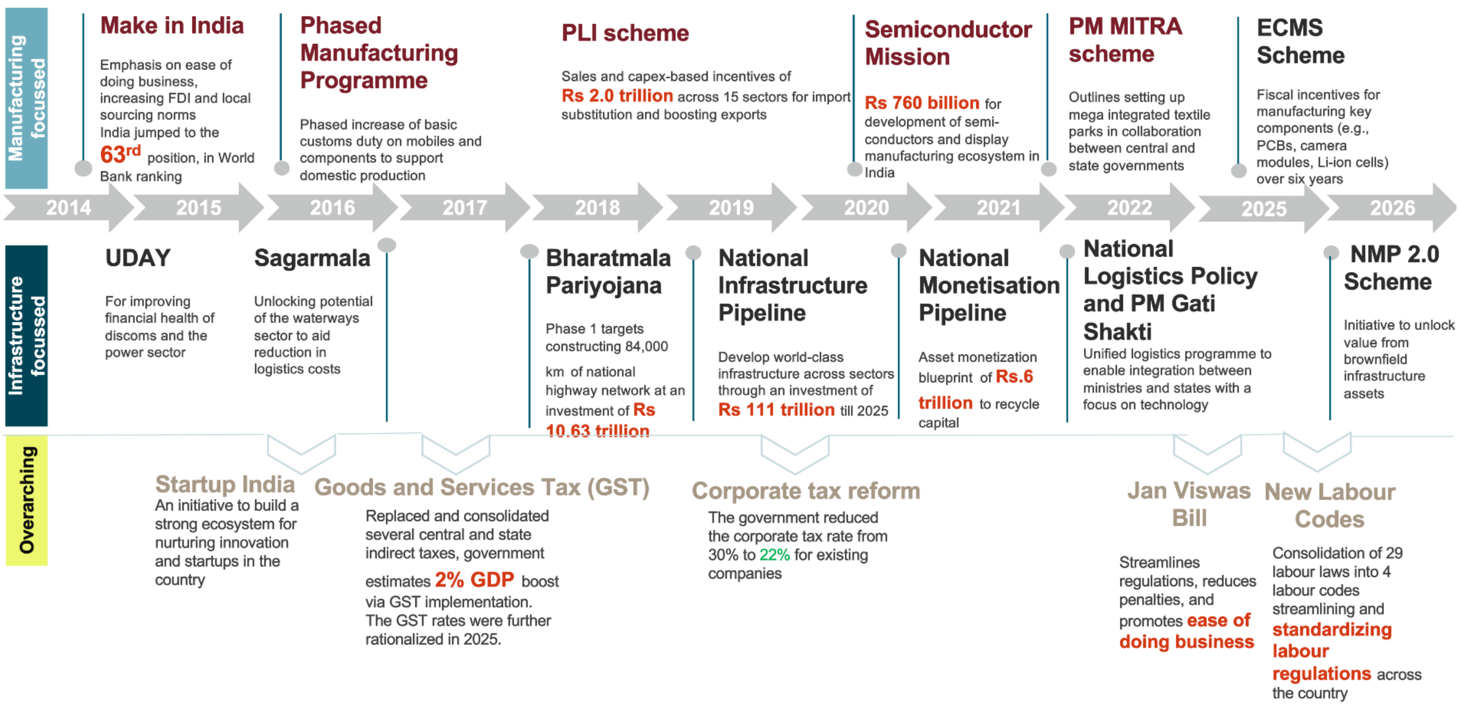
A significant portion of the Indian manufacturing sector is dominated by micro, small, and medium enterprises (MSMEs), which account for over 95% of manufacturing units. Many of these enterprises operate with outdated technology and limited capital, facing challenges in scaling up, digitizing, and integrating into global supply chains. Issues such as access to credit and compliance burdens further hinder their growth potential.

Government reforms

In the context of analyzing India's manufacturing sector trajectory, it becomes critical to understand not just which policies exist, but how they functionally contribute to the development of the manufacturing ecosystem. To do this effectively, the initiatives have been categorized under Manufacturing- focused initiatives, Infrastructure focused initiatives and overarching initiatives. This tripartite classification serves multiple objectives within the report:

- It helps stakeholders understand how different policies influence manufacturing through distinct levers—whether by directly boosting production, supporting inputs and infrastructure, or improving systemic conditions.
- Infrastructure-focused reforms are critical for manufacturing efficiency. Improved transportation networks, logistics facilities, and energy supply are essential for reducing operational costs and enhancing supply chain efficiency. Understanding these reforms allows for an assessment of how infrastructure improvements can directly impact manufacturing productivity and competitiveness.
- Targeted manufacturing focused reforms are critical to expanding domestic capacity, attracting investment, and deepening India's integration into global value chains.
- Overarching policy changes are crucial to simplifying compliance, reducing structural frictions, and enabling businesses to scale more competitively.

Figure 9: Reform push by the Indian Government



Source: Crisil Intelligence

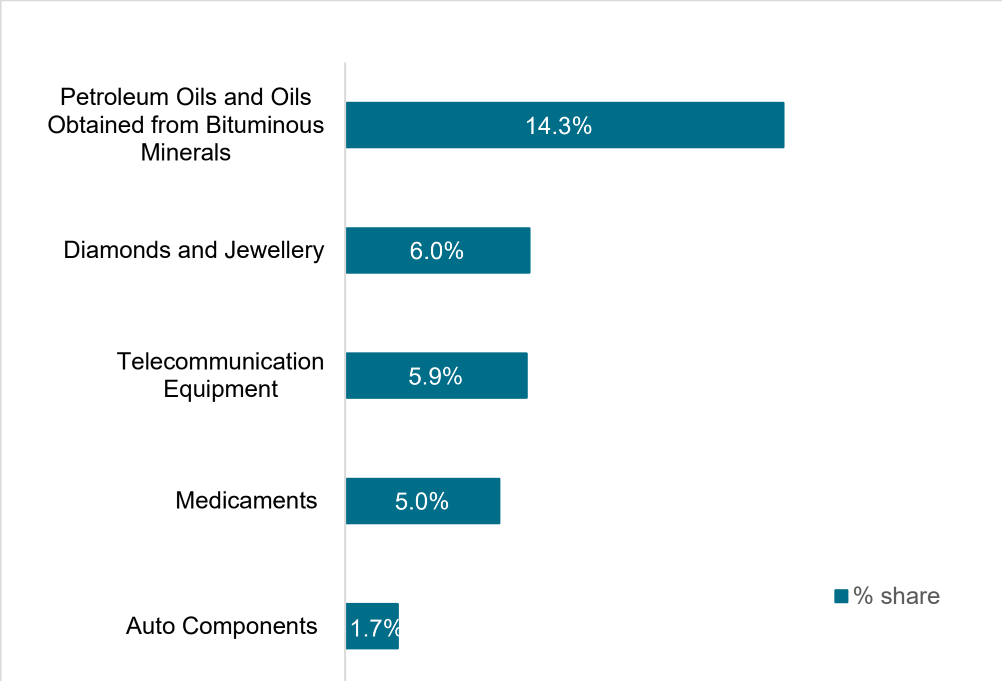
The Indian manufacturing and allied sectors have seen a host of reforms to aid in improving the competitiveness compared to peers. Overarching reforms such as Startup India, Goods and Service Tax have aided in formalisation of the economy and attracting capital. Infrastructure focused reforms have helped in building out infrastructure to aid in bringing down power cost, improving connectivity via roads, ports, airports aiding reduction in logistics cost. Manufacturing reforms have helped in seeding new-age sectors while providing a boost to existing manufacturing sectors while helping in employment generation and catering to the export market.

India’s export basket

As of fiscal 2025, India's merchandise exports are reported to be USD 437 billion, 1.8 % of the world’s trade, illustrating the country's active role in global trade. This figure reflects a diverse range of products and commodities that India exports to various international markets.

Though India’s export basket has diversified in recent years, it remains more concentrated than that of major export-driven economies. A significant share of India’s goods exports is still dominated by a few categories—petroleum products, gems and jewellery, pharmaceuticals, engineering goods, chemicals, and textiles and now increasingly electronics driven by mobile phones. While this mix spans both low- and medium-technology segments, the overall structure is less broad-based compared to countries like China, South Korea, or even Vietnam, which have a much larger proportion of high-technology and electronics exports. This relative concentration leaves India more exposed to commodity price swings and sector-specific downturns, underscoring the need to deepen capabilities in emerging, higher-value export categories to reduce vulnerability and enhance competitiveness.

Figure 10: Share of top commodities in India's export basket, FY25 (%)



Source: DGFT
Note: Commodities have been classifed at the HS 4-digit level

Petroleum Oils and Oils Obtained from Bituminous Minerals stand out as the highest exported commodity, accounting for 14% of India's export value. Export values for this category have increased substantially, rising from USD 31,137 million in fiscal 2017 to USD 62,550 million in fiscal 2025. This significant leap has been driven by advanced refining infrastructure, increased production capacity, and adherence to international standards, solidifying India's reputation as a dependable energy supplier worldwide.

As of fiscal 2025, Diamond and Jewellery exports from India reached a value of USD 26,319 million, 6% of the fiscal 2025 exports, making it the second highest exported commodity by value for the country. This sector is a vital component of India's export economy, reflecting the nation's rich heritage in craftsmanship and design. The global demand for high-quality diamonds and intricately crafted jewellery has contributed to this significant export figure, positioning India as a key player in the international market for luxury goods. The industry's growth is supported by a well-established supply chain and a reputation for quality, further enhancing India's status as a leading exporter in this domain.

Electronics is the third highest exported commodity by value, driven by technological advancements, the ramp up in manufacturing of mobile phones driven by the PLI scheme coupled with the supply chain diversification pursued by companies. Exports of electronics surged from USD 1,043 million in fiscal 2016 to USD 25,874 million in fiscal 2025, accounting for approximately 6% of India's export basket as of fiscal 2025. The primary destinations for these exports include the USA, UAE, and the Netherlands.

As of fiscal 2025, Medicaments emerged as the fourth largest export commodity from India, with an export value of USD 22,026 million, accounting for 5% of the export basket. This sector plays a crucial role in India's pharmaceutical industry, which is recognized globally for its capacity to produce a wide range of affordable and high-quality medicines. The growth in medicament exports can be attributed to India's strong manufacturing capabilities, adherence to international quality standards, strong manufacturing capability in generics and a robust regulatory framework. Additionally, the increasing global demand for healthcare solutions, particularly in developing countries, has further bolstered India's position as a significant supplier of pharmaceutical products. The country's commitment to providing accessible healthcare options has solidified its reputation as a reliable source of medicaments in the international market.

Although rice ranks as India's fifth-largest export by value, it is excluded from the chart above as the report focuses specifically on manufactured goods. Accordingly, the next largest manufactured export, automotive components, is highlighted. Auto components recorded exports worth USD 7,508.87 million in fiscal 2025. The sector's export performance reflects the rising global competitiveness of India's automotive component players driven by localization efforts, close collaboration with OEMs, JVs with global auto-component players and focus on quality. Indian component manufacturers are increasingly integrated into global value chains, supplying major OEMs across Europe, North America, and Asia.

In addition to the top exported commodities, several other sectors have demonstrated remarkable growth and are noteworthy in India's export landscape.

India has achieved notable success in the agrochemical sector, particularly in insecticides and fungicides. With exports reaching USD 2,436 million in fiscal 2025, capturing a sizeable share globally. Investments in research and development, coupled with compliance with international agricultural standards, have positioned India as the third-largest exporter globally, underscoring its pivotal role in supporting sustainable agriculture.

The capital goods sector has shown significant advancements, reflected in the exports of electrical transformers and related components, which grew from USD 1,188mn in fiscal 2017 to USD 3,146mn in fiscal 2026. Government initiatives such as "Make in India" and production-linked incentive schemes have bolstered this progress, creating a robust manufacturing ecosystem.

India's export basket reflects a blend of both primary goods and manufactured products. While the share of value-added exports such as petroleum, machinery, transport equipment, chemicals, and electronic items has grown over the years, a significant portion of export earnings still comes from primary goods and raw materials. Approximately, 70% of India's exports are manufactured products, with the remaining 30% comprising primarily or minimally processed goods. Sectors such as agricultural and allied products, base metals, and even gems in uncut or semi-processed form highlight this continued reliance on less processed exports. This indicates that despite strides toward industrialization and higher value manufacturing, India remains partly dependent on commodity-based exports. The challenge ahead lies in moving further up the value chain—shifting from raw material exports to more refined, processed, or technologically sophisticated goods that can generate better margins and long-term economic resilience.

Background of the study

The study is intended to identify manufacturing sectors in India that can support the country's ambition of becoming a global manufacturing hub. The assessment focuses on understanding India's manufacturing landscape in relation to global trends, sectoral growth opportunities and global benchmarks. It also examines the factors that influence manufacturing competitiveness, including market potential, infrastructure readiness, policy support, raw material availability, technology readiness, employment potential and India's current position in the value chain.

The project has been approached with the objective of identifying sectors where India has strong growth potential and where targeted interventions can help strengthen domestic capabilities, improve competitiveness, enhance value addition and support export-led manufacturing growth. The study also draws on the experience of leading manufacturing countries to identify relevant learnings and develop sector-specific recommendations for addressing key challenges and promoting growth in the identified sectors.

Methodology

Crisil leveraged its ongoing coverage of over 75 traditional, sunrise, and PLI sectors to evaluate manufacturing opportunities in India. The project was divided into four phases.

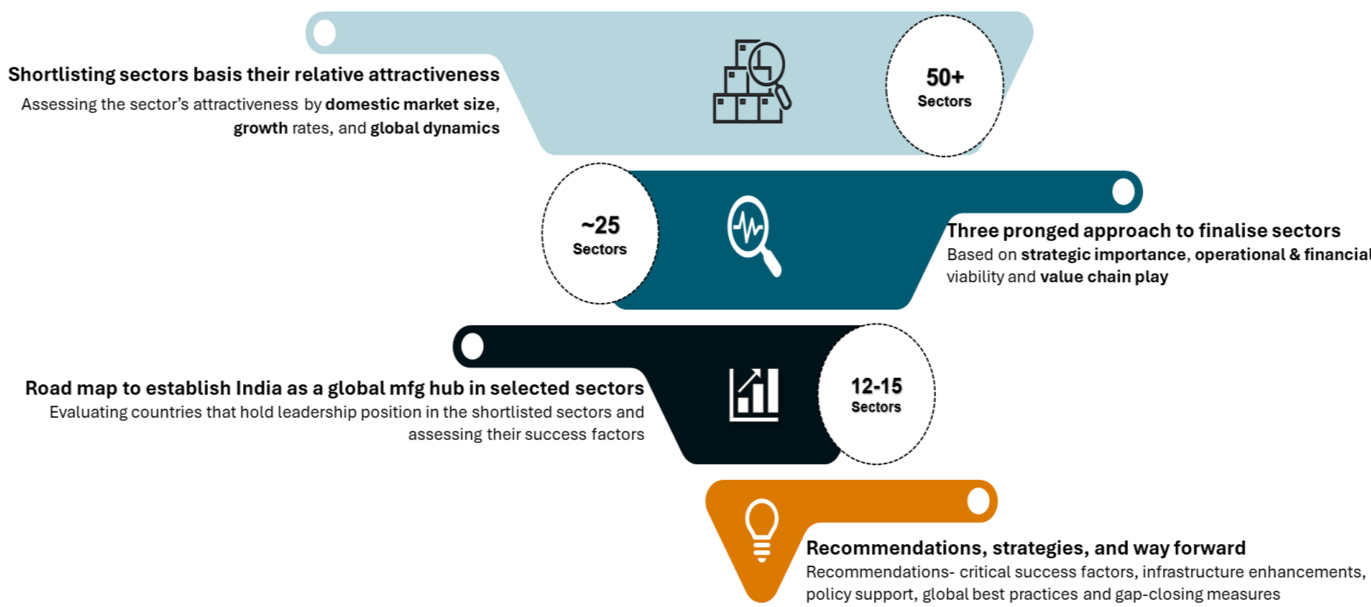
Phase 1: Shortlisting Sectors basis their relative attractiveness - Identifying sectors with high growth potential, based on market size and growth rate in India and globally.

Phase 2: Conducting a comprehensive, three-pronged examination of the shortlisted sectors.

Phase 3: Analyzing best practices in champion countries to inform strategies for the shortlisted sectors.

Phase 4: Developing actionable recommendations and a clear path forward for each sector.

Figure 11:Methodology adopted for the study



Phase 1: Sector selection

In the first phase, the aim was for selection of 12 manufacturing sectors for which a relative attractiveness method was used. To judge relative attractiveness of each sector, the growth potential across both global as well as domestic, existing market size, coupled with the employment creating opportunity and strategic alignment with the priorities of the Indian government were considered.

The list of 62 sectors was primarily sourced from the Ministry of Statistics and Programme Implementation (MOSPI) database and supplemented by sunrise sectors and those included under the Production-Linked Incentive (PLI) scheme.

Figure 12: List of manufacturing sectors considered for shortlisting

1	Capital Goods	MoSPI
2	Oil Field Equipments	MoSPI
3	Food Processing	PLI Sectors
4	Railway Equipment Manf	MoSPI
5	Other electronics	MoSPI
6	Electric Vehicles	Sunrise Sectors
7	Solar Module Manf.	PLI Sectors
8	Drones	PLI Sectors
9	Green Hydrogen/Electrolyser	Sunrise Sectors
10	Electronic/Technology Products	PLI Sectors
11	Semiconductors	MoSPI
12	Wind Equipment Manf	Sunrise Sectors
13	Advanced Chemistry Cell Battery	PLI Sectors
14	Hearables and wearables	Sunrise Sectors
15	Industrial electronics	MoSPI
16	Telecom Equipment	PLI Sectors
17	IT Hardware	PLI Sectors
18	Medical Equipment	PLI Sectors
19	Aircraft manufacturing	MoSPI
20	Mobile Phone Manf	PLI Sectors
21	Specialty Steel	PLI Sectors
22	Leather and Footware	Sunrise Sectors
23	Construction Equipment	MoSPI
24	Paints	MoSPI
25	Farm Equipment	MoSPI
26	Chemicals	MoSPI
27	Toys	MoSPI
28	Two wheelers	MoSPI
29	Building Material (Pipes)	MoSPI
30	Ceramic Tiles	MoSPI
31	Steel	MoSPI
32	Electrical Equipment	MoSPI
33	Non-ferrous metals	MoSPI
34	Pharmaceuticals (Dom formulation)	PLI Sectors
35	Consumer Durables	MoSPI
36	Home Textiles	MoSPI
37	Cars and Utility Vehicles	MoSPI
38	Cement	MoSPI
39	Automotive Components	PLI Sectors
40	Defence equipment	MoSPI
41	Petrochemicals	MoSPI
42	Refractories	MoSPI
43	Tyres	MoSPI
44	Power equipment	MoSPI
45	Speciality Chemicals	MoSPI
46	White Goods (LEDs)	PLI Sectors
47	Bicycles	MoSPI
48	Gems & Jewellery	MoSPI
49	Pesticides	MoSPI
50	FMCG	MoSPI
51	RMG	MoSPI
52	Commercial Vehicles	MoSPI
53	Packaging	MoSPI
54	Tractors	MoSPI
55	Refining	MoSPI
56	Sugar	MoSPI
57	Edible Oil	MoSPI
58	Biotechnology	Sunrise Sectors
59	Shipping	MoSPI
60	Chlor Alkalies	MoSPI
61	Cotton Yarn	MoSPI
62	Paper	MoSPI

MoSPI   Sunrise Sectors   PLI Sectors

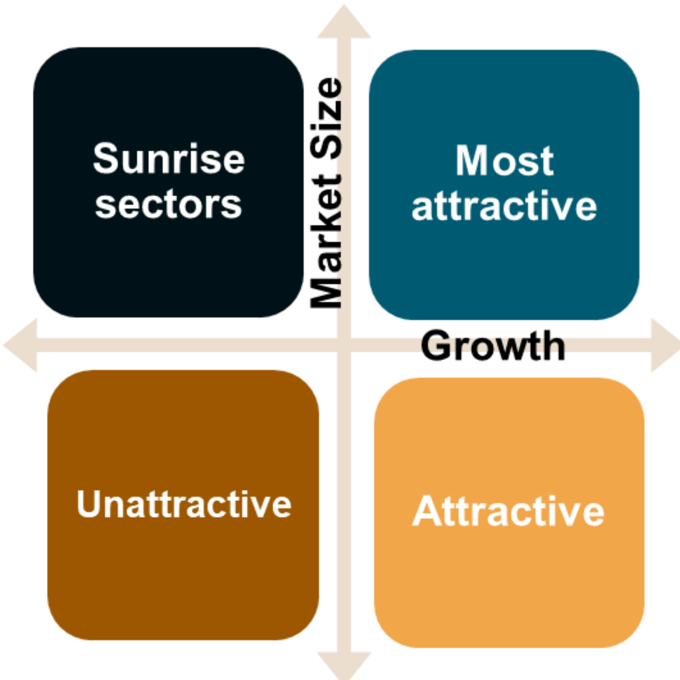
To determine the relative score for each sector, a 4-step methodology was employed, using the following parameters: domestic market size, global market size, domestic growth rate projection (fiscal 2023 to fiscal 2030), and global growth rate (fiscal 2023 to fiscal 2030). The calculation process involved:

1. Data Collection: Gathering current and projected market size and growth rate data for the 62 shortlisted sectors.
2. Median Calculation: Determining the median values for each parameter across all 62 sectors.
3. Median Multiplier Calculation: Computing median multipliers for each parameter, which normalized the sector-specific values against the median values. For example, the Median Multiplier for Domestic Market Size was calculated as the sector's current domestic market size divided by the median domestic market size of all 62 sectors.
4. Cumulative Score Calculation: Assigning a 25% weightage to each median multiplier and calculating a cumulative score for each sector.

To provide a visual representation and facilitate a more nuanced understanding, the market size and growth rate scores were plotted in a 4x4 matrix with quadrants classified as below:

- Q1: High Market Size – High Growth [Most Attractive Sectors]
- Q2: Low Market Size - High Growth [Sunrise Sectors]
- Q3: Low Market Size - Low Growth [Unattractive Sectors]
- Q4: High Market Size - Low Growth [Attractive Sectors]

Figure 13: Sector classification matrix based on market size and growth



Source: Crisil Intelligence

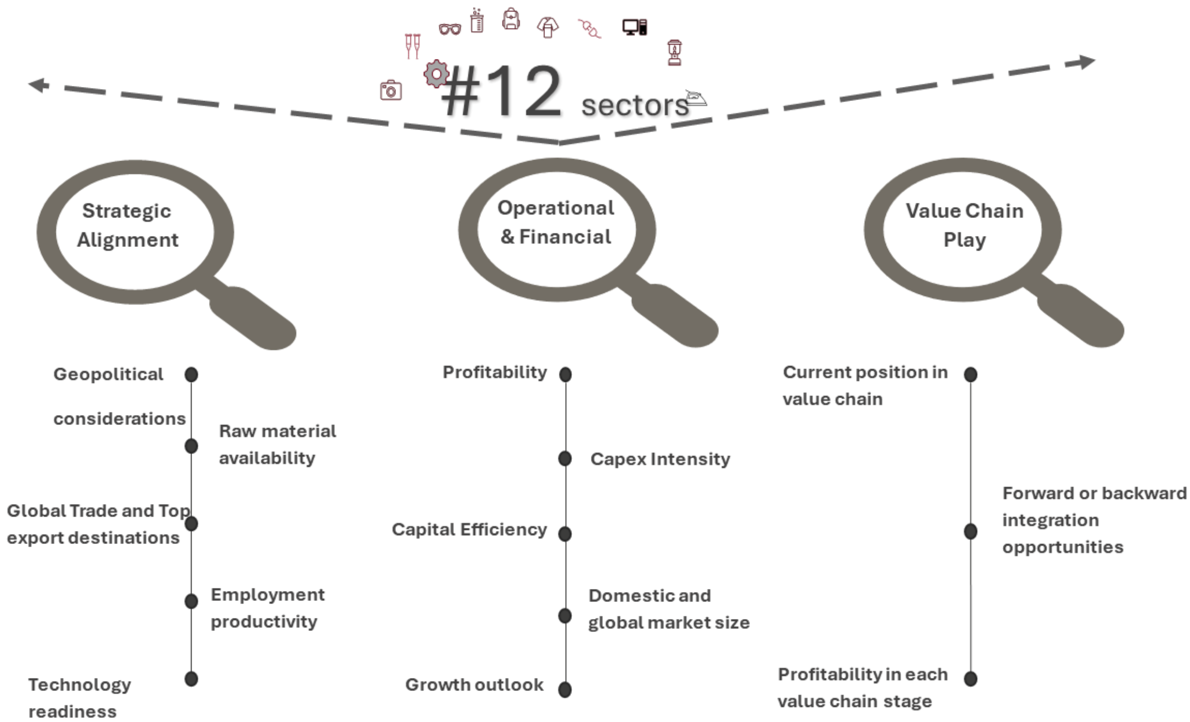
Following this analysis, 12 high-potential sectors from the Q1, Q2, and Q4 quadrants, which exhibited strong market size and growth prospects were identified. The shortlisted sectors were:

1. Automobiles
2. Chemicals
3. Capital Goods
4. Electronics
5. Pharmaceuticals
6. Defense: Defense & Drones
7. Food Processing
8. Textiles
9. Steel
10. Leather and Footwear
11. Telecom Equipment
12. Solar PV Manufacturing

Phase 2: Sector assessment

In Phase 2 of the project, the sectors shortlisted based on market attractiveness underwent a deeper evaluation to determine their true potential within the Indian context. To achieve this, each sector was evaluated using a 3-pronged approach: strategic alignment, operational and financial viability, and value chain play. Each prong provided a distinct perspective on a sector's suitability.

Figure 14: Framework for detailed evaluation of shortlisted sectors



Source: Crisil Intelligence

1) Strategic alignment:

The first approach, strategic alignment, is essential to ensure that sector development is not only economically viable but also consistent with India's long-term national priorities. This approach assesses how well each sector aligns with India's critical priorities. A sector that is geopolitically advantageous, rich in local raw materials, raw material dependence on friendly nations, linked to high-export potential, and supportive of productive employment generation will offer stronger long-term strategic value. This means that sectors are chosen based not just on profitability but because they serve India's broader strategic ambitions, including reducing import dependence, enhancing global competitiveness, and driving inclusive economic growth

- Raw material availability: Identified the key global raw material suppliers for each sector and the suppliers that India relies for import of the raw materials
- Geopolitical considerations: Evaluated India's geopolitical relationships with major supplier countries. These relationships were classified into positive and neutral

- Global trade landscape: Analyzed the global trade patterns of each sector by identifying the major exporting and importing countries and their share in total exports as well as imports
- Employment intensity: Examined the employment intensity of sectors, including employment rates, productivity, and skill requirement levels.
- Technology readiness: Assessed the availability of local technology, foreign partnerships, and tech-know-how in each sector.

2) Operational & financial viability analysis:

Even if a sector is strategically important, it must also be operationally and financially viable to scale in India and attract private capital and investors. This approach assesses the profitability and sustainability of sectors, ensuring that they do not rely on ongoing government support and can scale on their own. It evaluates whether India has, or can develop the necessary cost structures, capital environment, and market access to make the sector viable for long-term private and public investment that would aid in attracting private capital. Furthermore, it considers scalability, efficiency, and the return on capital required to foster sustainable growth. This approach grounds the analysis in financial realism, ensuring that shortlisted sectors are not only desirable but also capable of thriving independently within India's current economic structure and business climate.

- Profitability: Evaluated the financial performance of each sector by examining the operating margins, Net margins and Returns on capital (ROCE) for domestic as well as international players.
- Capex intensity: Assessed the capital expenditure requirements for each sector by using the capex-to–sales metric for domestic and international companies.
- Market size and growth outlook: Evaluated the size and growth potential of each sector in both domestic and global markets.

3) Value-chain play analysis:

This phase focuses on assessing India's position within the current manufacturing value chain, identifying specific segments where the country has a competitive edge based on where the bulk of value addition occurs. Rather than evaluating the sector as a whole, it examines the extent of current participation in the value chain and identifies untapped opportunities for both forward and backward integration. By analyzing India's position within the value chain, we can avoid becoming a low-margin, peripheral assembler in global value chains and instead chart a path toward deeper integration and greater value addition.

- Current position in value chain: Mapped the current position of India in the global value chain of each sector, including the nodes where India has a presence.
- Forward or backward integration opportunities: Identified opportunities for forward or backward integration in each sector, including potential partnerships, joint ventures, or acquisitions.
- Profitability in each value chain stage: Analyzed the profitability of each stage in the value chain by using EBITDA and ROE metrics.

Phase 3: Benchmarking with champion countries

To identify opportunities for India to become a global manufacturing hub, a benchmarking exercise with two leading manufacturing countries for each of the 12 selected sectors was conducted. This dual-country approach is designed to extract valuable insights into the factors that have enabled these countries to achieve global supremacy in their respective sectors. By analyzing two countries per sector, the project aims to understand the effective policy environment, company actions, and other critical aspects that have contributed to their success and to see which of the identified best practices can be adapted to India’s context. For example, one country may exemplify a high-tech, capital-intensive model, such as South Korea’s expertise in electronics, while another may represent a low-cost, labor-driven model more akin to India’s strengths, such as Vietnam in apparel. This comparative assessment allows us to contrast different development paths and identify strategies that could be realistically emulated or adapted in India’s context.

The approach for Phase 3 involved the following steps:

a) **Identification of leading manufacturing countries**: Top two manufacturing countries based on criteria such as manufacturing output and competitiveness.

b) **Key success factors and best practices:** Key success factors and best practices that have driven the manufacturing growth of the selected countries. This included an analysis of their economic policies, trade agreements, skilling initiatives, investment climate, and other factors in their success.

Phase 4: Recommendations and way forward

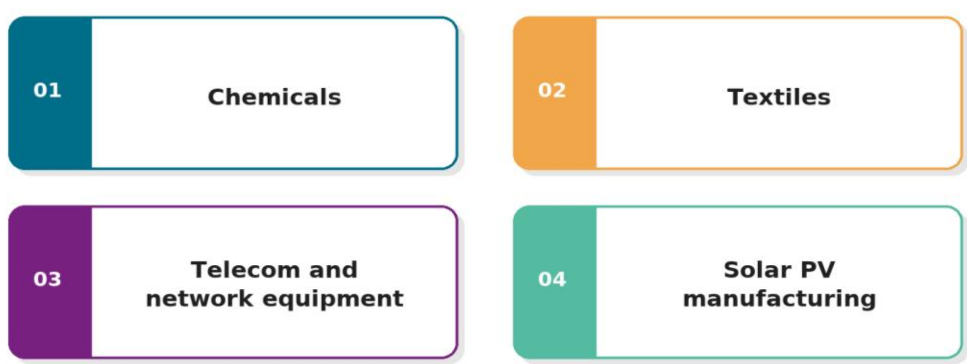
In Phase 4, a detailed round of stakeholder consultation meetings with industry leaders from the shortlisted sectors was organised. The purpose of these meetings was twofold: to uncover insights from the industry leaders themselves on the ground-level challenges they face and gather their recommendations for scaling up these sectors. These meetings enabled incorporation of firsthand perspectives, enhancing the accuracy and relevance of the assessments in previous phases. These on-ground challenges and recommendations from the stakeholders were combined with challenges emerging from secondary research and recommendations emerging from the best practices from other countries. The output from phase 4 is targeted recommendations for implementation across factors of production, regulatory landscape, taxation, FTAs, Technical recommendations based on the gaps identified in Phase 2 and best practices identified from Phase 3.

To ensure a structured and outcome-oriented approach, each sectoral recommendation follows a three-step framework:

- Identifying key challenges: The major bottlenecks and constraints currently inhibiting sectoral growth were identified.
- Recommendation to address the challenge: For each identified challenge, a specific, actionable recommendation is proposed. These are designed to be transformative yet practical, targeting root causes of the challenge.
- Execution Strategy:
  Clear steps to operationalize the recommendation, including necessary policy reforms, infrastructure development, or investment incentives.
  This structured approach ensures that each recommendation is evidence-backed and context-aware.

This edition of the report focuses on four high-potential manufacturing sectors: chemicals, textiles, telecom and network equipment and solar photovoltaic manufacturing with the other 8 identified above to be released in subsequent volumes.

Figure 15: Constituents of Volume I



Source: Crisil Intelligence

The selected sectors represent a combination of export-oriented, technology-intensive and employment-focused manufacturing opportunities. Chemicals is deeply integrated into global value chains and offers significant scope for strengthening India's role in export-led manufacturing. Textiles remains one of India's most employment-intensive sectors, with strong linkages to micro, small and medium enterprises (MSMEs), rural and semi-urban economies and global trade. Telecom and network equipment is critical for reducing import dependence, strengthening domestic technology capabilities and building competitiveness in digital infrastructure. Solar PV manufacturing is strategically important for India's energy transition, domestic manufacturing scale-up and participation in the global clean energy value chain.

Together, these sectors reflect the broader objective of identifying manufacturing opportunities that can support India's transition into a globally competitive manufacturing hub. The study evaluates each sector through a structured framework covering market attractiveness, strategic alignment, raw material availability, global trade positioning, technology readiness, financial viability, value-chain opportunities and policy support requirements. It also draws on international benchmarking and stakeholder consultations to identify actionable recommendations for strengthening domestic manufacturing capabilities, improving competitiveness and enabling scale.

Volume 1

NITI AAYOG

GMH REPORT

Identifying Key Sectors to Position India as a Global Manufacturing Hub

Chemicals

Textiles

Telecom and Network Equipment

Solar PV

CHEMICALS

Specialty

Export-led growth

Feedstock

Methanol, phenol, acetic acid

Policy

PCPIRs, QCOs, FTAs

Table of contents

Executive summary

Chemicals sector at a glance

$200-220B
India market, fiscal 2025

6-8%
Expected CAGR

$290-310B
Expected market, fiscal 2030

3-3.5%
India global share

$45B
Specialty export target

5-6%
Target global value-chain share

Import substitution | Export potential | PCPIRs | Water treatment | Skills gap

Sector overview

India's chemicals industry is a strategically important part of the country's manufacturing ecosystem, supplying critical inputs to agriculture, pharmaceuticals, textiles, automotive, construction, electronics, consumer goods and several other downstream sectors. The industry accounts for 3-3.5% of the global chemicals market, ranks sixth globally and fourth in Asia by production, and was valued at $200-220 billion in fiscal 2025. It is expected to grow at a 6-8% CAGR over the next five fiscals, supported by rising domestic consumption, favourable government policies, expanding manufacturing capacity, higher disposable incomes, urbanisation and changing consumer preferences.

Globally, the chemicals industry remains large and diversified, with the market projected at $4,300-4,500 billion in 2025 and expected to reach $5,000-5,500 billion by 2030, implying a 2-4% CAGR. Asia-Pacific is the largest and fastest-growing region, led by China, while India's current share remains relatively modest, indicating significant headroom for expansion. By fiscal 2030, India's domestic chemicals market consumption is expected to reach $290-310 billion, with the country aiming to increase its share in global chemical consumption to 5-6%.

The sector's long-term growth is expected to be driven by multiple structural factors. Low per capita consumption presents a large opportunity for demand expansion across consumer goods, agriculture, construction, pharmaceuticals and personal care. India's large domestic market, improving engineering and research capabilities, supply-chain diversification away from China, and rising purchasing power further strengthen the growth outlook. The report also highlights that India can transition from being a large consumption-led market to a more globally relevant manufacturing and export hub if policy, infrastructure and capability gaps are addressed in a coordinated manner.

Industry structure

The domestic chemicals industry is broadly led by three key consumption segments: petrochemicals and organic chemicals, specialty chemicals, and inorganic chemicals. Petrochemicals and organic chemicals form the largest segment and include polymers, synthetic fibres, performance plastics, building blocks, intermediates and end-products. These products support industries such as packaging, textiles, pharmaceuticals, dyes, adhesives and plastics. In fiscal 2025, petrochemicals and organic chemicals accounted for a sizeable share of the domestic chemicals market.

Specialty chemicals are high-value, low-volume products customised for specific applications. They include dyes and pigments, paints and coatings, agrochemicals, surfactants, flavours and fragrances, construction chemicals, polymer additives and textile chemicals. This segment is attractive because it offers higher value addition, stronger margins and export potential. India is already a net exporter in agrochemicals and colourants, while global supply-chain diversification creates further opportunities for Indian manufacturers. However, India remains import-dependent in certain specialty segments such as polymer additives and surfactants.

Inorganic chemicals are essential industrial inputs used in construction, water treatment, food processing, electronics, manufacturing and agriculture. This segment includes products such as soda ash, caustic soda, chlorine, hydrochloric acid, carbon black and inorganic pigments. Demand is supported by the versatility of these chemicals and their relevance across multiple end-use industries. However, the segment faces challenges related to raw material availability, limited domestic capacity in some products and dependence on imports.

The report highlights that India's industry structure is constrained by a persistent gap between domestic production and consumption, particularly in petrochemicals and inorganic chemicals. Feedstock allocation in India is skewed towards bulk commodities rather than higher-value downstream derivatives. For example, a large share of propylene is used to produce polypropylene, while ethylene is largely used for polyethylene production. This limits the availability of building blocks for more complex and value-added chemicals. Strengthening downstream integration and incentivising complex derivatives are therefore critical to enhancing domestic value addition.

Global case studies

Global example	What worked	What India can adopt
China	Large-scale integrated manufacturing, strong supplier networks, low-cost production, industrial zones and active policy support	Build scale, deepen domestic supply chains, incentivise downstream derivatives and strengthen cluster-based manufacturing
ASEAN economies	Country-level chemical roadmaps, investment incentives, petrochemical self-sufficiency and sector-specific policies	Create long-term sectoral plans with clear investment targets, feedstock security and technology priorities
Jurong Island, Singapore	Anchor investments, shared infrastructure, strong logistics connectivity and proactive governance	Develop plug-and-play chemical parks with shared utilities, pipelines, effluent systems and efficient approvals
Rotterdam and Nanjing chemical hubs	Integrated port, pipeline, storage and industrial ecosystems with stable zoning and strong cluster discipline	Front-load infrastructure, ensure land-use stability and create empowered authorities for chemical hubs

Challenges and recommendations

Key challenge	Impact on industry	Recommended action
Import dependency on raw materials	Exposure to price volatility, supply disruptions and geopolitical risk	Identify critical chemicals for import substitution; support domestic production through incentives and viability gap funding
Infrastructure and connectivity gaps	Higher logistics cost, slower project execution and lower competitiveness	Develop integrated PCPIRs, shared utilities, pipeline grids, common effluent systems and port-linked chemical hubs
Impact of free trade agreements (FTAs) and regulatory interventions	Domestic industry growth and competitiveness	Negotiate balanced FTAs, create awareness and ensure effective utilisation of FTAs, promote localised production and sustainable shipping methods

Chemicals

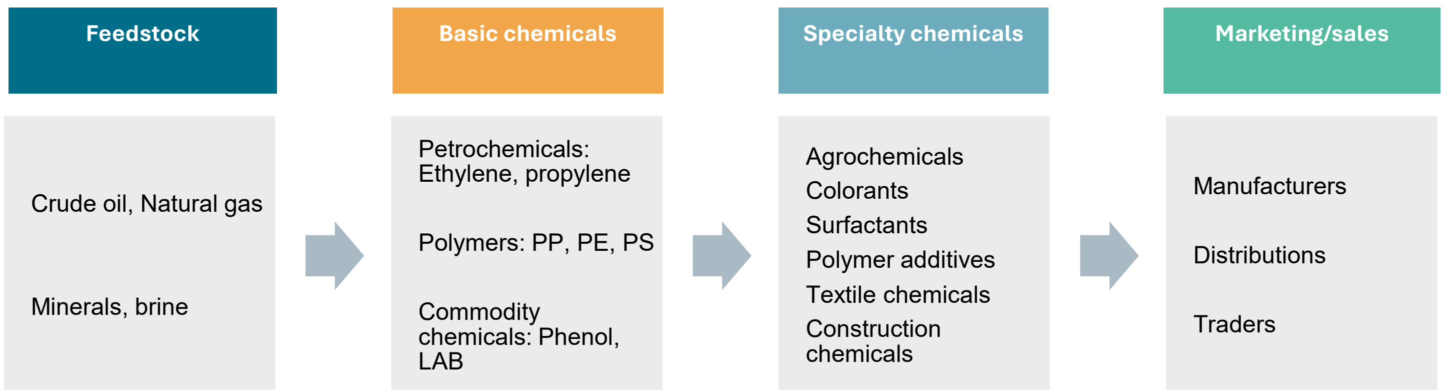
Introduction

The Indian chemicals industry accounts for 3-3.5% of the global chemical industry and ranks sixth globally and fourth in Asia by production. It was valued at $200-220 billion in fiscal 2025 and is expected to grow at a compound annual growth rate (CAGR) of 6-8% over the next five fiscals.

On the production side, domestic output is estimated to be **16,000-17,000 kilotonnes** (KT) in fiscal 2025, with a **4-6% CAGR** expected through fiscal 2030. Growth is underpinned by rising domestic consumption, favourable government policies, expanding manufacturing capacity, higher disposable incomes, urbanisation and shifting consumer preferences.

Petrochemicals and organic, inorganic, and specialty chemicals are the key segments of India's chemicals industry based on market consumption.

Figure 16: Supply chain of the chemical industry



Note: PP – Polypropylene, PE – Polyethylene, PS – Polystyrene
Source: Crisil Intelligence

Petrochemicals and organic chemicals

Petrochemicals, also known as petroleum distillates, are derived from petroleum and natural gas through a refinement process. This segment encompasses a wide range of products, including polymers, synthetic fibres and performance plastics. The category can be broken down into three main sub-segments:

- Building blocks: These are the basic chemicals used to produce other petrochemicals, such as ethylene, propylene, benzene, toluene and butadiene, which are used in the production of plastics, synthetic fibres, dyes, pharmaceuticals and adhesives
- Intermediates: These are chemicals used to produce other petrochemicals, including terephthalic acid (PTA), styrene, vinyl chloride monomer (VCM), phenol, methanol and formaldehyde, which are used in the production of adhesives, resins and plastics
- End-products: These are the final petrochemical products, such as high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), and polyvinyl chloride (PVC). Petrochemicals represent the largest segment of the chemicals industry

Organic chemicals, on the other hand, are carbon-based compounds used in various applications, such as pharmaceuticals, agrochemicals and dyes.

Examples of organic chemicals are fertilisers and pesticides, which are used in the agriculture sector.

In fiscal 2025, petrochemicals and organic chemicals accounted for approximately 24% of the domestic chemical industry, with a market size of ~$50 billion.

Inorganic chemicals

Inorganic chemicals are a vital component of India's industrial foundation, providing crucial materials for various sectors, such as construction, water treatment and electronics. This broad category of compounds, characterised by the absence of carbon-hydrogen bonds, includes a wide range of substances, such as metals, salts and minerals.

The applications of inorganic chemicals are diverse and widespread, catering to numerous industries, including

- Agriculture (ammonia is used in fertilisers to promote crop growth)
- Manufacturing (hydrogen peroxide is used for surface treatment of metals)
- Food processing (sodium hydroxide is used in various food processing applications)

Other examples of inorganic chemicals are:

- Alkali chemicals (such as soda ash and caustic soda)
- Chlor-alkali products (such as chlorine and hydrochloric acid)
- Carbon black (used in the production of tyres and other rubber products)
- Inorganic pigments (such as titanium dioxide and iron oxide)

Demand for inorganic chemicals is driven by their versatility and the availability of raw materials, making them an essential part of various industries. Overall, inorganic chemicals play a significant role in supporting the growth and development of multiple sectors.

In fiscal 2025, inorganic chemicals accounted for approximately 9% of the domestic chemical industry, with a market size of ~$17 billion.

Specialty chemicals

Specialty chemicals are high-value, low-volume chemicals used in specific applications. They are often customised based on the needs of a particular industry or customer and are used to add value to a product or process. Specialty chemicals can be either organic or inorganic.

Some examples of specialty chemicals are:

Dyes and pigments (used in textiles, paints and coatings)

Paints and coatings (used in construction, automotive and industrial applications)

Agrochemicals (used to control pests and diseases)

Surfactants (used to reduce surface tension and types are anionic, non-ionic, cationic and amphoteric)

Flavours and fragrances (used in food, beverages and personal care products)

In fiscal 2025, the specialty chemicals accounted for approximately 18% of the domestic chemical industry, with a market size of ~$37 billion.

Overview of the global chemicals industry

The chemicals industry is a critical enabler of industrial and consumer value chains, supplying materials that underpin sectors such as agriculture, pharmaceuticals, automotive, construction, electronics and consumer goods. The industry encompasses commodity chemicals, specialty chemicals, agrochemicals, polymers and advanced materials.

The global chemicals market is projected to be valued at $4,300-4,500 billion in 2025, comprising a diverse range of chemicals categorised by chemistry, source and end-users.

From a production and trade perspective, China continues to dominate with a share of approximately 39%, supported by large-scale integrated complexes and favourable feedstock economics. The European Union (~15%) and the United States (~13%) follow, with competitive advantages in innovation, regulatory compliance and high-value derivatives. India currently accounts for 3-3.5% of global output, reflecting substantial scope for market share expansion in the coming decade.

Market growth and projections

The global chemicals market is projected to expand at a CAGR of 2-4% through 2030 to $5,000-5,500 billion. Growth will be driven predominantly by Asia-Pacific economies, with sustained demand from end-use industries and incremental contributions from sustainability-driven and technology-intensive segments.

The sector demonstrated resilience during the pandemic-related downturn and has since benefitted from supply-chain restocking, structural demand in healthcare and food security, and accelerated adoption of specialty chemicals in electric mobility, renewable energy and sustainable packaging. Long-term growth will be further supported by regulatory push towards lower-carbon processes, circular-economy initiatives, and advances in bio-based and recyclable materials.

Regional market distribution (2024)

- Asia-Pacific (~55%) remains the largest and fastest-growing region, led by China and supported by expanding capacities in India, South Korea, Japan and Southeast Asia
- Europe (including Russia, ~20%) is strong in high-value specialties, performance chemicals and sustainability-focused solutions
- North America (~15%) benefits from cost-competitive shale-gas feedstocks and leadership in life sciences and advanced materials segments
- Rest of the world (~10%): Africa continues to represent the smallest regional market due to limited industrial infrastructure and investment

Key players

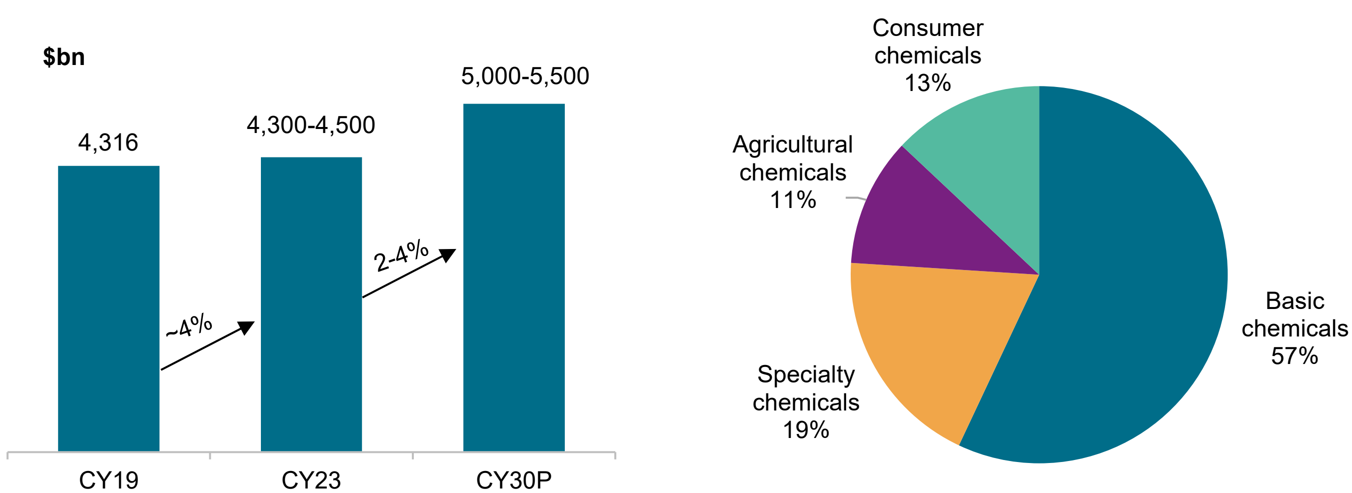
At a country level, China, Germany, Japan and the United States remain the pre-eminent forces in production, innovation and international trade. Leading multinational corporations maintain diversified global footprints, while increasingly evaluating additional manufacturing bases in cost-competitive and geopolitically stable jurisdictions such as India to enhance supply-chain resilience.

Table 1: Key components of chemicals segments

Segments	Sub-segments
Basic chemicals	Inorganic chemicals (caustic soda, soda ash, chlorine, titanium dioxide), bulk petrochemicals and intermediates (ethylene, propylene, BTX, methanol), plastic resins (PE, PP, PVC, PET, PS), synthetic rubber and fibres
Specialty chemicals	Agrochemicals (active ingredients and formulations), electronic chemicals, polymer additives and masterbatches, construction chemicals, water treatment chemicals, adhesives and sealants, flavours and fragrances, dyes and pigments, personal care actives, performance lubricants and fuel additives
Agricultural chemicals	Fertilisers (nitrogenous, phosphatic, potash, complexes), crop protection (insecticides, herbicides, fungicides, biopesticides)
Consumer chemicals	Surfactants, oleochemicals, preservatives, emulsifiers, rheology modifiers used in soaps, detergents, shampoos, cosmetics, oral care, household cleaners

Note: PP – Polypropylene; PE – Polyethylene; PS – Polystyrene; PVC – Polyvinyl Chloride; PET – Polyethylene Terephthalate; BTX – Benzene, Toluene, Xylene
Source: Crisil Intelligence

Figure 17: Global chemicals industry and segment-wise share of the chemicals industry



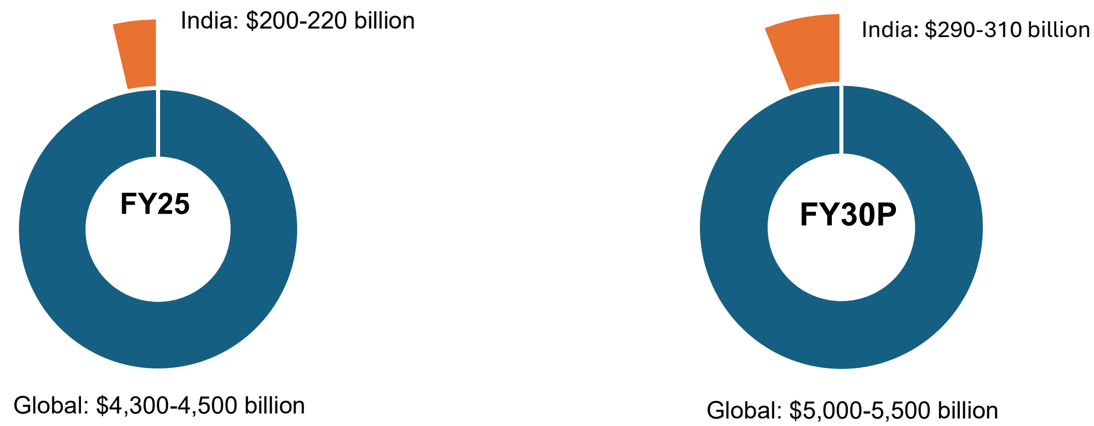
Note: Industry size excludes pharmaceuticals. P: Projected
Source: Crisil Intelligence

- The basic chemicals segment remains the domain of feedstock-advantaged nations and mega-scale integrated players
- Specialty chemicals offer the highest profitability and resilience; leadership is concentrated in Germany, Switzerland, the US, Japan, and increasingly China and India (for cost-competitive innovation)
- Agricultural chemicals are undergoing rapid transformation due to sustainability regulations, patent expiries and the rise of biological alternatives
- Consumer chemicals are seeing a structural shift in the supply chain: While formulation and branding remain with Western fast-moving consumer goods (FMCG) majors, a growing share of functional ingredients is now manufactured in Asia, particularly India and Southeast Asia.

Domestic chemicals industry: A detailed profile

The Indian chemicals industry accounts for 3-3.5% of the global industry and ranks sixth globally and fourth in Asia by production. It was valued at $200-220 billion in fiscal 2025 and is expected to grow 6-8% over the next five fiscals. Inorganic chemicals, petrochemicals and specialty chemicals are the three key attractive segments for manufacturers. The domestic industry produces more than 80,000 products.[1]

Figure 18: India's share in the global chemicals industry



Source: Crisil Intelligence

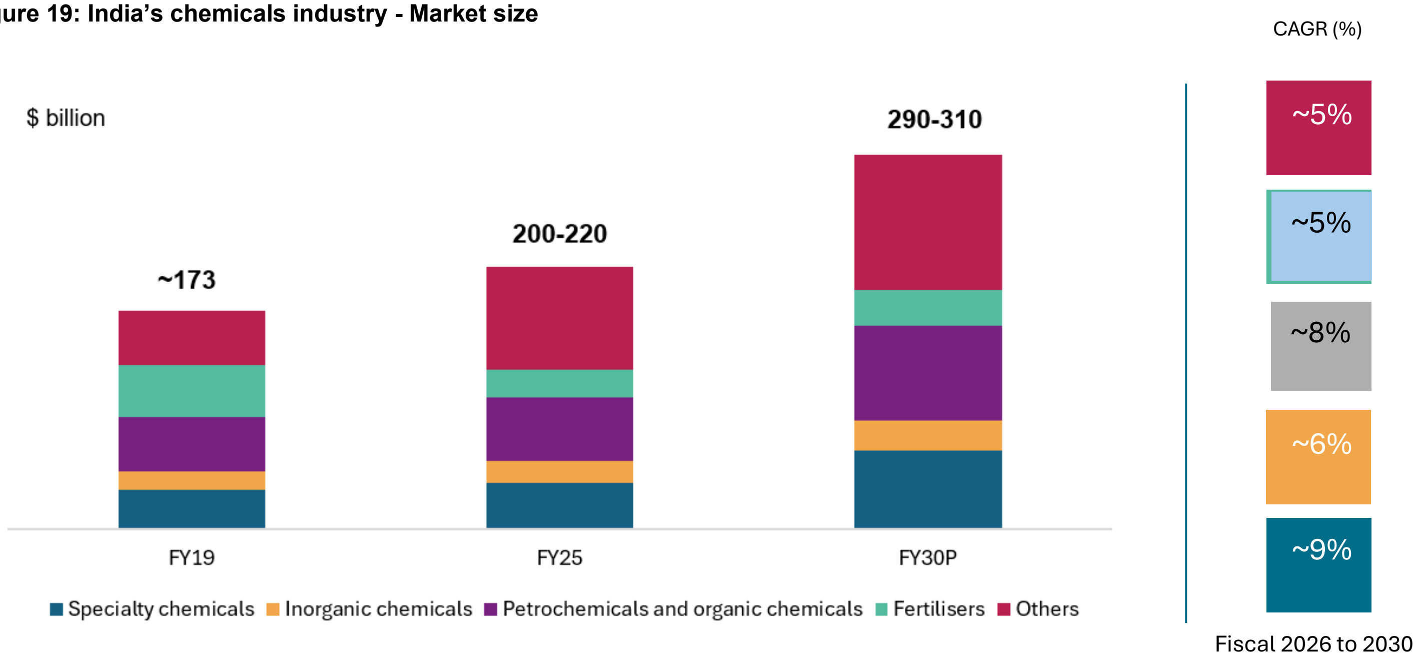
India's chemicals industry is a cornerstone of the country's manufacturing ecosystem, supplying essential raw materials to critical industries such as agriculture, pharmaceuticals, textiles, automotive and construction.

Besides its hold on domestic production, India also captures the export market and ranks 11th in terms of exports by value for chemicals. As of fiscal 2025, India is a net exporter in agrochemicals and colourants, which account for nearly 59% of the specialty chemicals industry total market size domestically. For polymer additives and surfactants segments, which comprise ~29% of the specialty chemicals market, India is a net importer, whereas the textile chemicals and construction chemicals segments operate mostly via domestic production (forming ~12% of the specialty chemical market in India).[2] Owing to limited feedstock materials and minerals, both inorganic chemicals and petrochemicals will have a trade deficit. India's high import requirements highlight a significant shortfall in domestic production, underscoring the need to enhance domestic manufacturing capabilities. By addressing capacity gaps, India can transform its chemicals industry and emerge as a key global player.

[1] India Brand Equity Foundation

[2] *Crisil Intelligence*

Figure 19: India's chemicals industry - Market size



Note: Others include pharma, API, biotech, etc.
Source: Crisil Intelligence

Besides robust domestic production, the industry has a strong export footprint, positioning India as the eleventh-largest exporter of chemicals by value, even though the inorganic chemicals and petrochemicals segments will have a trade deficit due to limited feedstock of materials and minerals.

India's chemicals industry is hindered by structural constraints that limit its growth and integration into global value chains, necessitating government intervention to unlock its full potential. Key challenges include:

1. **High reliance on imports**: India heavily relies on imports, particularly for petrochemical intermediates and specialty chemicals.
2. **Trade deficit**: This reliance on imports has resulted in a significant trade deficit, undermining the industry's competitiveness and sustainability.

By providing targeted support and addressing these structural constraints, the government can help the Indian chemicals industry to achieve its full potential, reduce its trade deficit, and become a more significant player in the global chemicals market.

Infrastructure limitations, including insufficient feedstock availability, inadequate common user facilities, and logistical constraints, further impact cost competitiveness. Additionally, complex regulatory frameworks, environmental compliance hurdles and skill shortages present significant barriers to domestic production and investment.

The Indian petrochemical industry's feedstock allocation is skewed towards producing bulk commodities, rather than higher-value chemicals. For instance:

1. **Propylene**: 95% is used to produce polypropylene (PP) in India, compared with 70% globally[3]

[3] *Powering India's participation in Global Value Chains, July 2025*

2. **Ethylene**: 75% is used for polyethylene (PE) production in India, versus 63% globally[4]

3. **Benzene**: 87% is allocated to alkylbenzene, chlorobenzene and cumene in India, whereas globally only 25% is used for these chemicals, with a larger share going to more complex derivatives[5]

4. **Butadiene**: About 84% is converted to polybutadiene rubber (PBR) and styrene-butadiene rubber (SBR) in India, compared with a global average of 54%[6]

To address this imbalance and make the Indian petrochemical sector more competitive globally, targeted government support is necessary. This could include:

- **Viability gap funding (VGF)** to encourage investments in downstream, higher-value chemical manufacturing
- **Incentives for producing complex derivatives**, such as ethylbenzene, cumene, cyclohexane and nitrobenzene, which have higher value-added potential

By providing targeted support, the government can catalyse investments in higher-value chemical production, helping the Indian petrochemical industry become more competitive and diversified.

India's share of imports has tripled over the past 20 years, clocking the highest growth rate of ~15%, followed by China and Brazil.

Petrochemicals and organic chemicals, specialty chemicals, and inorganic chemicals are the three key segments of India's chemicals industry based on market consumption.

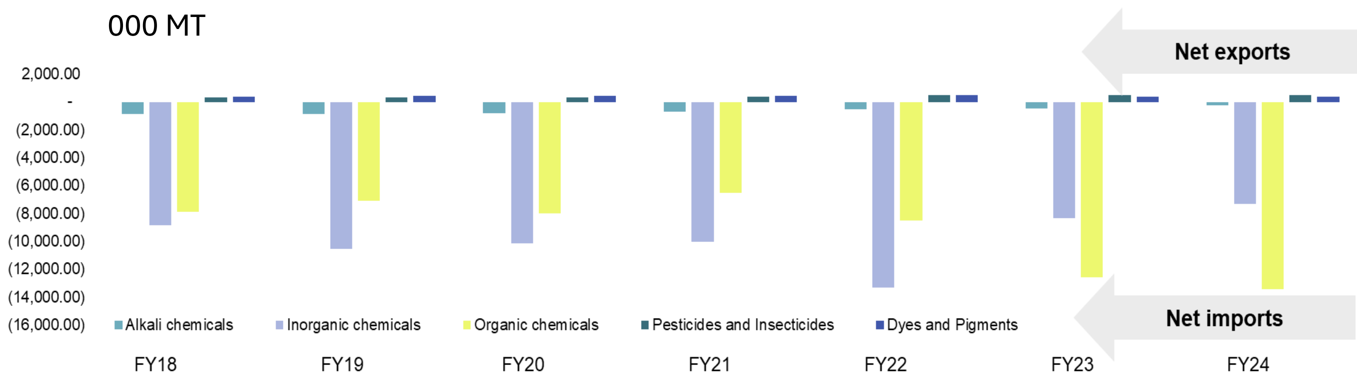
1. **Petrochemicals and organic chemicals:** Derived from petroleum and natural gas, this segment includes polymers, synthetic fibres and performance plastics. It is divided into building blocks, intermediates and end-products, and is the largest chemicals segment, with a persistent production-consumption gap

2. **Specialty chemicals:** High-value, low-volume chemicals that drive innovation and customisation in industries such as pharmaceuticals, agriculture and personal care. Examples include paints, dyes, agrochemicals and surfactants. This category is research-intensive and accounts for a significant portion of India's chemical exports

3. **Inorganic chemicals:** Essential materials for construction, water treatment, electronics and other sectors, these chemicals are a broad category of compounds without carbon-hydrogen bonds. They include metals, salts and minerals, and are used in various industries, such as agriculture, manufacturing and food processing, driven by diverse applications and raw material availability.

[4] *Powering India's participation in Global Value Chains, July 2025*
[5] *Powering India's participation in Global Value Chains, July 2025*
[6] *Powering India's participation in Global Value Chains, July 2025*

Figure 20: India has strong export potential in dyes, pigments and agrochemicals



Source: DCPC, Crisil Intelligence

As the external environment remains challenging, the industry requires short-term support from both the industry and policymakers to achieve the targets and vision set for the future.

Focused and timely interventions can help the industry meet evolving demand, while also ensuring environmental safety and the well-being of workers.

To cater to the increasing demand for chemicals in India, it is essential to significantly boost domestic production capabilities. This can help India achieve several goals, including:

1. **Doubling its share in the global chemicals value chain (GVC)[7]:** India aims to increase its participation in the global chemicals market, targeting a 5-6% share by fiscal 2030
2. **Becoming a net-zero importer:** By ramping up domestic production, India can reduce its reliance on imports and become self-sufficient in meeting its chemical needs
3. **Creating new job opportunities:** The industry is expected to generate 700,000-1 million[8] new jobs by the end of the decade

To achieve these objectives, India needs to double its production of chemicals to $220-280 billion by fiscal 2030. As of fiscal 2023, the country produces chemicals worth around $110 billion.[9] By 2030, the domestic chemicals market consumption is expected to reach $290-310 billion, accounting for 5-6% of global consumption.

This ambitious target requires significant investments, infrastructure development and policy support to drive growth in the industry.

Becoming a net-zero importer

To become a net-zero importer by 2030, India's chemicals industry can adopt a strategic approach that involves:

1. Boosting exports: Increasing exports of specialty chemicals to around $45 billion[10], driven by segments such as:
    - Dyes and pigments
    - Paints and coatings
    - Agrochemicals

[7] *Powering India's participation in Global Value Chains, July 2025*
[8] *Powering India's participation in Global Value Chains, July 2025*
[9] *Powering India's participation in Global Value Chains, July 2025*
[10] *Powering India's participation in Global Value Chains, July 2025*

- Flavours and fragrances

2. Balancing imports with exports: Offsetting imports of petrochemicals and inorganics with increased exports
3. Enhancing domestic production capabilities: Implementing focused initiatives to improve production capabilities, enabling India to increase its share of the global chemicals market and reduce reliance on imports

To achieve this aspiration, India's chemicals industry needs to demonstrate:

- A 10-11%[11] increase in the consumption CAGR to drive demand and growth for the next five fiscals
- A 14%[12] increase in production CAGR to meet growing demand and expand exports

By 2030, the industry can aim to achieve the following export targets[13] to become a net-zero importer:

Table 2: Chemical sector exports target by 2030:

Chemical segment	Export target by 2030
Specialty chemicals	$45 billion
Inorganic Chemicals	$5-10 billion
Petrochemicals	$26 billion

The industry requires targeted investments and interventions to help India meet its 2030 targets.

The industry has several strengths, including:

- Growing domestic demand
- Supportive government policies
- Robust manufacturing capabilities

However, there are challenges that need to be addressed, such as:

- Infrastructure gaps
- Regulatory hurdles
- Need for technological advancements

To overcome these obstacles and capitalise on opportunities, the industry requires a comprehensive road map that includes:

- Targeted investments to drive growth and innovation
- Policy interventions to support the industry
- An innovation-driven ecosystem to position India as a leader in the global chemicals value chain

A structured and strategic approach can help India unlock its full potential and become a major player in the global chemicals industry.

Growth opportunities and trends

The chemicals industry is poised for significant growth, driven by:

[11] *Powering India's participation in Global Value Chains, July 2025*
[12] *Powering India's participation in Global Value Chains, July 2025*
[13] *Powering India's participation in Global Value Chains, July 2025*

1. **Low per capita consumption**: India's per capita chemical consumption is much lower than the global average and that in developed economies such as the US or Germany. This gap reflects under-penetration in end-use sectors such as consumer goods, agriculture and construction, and presents opportunities for new investments.

   For instance, in personal care and pharmaceuticals, rising middle-class aspirations could double demand for specialty chemicals such as surfactants and polymers in the next five fiscals. Investment opportunities are present in greenfield projects for basic chemicals production, supported by the Production Linked Incentive (PLI) scheme. The low base creates fertile ground for both domestic firms and multinational entrants to scale up operations, potentially adding value through localised manufacturing.

2. **Large domestic market**: A vast population, strong agricultural sector, and growing export demand are expected to drive industry growth. With a population exceeding 1.4 billion, India represents one of the world's largest untapped markets for chemicals, particularly in agrochemicals (accounting for 20% of global demand) and industrial inputs. The agricultural sector, employing 40-50% of the workforce, relies heavily on fertilisers and pesticides, with demand projected to grow at a good pace amid efforts to boost farm productivity.

   Meanwhile, export demand is surging in textiles, automobiles and electronics, where chemicals like dyes, resins and adhesives are essential.

3. **Geopolitical shifts**: The global supply chain's shift away from China creates an opportunity for India to capitalise on challenges and become a preferred trade partner. Ongoing trade uncertainties, coupled with post-pandemic supply disruptions, have accelerated supply chain diversification strategies, positioning India as an attractive alternative for chemical manufacturing. The Atmanirbhar Bharat initiative, alongside free trade agreements with the UAE and Australia, enhances this pivot by streamlining logistics and reducing duties. Challenges like raw material shortages persist, but they offer entry points for joint ventures.

4. **Rising gross domestic product (GDP) and purchasing power**: The domestic market holds growth potential as GDP and purchasing power increase. India's GDP is forecast to reach $5 trillion by 2027, which directly correlates with heightened chemical demand across consumer durables, housing, and mobility. Purchasing power parity (PPP) improvements, with household incomes expected to rise, will fuel consumption in high-value segments such as paints, adhesives and water treatment chemicals.

   Government measures such as goods and services tax rationalisation, easier credit access for small and medium-sized enterprises (SMEs) will unlock growth potential, enabling a shift from low-margin commodities to premium products, thereby enhancing profitability margins.

5. **World-class engineering, research and development (R&D) capabilities**: India's strong engineering and research capabilities support the industry's growth. Indian chemical companies have developed cost-effective and efficient production processes.

   For example, the world's largest single-site refinery-cum-petrochemical complex in Jamnagar, has world-scale crackers, aromatics and downstream units that consistently achieve 98–99% capacity utilisation and top-quartile energy efficiency. Similarly, companies have mastered highly complex, multi-step chemistries (e.g., fluorination, high-pressure hydrogenation and continuous-flow reactions) that very few countries outside Germany, Japan and China can execute reliably at commercial scale.

   On the production side, Indian manufacturers excel in backward integration into critical intermediates and raw materials, which will help reduce import dependency and improve margins. These operational and engineering strengths, combined with in-house R&D teams that optimise yields and debottleneck plants, give Indian producers a decisive edge in both commodity and specialty segments. This capability is a key reason global majors are increasingly outsourcing complex molecules and partnering with Indian firms for co-development and toll manufacturing, driving higher value addition and sustained double-digit growth for the sector.

Growth projections

India's share in the global chemicals value chain is expected to reach $290–310 billion by fiscal 2030, clocking a healthy CAGR of 6 - 8%. This reflects India's steady shift from being a large importer to a global-scale producer and exporter. The key macro factors driving this long-term growth are:

1. **Rising disposable incomes**: The expected increase in disposable incomes in India is expected to contribute to household consumption growth by 2030. This will drive higher penetration of chemicals-intensive products in multiple end-use segments, including packaged foods, personal care, household products, pharmaceuticals, coatings and automotive care.

   As households cross key income thresholds, consumption patterns will shift toward branded, performance-oriented and value-added products, creating steady and broad-based demand for a wide range of basic and specialty chemicals.

2. **Urbanisation**: Growing urbanisation and evolving consumer preferences for sustainable and health-conscious options will drive demand for specialty chemicals. India continues to experience rapid urban growth, accompanied by changing lifestyle aspirations and increasing awareness of health, safety and sustainability. These trends are accelerating demand for advanced and differentiated chemical products such as low-VOC (Volatile Organic Compounds) and water-based coatings, eco-friendly surfactants, bio-based materials, performance polymers and functional additives.

   The shift towards modern retail, organised housing, personal mobility and green products is structurally increasing the share of specialty and functional chemicals in the overall consumption basket.

3. **Supply chain diversification**: Global companies seeking to diversify their supply chains present an opportunity for India to become a preferred trade partner. Heightened focus by global corporations on risk mitigation and resilience has accelerated efforts to reduce single-country concentration. India is emerging as a preferred alternative destination because of its scale advantages, established manufacturing base in agrochemicals and pharmaceuticals, improving regulatory alignment and competitive cost structure.

   This global rebalancing is translating into inbound investments, long-term supply agreements, technology partnerships and the qualification of Indian facilities as strategic second sources, thereby providing a durable platform for export-led growth.

Emerging trends

1. **Sustainable and health-conscious products**: Growing demand for eco-friendly and healthy products will drive innovation in the chemicals industry. Heightened environmental awareness and regulatory pressure, combined with evolving consumer preferences, are driving strong demand for eco-friendly, low-toxicity and bio-based chemical solutions. End-use industries such as personal care, home care, paints and coatings, textiles, and packaging are increasingly specifying greener formulations - including biodegradable surfactants, plant-derived additives, water-based resins, and low-VOC or zero-VOC products.

   This shift is compelling manufacturers to invest in green chemistry, renewable feedstocks and circular-economy processes. Companies that develop sustainable portfolios are gaining preferential access to premium domestic segments and regulated export markets (particularly Europe and North America), while also benefiting from favourable incentives under India's evolving environmental framework.

2. **Supply chain resilience**: India can leverage its manufacturing base to boost export capabilities and become a reliable trade partner. Global corporations are actively reconfiguring supply chains to reduce single-country risk and enhance operational continuity. India's established manufacturing depth in agrochemicals, pharmaceuticals, dyes, pigments, and specialty intermediates, coupled with its improving infrastructure and policy stability, positions it as a credible diversification destination.

This trend is manifesting through long-term offtake agreements, vendor qualification programmes, joint-venture investments and the establishment of India-based captive production units by multinational enterprises. The resulting increase in export-oriented capacity and technology inflow is strengthening India's reputation as a reliable, scale-capable trade partner in the global chemicals ecosystem.

3. **Global economic shifts**: India is expected to become the world's third-largest economy by 2030, with middle-income households likely to surge to 181 million[14] in the period, driving demand for chemical products. The resultant surge in consumption of automobiles, housing, consumer durables, packaged goods and healthcare products will directly translate into structurally higher demand across the chemicals value chain - from basic building blocks to high-performance specialties.

   This domestic demand tailwind, combined with India's growing integration into global value chains, is creating a virtuous cycle of scale, investment and innovation that will underpin long-term industry expansion.

Strategic alignment

Raw material availability

Table 3: Key raw materials used in specialty chemicals manufacturing and leading producer countries

Raw material	Methanol	Phenol	Palm oil	Acetic acid	Formaldehyde
Raw material intensity	**High**	**High**	**High**	**Medium**	**Low**
Producer 1	China	China	Indonesia	China	China
Producer 2	Saudi Arabia	US	Malaysia	US	US
Producer 3	Trinidad and Tobago	South Korea	Thailand	Malaysia	Germany

Source: Crisil Intelligence

Methanol, phenol, palm oil, acetic acid and formaldehyde are the key raw materials for the specialty chemicals industry. The table above shows the top three source countries for each.

The Indian specialty chemicals industry remains heavily dependent on imported key starting materials and intermediates. The five critical raw materials collectively form the backbone of several high-growth specialty chemical value chains (e.g., resins, agrochemicals, surfactants, pharmaceuticals and adhesives).

Strategic implications

- High-intensity materials (methanol, phenol, palm oil derivatives) are overwhelmingly sourced from a limited number of countries. This concentration exposes Indian manufacturers to price volatility, supply disruptions and geopolitical risks
- China's dominance in methanol, phenol, acetic acid and formaldehyde creates a structural vulnerability, particularly as global buyers pursue supply derisking strategies while Indian producers still rely on Chinese feedstocks for the same molecules they aim to export
- Palm oil derivatives are tied to Southeast Asia. While geographically closer than methanol or phenol sources, they remain subject to export restrictions (as seen in Indonesia's 2022 ban) and sustainability-related trade barriers in Europe and North America

[14] *Crisil Intelligence*

- Acetic acid and formaldehyde, though less import-intensive in volume terms, are still largely imported or produced domestically using imported methanol, creating indirect dependency

Emerging opportunities and strategic responses

- Backward integration initiatives: Several large Indian players and consortiums are investing in methanol and phenol projects (both coal/gas-based and green methanol routes) to reduce import dependence over the medium term.
- Alternative feedstock strategies: Companies are exploring bio-based routes (e.g., bio-methanol, fermentation-derived acetic acid) and diversifying palm oil derivative sourcing through long-term contracts with Malaysia and new plantations in northeast India and Andaman and Nicobar Islands.
- Policy support: The government is prioritising these molecules under the Petroleum, Chemicals and Petrochemicals Investment Regions (PCPIRs) and the PLI scheme for key starting materials, offering viability gap funding and capital subsidies for domestic mega-plants.
- Inventory and hedging mechanisms: Industry bodies are working with the government to create strategic raw material buffers and coordinated procurement platforms to reduce price volatility.

Table 4: Geopolitical relation with major raw material supplier countries

Raw material	Methanol	Phenol	Palm oil	Acetic acid	Formaldehyde
Supplier country 1	Oman	Thailand	Indonesia	China	Spain
Supplier country 2	Saudi Arabia	Saudi Arabia	Malaysia	Malaysia	Germany
Supplier country 3	Iran	US	Thailand	Singapore	China
Domestic availability	Yes	Yes	Yes	Yes	Yes
Import share	93-98%	35-40%	60-65%	85-90%	~1%

Geopolitical relationship	Positive	Neutral

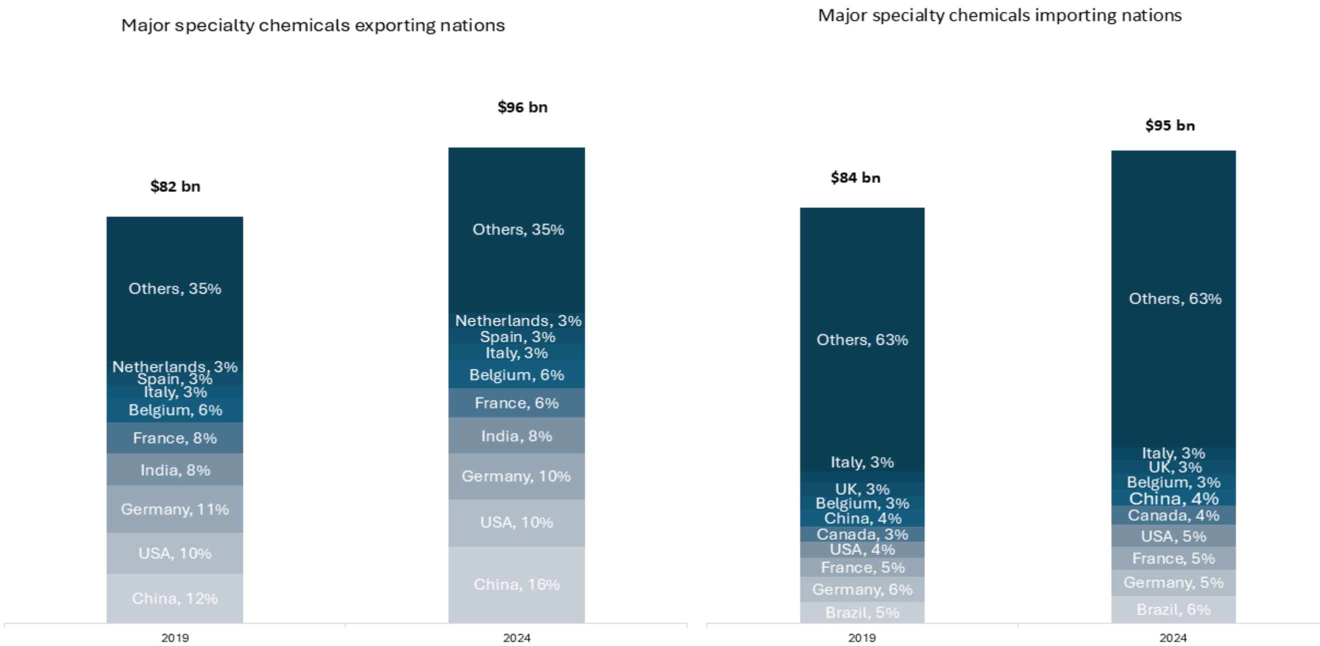
Source: Crisil Intelligence

India imports these materials from multiple countries, often because of lower cost and unutilised capacity. For methanol, major suppliers include Oman, Saudi Arabia and Iran, which together account for over 70% of the total imports. In Iran and Saudi Arabia, methanol is produced from natural gas which is abundantly available there at much lower cost. Phenol is imported from Thailand, Saudi Arabia and US since India's production has not kept pace with the growing downstream demand.

Palm oil is imported from Indonesia, Malaysia and Thailand owing to its low availability in India because of its unsuitable climate. Acetic acid is primarily imported from China, Malaysia and Singapore because of its limited domestic installed capacity. Imports account for less than 1% in formaldehyde supply because of overcapacity in India.

1. World trade

Figure 21: World trade

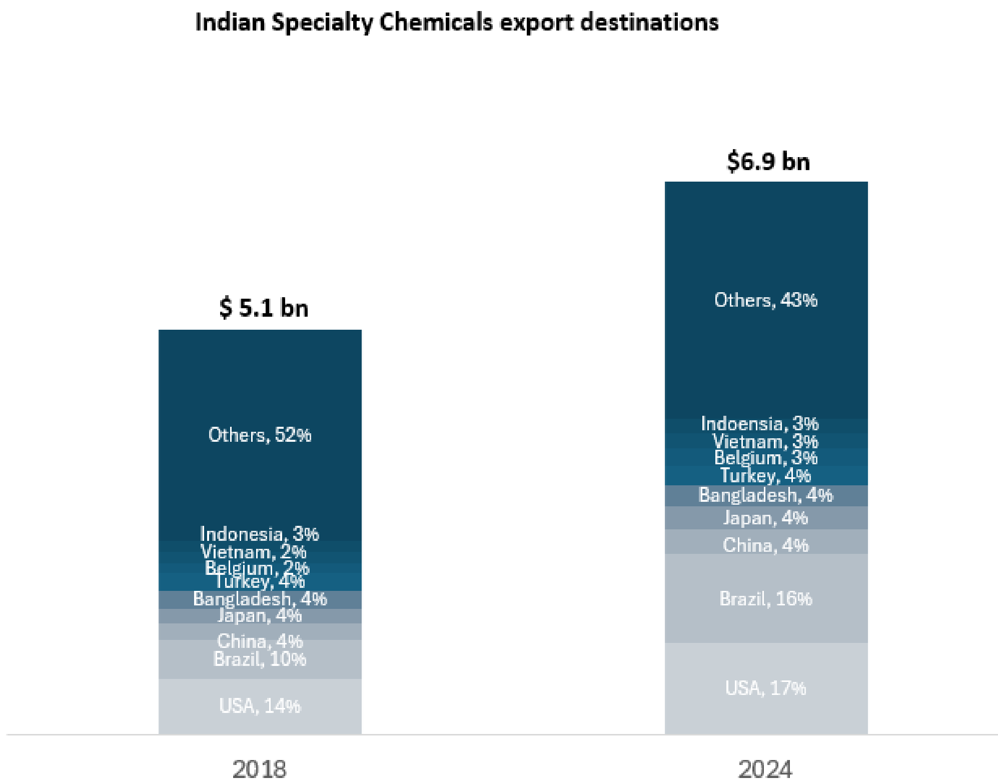


Note: Import and export data includes agrochemicals, dyes and pigments, and surfactants
Source: Trade Map, Crisil Intelligence

China, the US, Germany, India and France dominate the specialty chemical export market owing to abundant low-cost raw materials, strong process engineering capabilities and low-cost manufacturing capabilities. China leads with a 16% share (2024), driven by the country's engineering expertise, technological advancement, high production capacity and abundance of low-cost raw material. The US, with a 10% share, is home to some top specialty chemical players. It is the second largest producer of specialty chemicals with abundant natural resources, a highly skilled workforce and global distribution networks. Germany also holds a 10% share (2024), with companies benefiting from large production facilities, excellent research landscape and world-class infrastructure. India's share (8%) is because of its increased production capacity, technological advancement and favourable government policies, whereas France (6%) is the leading partner in the European Union for chemicals owing to its stable business climate that attracts global investors.

On the import side, Brazil leads with a share of 6%, driven by surging demand from key end-user industries such as personal care and agriculture. Despite its economic strength, the country faces challenges owing to limited domestic investments in R&D. Germany holds a 5% share, mostly importing dyes and pigments despite its strong presence in the specialty chemicals industry. France (5%) depends heavily on imports for raw materials and intermediate products to support its industries and maintain production levels. The US (5%) has substantial import demand, driven by essential inputs used for domestic chemical production. Canada (5%) imports specialty chemicals because of its limited capacity.

Figure 22: World trade



Note: Export data includes agrochemicals, dyes and pigments, and surfactants
Source: Directorate General of Foreign Trade (DGFT), Crisil Intelligence

Indian specialty chemicals exports to various destinations have increased owing to a combination of market demand, trade agreements, competitive manufacturing costs and strategic positioning. In 2024, the US (17%) remained the largest destination, benefitting from the increased technological prowess of Indian manufacturers and infrastructure development in the US. Brazil (16%) is also an important export destination, given its increasing demand from end users such as personal care and agriculture. Bangladesh (4%) has also become a key market, owing to increased demand for specialty chemicals driven by rising requirement for high-performance chemicals and emphasis on value-added manufacturing sectors.

China (4%) mostly imports dyes and pigments from India because of its availability of resources and since they are cheaper. Japan (4%) has also been an important market owing to its commercial relations with India, aided by partnerships such as the Comprehensive Economic Partnership Agreement.

As of calendar year 2024, India's presence in major import markets was limited at ~8%, indicating a huge opportunity for the growth in exports. This share is moderate mainly due to intense international competition and a strong focus on the domestic market. As a net exporter of specialty chemicals, India is poised to see an increase in exports on account of its cost competitiveness, rising international demand and technological advancement. The global shift away from China creates new opportunities for Indian exporters.

To cater to the increasing demand for chemicals in India, it is essential to improve domestic production, which could boost India's share in the global chemicals value chain and transform the country into a net zero importer.

By fiscal 2030, India's chemicals market consumption is projected to reach $290-310 billion, accounting for 5-6% of global chemical consumption. To achieve this, the country’s consumption needs to log a CAGR of 10-11% and production needs to log a 14% CAGR.

This can be accomplished by boosting specialty chemical exports to $45 billion, driven by segments such as dyes and pigments, paints and coatings, agrochemicals, and flavours and fragrances. Additionally, the inorganic chemicals segment could contribute $5-10 billion in exports, while the petrochemicals segment could expand exports to $26 billion from $21 billion.[15]

To become a net zero importer, India aims to balance imports of petrochemicals and inorganic chemicals with $20-25 billion exports of specialty chemicals. Reaching these milestones requires a plan that prioritises investments and interventions.

India's chemicals industry has competitive advantages, including rising domestic consumption, supportive policies and strong manufacturing capabilities. However, challenges such as infrastructure gaps, regulatory hurdles and the need for technological advancements need to be addressed.

To overcome these challenges and capitalise on opportunities, a comprehensive roadmap is necessary. This includes fostering targeted investments, enabling policy interventions and building an innovation-driven ecosystem to position India as a leader in the global chemicals value chain.

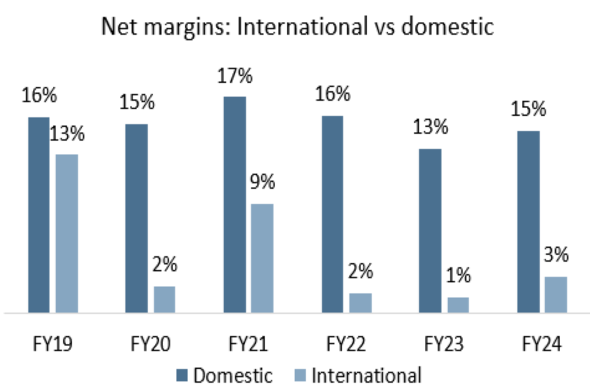
[15] *Powering India's participation in Global Value Chains, July 2025*

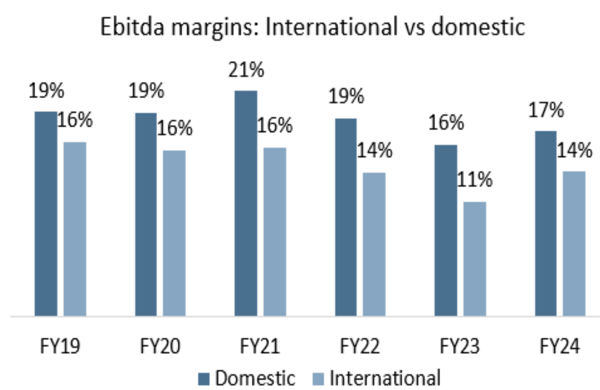
2. Technological readiness

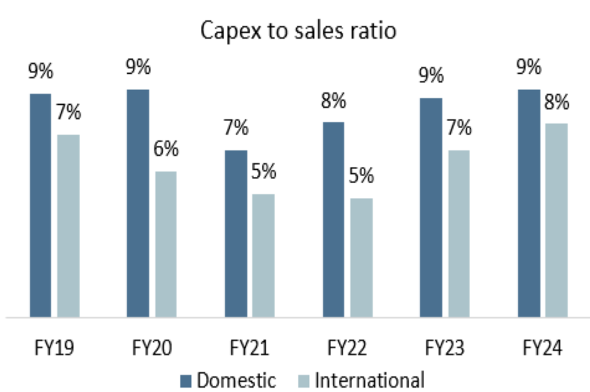
Technological readiness		
Local Availability of Tech	**Foreign partnerships**	**Tech Know-How**
With key player manufacturing specialty chemicals domestically, Indian players have developed technology prowess in specialty chemicals manufacturing	Some foreign players have their subsidiaries in India, in additions collaboration of domestic companies with international companies	India players posses know how to manufacture specialty chemicals and investing in research & development to develop products customized to meet specific customer need.

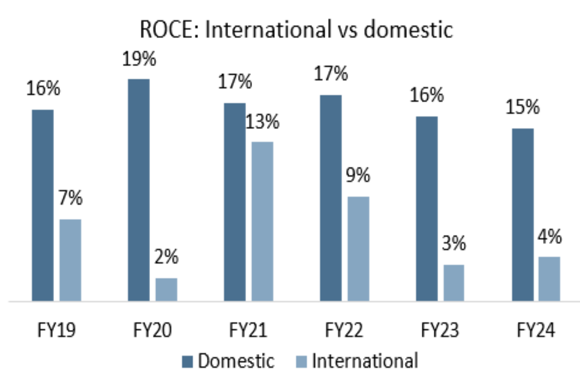
Source: Crisil Intelligence

Financial viability









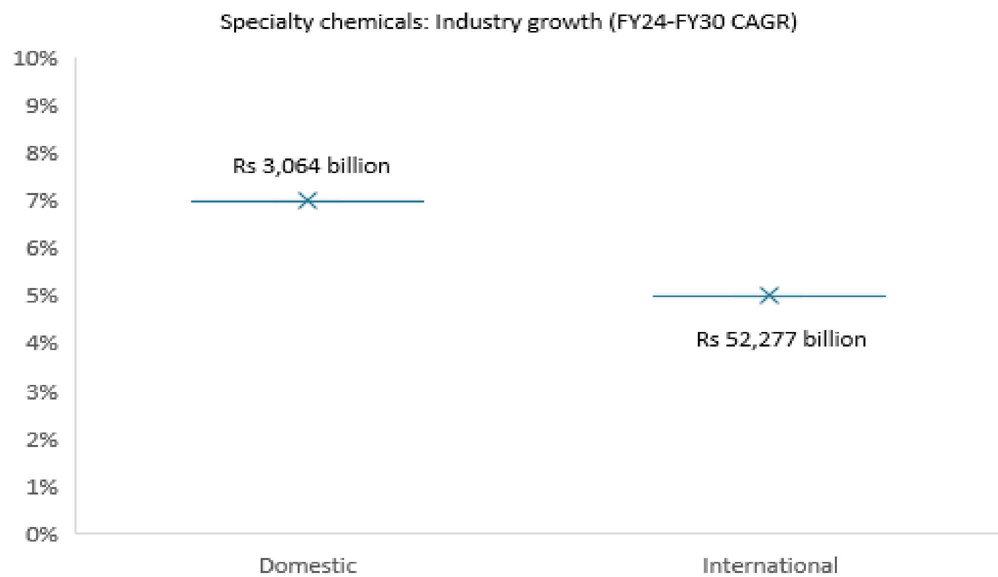
Source: Crisil Intelligence, company reports.
Note: The capex number reflects capital expenditure data reported at the company level.

Operating margins, net margins and return on capital employed (ROCE) are consistently higher for the international players compared with domestic ones, indicating higher input costs and intense competition among domestic players. The industry faces challenges and stiff competition due to China's dominance, driven by its massive production capacity and lower costs. Additionally, international companies benefit from cost efficiencies by leveraging economies of scale, accessing cost-effective global supply chains and optimising production.

Sectoral outlook

The domestic market size as of fiscal 2024 (~Rs 3,064 billion) is estimated to log a CAGR of 6-8% between fiscals 2024 and 2030, driven by increasing demand in domestic and international markets, advancement in chemical technology and shift towards higher value chemicals. In contrast, the international specialty chemical market (~Rs 52,277 billion) is expected to log a moderate 4-6% CAGR due to increasing demand from end-user industries such as automotive, pharmaceuticals, agrochemicals and construction.

Figure 23: Domestic and global growth outlook for specialty chemicals

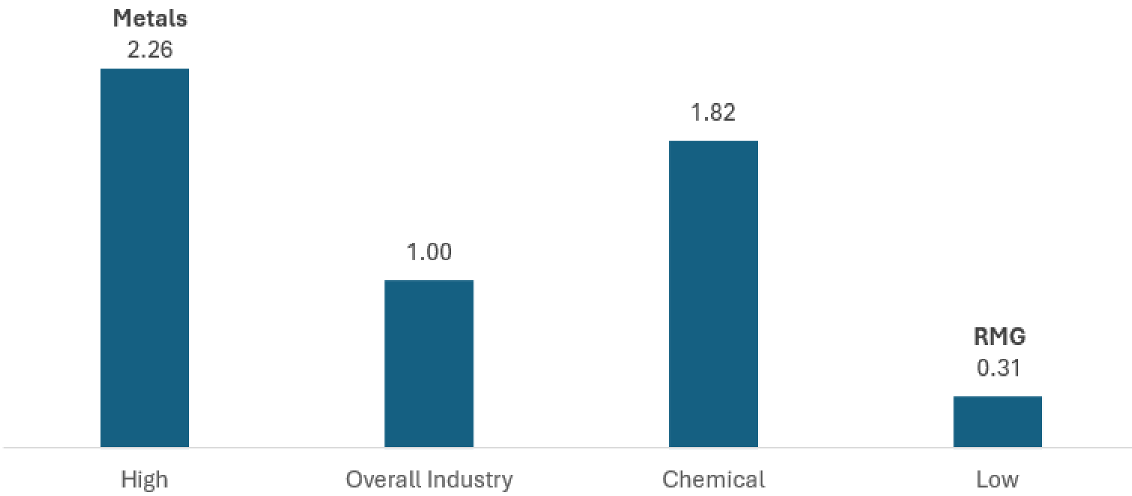


Note: The number represents the market size
Source: Crisil Intelligence, company reports.

Employee productivity

The specialty chemical industry's employee productivity is 1.82 times compared with the aggregate manufacturing sector in value terms on account of its complex manufacturing processes coupled with automation and skilled employees.

Figure 24: Employee productivity

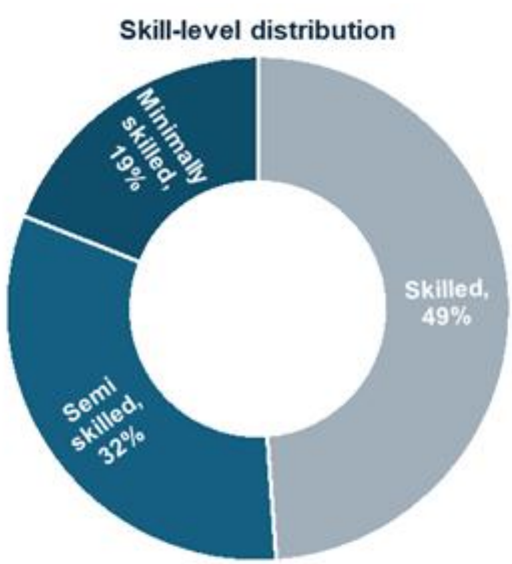


Note: The numbers represent the ratio of gross value added per person engaged in the sector relative to that of the industry, RMG: Ready-made garments
Source: Crisil Intelligence, Annual Survey of Industries 2022

Skill requirement

The chart below shows the skill level distribution in the workforce in the specialty chemical sector. Minimally skilled workers handle tasks like material handling and distribution. Semi-skilled workers operate machinery, perform basic quality checks, etc. Skilled workers are involved in advanced manufacturing, research and development, among others.

Figure 25: Skill requirement



Source: Crisil Intelligence, National Skill Development Corp

Value chain play

The chemical industry is complex and multifaceted, relying on a range of raw materials, including organic and inorganic inputs. The industry can be categorised into several stages, including feedstock, basic chemicals, specialty chemicals, along with marketing and sales.

Feedstock

The chemical industry relies on a range of raw materials. For instance, organic raw materials include oil, gas, coal and bio-based products. Petrochemicals come from oil and gas, while oleochemicals are derived from plants and animal materials, primarily palm kernel oil and coconut oil. Inorganic inputs include minerals, salt and brine.

Basic chemicals

Basic chemicals are produced in large quantities and serve as the building blocks for a range of consumer and industrial products. This includes petrochemicals such as ethylene, propylene and benzene, which are used in plastics and other products. Inorganic chemicals are extracted from raw materials such as brine and minerals using processes such as chlor alkali method. These chemicals are essential for manufacturing a range of products across various industries.

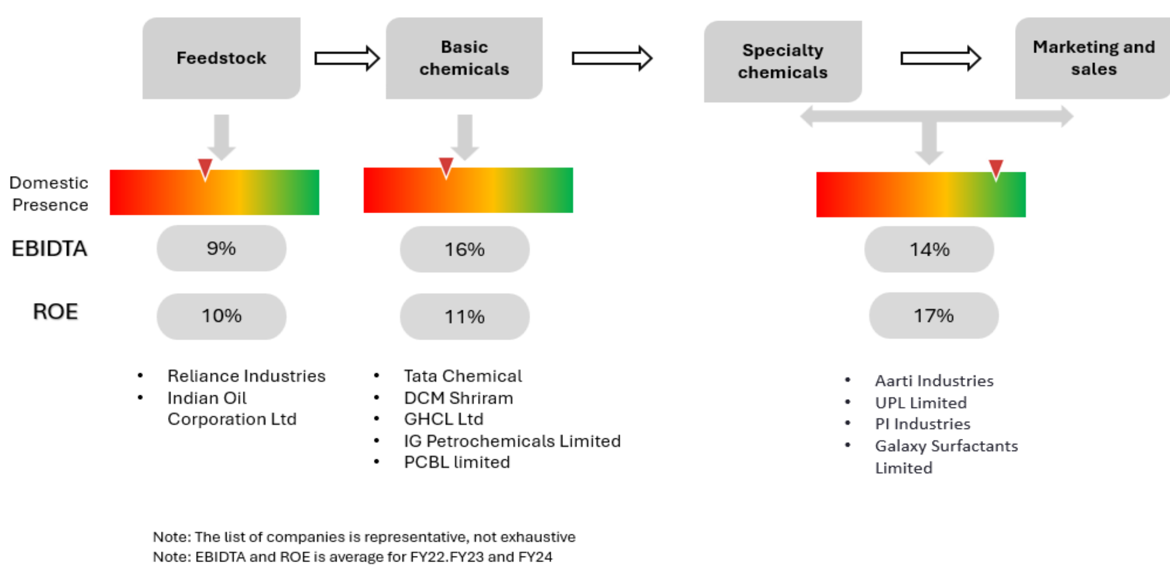
Specialty chemicals

This stage involves production of specialty chemicals such as paint, adhesive, inks, coatings and surfactants. These products are specialised and diverse, designed to meet specific market or customer demands, primarily within other industries. They are directly sold to end markets such as automotive, construction, pulp and paper, printing and textiles.

Marketing and sales

This stage of the value chain focuses on marketing and selling products. These chemical products cater to a diverse range of industries including agriculture, automotive, construction, pharmaceuticals, surfactants and personal care.

Figure 26: Performance benchmarking of India's chemical value chain



Source: Crisil Intelligence, company reports

Profitability lies in specialty chemicals, which are high-margin products. However, in fiscal 2024, margins were affected due to oversupply caused by inventory destocking, increased imports and declining discretionary spending, leading to reduced revenue.

Areas where the sector has government support

Significant market potential and a rapidly growing Indian economy have increased the demand for chemicals.

The following table illustrates support and guidance from the government for India to position its chemicals sector as a global leader:

Table 5: Key government initiatives supporting the chemicals sector

Scheme	Objective
Petroleum, Chemicals and Petrochemicals Investment Regions (PCPIRs)	Under the new PCPIR Policy 2020-2035, the government aims to make a combined investment of $142 billion by 2025, $213 billion by 2030 and $284 billion by 2035 in all PCPIRs across the country. The four PCPIRs — Andhra Pradesh (Visakhapatnam), Gujarat (Dahej), Odisha (Paradeep) and Tamil Nadu (Cuddalore and Nagapattinam) — are expected to generate employment for ~34 lakh people
Supply chain derisking by global multinationals	The rerouting of manufacturing to India has benefited some Indian specialty chemicals players
Anti-dumping duty (ADD)	With the over-supply of chemical commodities, particularly from countries such as China, Taiwan and South Korea, the government of India has implemented proactive anti-dumping measures to safeguard local producers and reduce cheap imports. The ADD is applicable on imports of sodium nitrite, toluene diisocyanate (TDI), purified terephthalic acid (PTA), phthalic anhydride, phenol, aniline, chlorinated polyvinyl chloride (CPVC), isopropyl alcohol and soda ash, among others.
Chemical Promotion Development Scheme (CPDS)	The primary objective of this scheme is to facilitate growth in the chemicals and petrochemicals industry with knowledge dissemination through studies, surveys, data banks and promotional materials. The three main components of the scheme are knowledge-product creation, knowledge dissemination and excellence awards for research and innovation
Centres of excellence (CoEs)	The scheme aims to modernise manufacturing, improve product quality and drive technological advancement by incentivising educational and research institutions. 18 CoEs were approved as of December 2024
Quality control orders (QCOs)	The scheme aims to make adherence to specific product standards mandatory, so domestic manufacturers and overseas suppliers meet the quality and safety parameters set by the Bureau of Indian Standards (BIS)

Source: Crisil Intelligence

Case studies and global best practices

Evaluating countries that lead the chemical manufacturing sector globally and assessing government policies/initiatives/frameworks/incentives which have contributed to the sector's growth, with a focus on nations with high production volumes and those with economic conditions like India. This approach can help in identifying key strategies which India could adopt to boost its own chemical manufacturing sector.

Table 6: Selection of top chemical manufacturing countries

Country	Production ($ billion, CY24)	CAGR (CY24-CY30)
China	2,269	2-3%
India	192	7-9%
South Korea	166	1-2%
Malaysia	47	6%
Indonesia	36	5%
Thailand	26	3%
Vietnam	4	9%

Source: Crisil Intelligence

China, India and ASEAN countries such as South Korea, Indonesia, Malaysia, Vietnam and Thailand are top chemical manufacturing countries, driven by high demand from downstream industries. Among these, China leads through rapid investment and intense competition and fragmentation across large numbers of segments.

India is rapidly growing on account of a favourable regulatory environment, labour utilities and capital cost, while ASEAN countries benefit from government policies, geographical locations and labour cost.

China

Investments in the new chemical segments

In 2023, China accounted for nearly 45%[16] of the total global chemical production and 46%[17] of capital investment. Initially focussed only on basic chemicals to meet the domestic demands with minimal technology requirement, the country now dominates the global market for many commodity and fine chemicals. China holds 55%[18] of the global acetic acid capacity, 50%[19] of the global carbon black capacity and 45%[20] of the global titanium dioxide capacity.

China's petrochemicals and plastics production have logged remarkable growth, driven by strategic investments in infrastructure, research and development (R&D) and by leveraging the country's unique competitive advantages. China's chemical industry accounts for ~23% of global exports and 12% of global imports, while meeting 75-80% of the domestic demand. Over the last two decades, the country has transformed from being a net importer in 2010 to a net exporter across multiple product categories, establishing itself as a dominant player in the global chemical market.

The industry's growth trajectory can be divided into three distinct phases. In the initial phase, state-owned enterprises drove expansion through significant investments and the establishment of small-to-medium-scale production facilities, relying heavily on imported technologies to build critical capabilities, such as, ethylene production. As the industry matured, multinational corporations entered the market, and joint ventures emerged, combining local resources with foreign expertise.

In recent years, government policy reforms have enabled private enterprises to consolidate and develop domestic technologies. This has accelerated the sector's modernisation and large-scale expansion, with privately owned companies now playing a major role in advancing China's petrochemicals and plastics industry.

All such chemicals require relatively low levels of technology and innovation, allowing them to be produced in large volumes, enabling Chinese producers to benefit from strong economies of scale. However, companies focussed on these basic products increasingly face economic pressure owing to intense competition, overcapacity and slowing demand growth.

As a result, the industry is shifting toward new-age chemicals, specialty chemicals and energy transition related products. Several state-owned enterprises have expanded into these emerging areas and are making rapid progress as innovators.

Supply chain competitiveness

The Chinese supply chain has become highly competitive, largely due to its favourable capital expenditure (capex) structure, which is ~70%[21] of that in Western countries. This cost advantage has made China an attractive location for multinational corporations (MNCs) seeking cost-efficient manufacturing locations. Factors contributing to China's competitive advantage include:

1. **Labour costs** In China, labor cost comprises 44[22] percent of overall cost which accounts to 20 to 40[23] percent of the cost of labor in the US. This significant gap allows Chinese firms to maintain a much lower overall cost structure.

2. **Labour productivity**: China has 2-3[24] times higher labour productivity compared with many other regions, resulting in a more efficient supply chain with a greater output in lesser time. This higher productivity enables Chinese firms to produce more goods at a lower cost.

---

[16] China Britan Business Focus
[17] China Britan Business Focus
[18] Information Technology and Innovation Foundation
[19] Information Technology and Innovation Foundation
[20] Information Technology and Innovation Foundation
[21] Powering India's participation in Global Value Chains, July 2025
[22] Powering India's participation in Global Value Chains, July 2025
[23] Powering India's participation in Global Value Chains, July 2025
[24] Powering India's participation in Global Value Chains, July 2025

3. **Competitive supplier network**: China's supplier network is also among the most competitive globally, with continuous price competition driving down material costs. This allows firms operating in China to access key components and materials at significantly lower prices.

4. **End-to-end domestic supply chain**: China offers a distinct advantage through its end-to-end supply chain, enabling companies to source most required materials and services locally. This reduces import costs, minimises supply chain bottlenecks, and enhances overall operational efficiency.

While China's chemical industry has grown rapidly, the country has also faced an economic slowdown and rising geopolitical uncertainties in recent years. Several nations have imposed trade restrictions—such as the US import tariffs, Germany's de-risking efforts, and the European Union's (EU) Green Deal Industrial Plan, which includes tariffs on titanium dioxide imports—creating challenges for Chinese chemical companies.

Despite these pressures, China's competitive supply chain remains its major strength, helping the country to maintain its position as an attractive investment destination. The government continues to support the sector through infrastructure development and initiatives that promote innovation. As the global landscape evolves, China's favourable capex structure, low labour costs, high labour productivity, competitive supplier network and integrated domestic supply chain are likely to sustain its competitiveness and continued growth in the chemical industry.

Regulatory environment and government policies -

Import tariffs and anti-dumping duties

China imposed tariffs on paraxylene, propylene and Ortho xylene exported from Taiwan in 2024, raising the import duty on paraxylene from 0%[25] to 2%[26] that year.

PP copolymer grade tariffs to move up to 6.5%[27] from its duty-free status.

Country to retain the anti-dumping duties on imports of o-chloro-p-nitroaniline from India

Easing trade restrictions

- China's proactive approach to industrial development has been a major driver of its competitiveness. The creation of specialised industrial zones and clusters has significantly reduced production and logistics costs for domestic companies. These zones feature modern infrastructure, including advanced wastewater treatment facilities, energy-efficient systems and compliance with stringent regulatory standards.
- Clustering of companies within the same sector also lowers transportation costs and boosts overall productivity. The government has strengthened competitiveness further by liberalising trade and improving market access for foreign investors. Trade restrictions have fallen sharply—from nearly 200 in 2013 to just a few dozen in 2021. The expansion of free trade zones, growing from 1 in 2013 to over 20 in 2022, has also enhanced China's position as a global manufacturing hub. These zones offer attractive incentives such as reduced barriers and improved market access to international markets, encouraging foreign direct investment and supporting continued economic growth.

Work plan for the petrochemical and chemical industry

China's 14th Five-Year Plan[28], introduced in 2020 during the Covid-19 pandemic, prioritises self-reliance and sets ambitious targets for the chemicals and petroleum sectors, including the development of innovative materials. The plan seeks to achieve high levels of self-sufficiency in various areas, such as:

---

[25] S&P Global
[26] S&P Global
[27] S&P Global
[28] Powering India's participation in Global Value Chains, July 2025

- 70% in engineering plastics
- 90% in specialty rubbers and elastomers
- 85% in high-performance fibres, and
- 75% in new chemical materials

To support these goals, the government is promoting the development of advanced technologies, such as next-generation catalysts, efficient purification processes, and carbon capture and utilisation solutions. China has also outlined strong environmental goals for 2025 under the Industrial Green Development Plan, which include increasing the share of renewable energy to 33%, reducing carbon emissions by 2.6 giga tonnes and limiting crude oil processing.

The government has committed to achieving peak carbon emissions by 2030 and net-zero emissions by 2060, with a focus on carbon-neutral production, carbon capture technologies, and the use of renewable energy and green feedstocks. To support these goals, it has introduced supportive policies and eased trade restrictions, attracting increased foreign investment into the industry.

Additionally, a two-year work plan (2023-2024) was launched to boost the development of the petrochemical and chemical sectors, emphasising energy conservation, carbon reduction, and pollution control. The plan included the following measures:

- Promoting energy efficiency and pollutant emission limits in the refining, ethylene and other sectors
- Encouraging the adoption of intelligent manufacturing technologies
- Improving management of chemical parks and refining fiscal policies
- Securing stable supplies of production factors at reasonable prices through medium-to-long-term contracts

Overall, China's strategic plans and policies aim to drive growth in the petroleum and chemical sectors while minimising the environmental impact and achieving self-sufficiency in key areas.

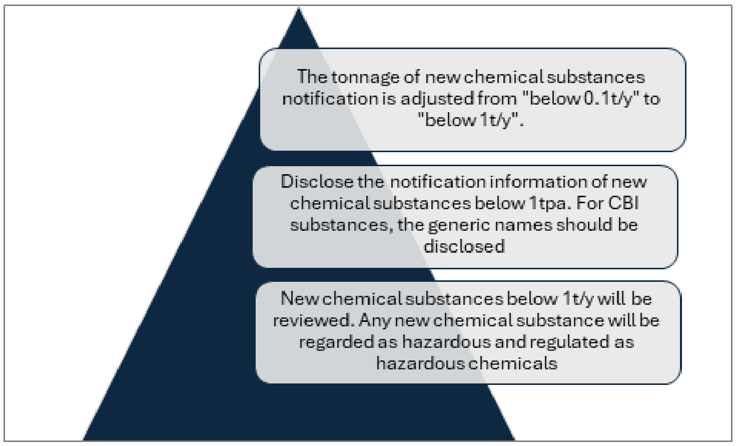
ASEAN (South Korea, Indonesia, Malaysia, Vietnam, and Thailand)

A coordinated approach among South Korea, Indonesia, Malaysia, Vietnam and Thailand leverages each country's strengths to build a self-sustaining regional chemical ecosystem. Governments in these countries are prioritising the sector through significant investments and strategic policies.

Regulatory environment and policies in ASEAN

South Korea

In South Korea, the Ministry of Environment of Korea (MoE) established the Act on Registration and Evaluation of Chemical Substances (K-REACH) in January 2015.



Source: Crisil Intelligence

In 2024, the country revised its requirements for new chemical substances registration under K-REACH. These revisions not only revised the regulatory framework, introducing new requirements for registration, evaluation and risk management of chemical substances, but also aligned South Korea's chemical regulations with international standards, facilitating global trade.

Import tariffs

- South Korea applies a flat 10%[29] value added tax (VAT) on all imports and domestically manufactured goods.
- Tariffs and taxes must be paid in Korean won within 15 days after goods clear customs.

Indonesia

Investment goals

- Indonesia aims to become ASEAN's largest petrochemical producer with $31 billion[30] in planned investments by 2030, focusing on self-sufficiency through the North Kalimantan superhub.
- The country imported $22.2 billion[31] and exported $11.2 billion[32] in chemicals.

Recent developments

- Lotte Chemical Titan is investing $4[33] billion in a new ethylene project. Indonesia's refining capacity stands at 1.1 million[34] barrels per day (b/d), the third largest in the region.

Government actions

- The 'Making Indonesia 4.0' roadmap emphasises reducing imports, expanding domestic petrochemical capacity and developing biofuels and bioplastics.

Malaysia

Investment goals

- Malaysia's chemical industry roadmap 2030 (CIR2030) targets increasing the sector's contribution to over 4.5%[35] of GDP by 2030, with $8.8 billion[36] in added-value contributions.

Recent developments

- CIR2030 identifies base chemicals and specialty chemicals as priority segments, aligning with the New Industrial Master Plan 2030 (NIMP 2030).

Government actions

- The roadmap supports targeted investments and industrial development to advance Malaysia's petrochemical sector into more complex specialties and strengthen downstream capabilities.

Vietnam

Investment goals

---

[29] *Southeast Asia Chemicals*
[30] *Southeast Asia Chemicals*
[31] *Southeast Asia Chemicals*
[32] *Southeast Asia Chemicals*

[33] *Southeast Asia Chemicals*
[34] *Southeast Asia Chemicals*
[35] *Southeast Asia Chemicals*
[36] *Southeast Asia Chemicals*

- Vietnam's chemical industry, valued at $4 billion[37] by 2024, is growing at CAGR of 8.73%[38]. Key segments include fertilizers, pharmaceuticals and petrochemicals.

Government actions

- The 2022 strategy targets 10-11%[39] annual growth by 2030, focussing on sustainable development and technological advancement. It also emphasises cross-ministerial collaboration in policy, investment, technology and workforce development.

Thailand

Investment goals

- The petrochemical industry currently contributes ~5%[40] to GDP, driven by strong domestic demand. The Map Ta Phut complex is a key asset.

Recent developments

- The RAPID project, part of Petronas's $27 billion[41] Pengerang Integrated Complex, includes a petrochemical refinery and related units, although its inauguration has been delayed.

Government actions

- Thailand's 'Bangkok Goals on Bio-Circular-Green (BCG) economy' focusses on climate mitigation, sustainability, trade and effective waste management.

How Asian policies supercharged the chemical industry over the last decade

China

- **Reform and open-door policy (1978):** This attracted foreign investment to special economic zones, fuelling growth
- **Government support:** Low-cost capital, subsidies and relaxed environmental regulations reduced operating costs
- **R&D investment:** Between 2007 and 2017, heavy investments in research and development (R&D) strengthened China's global competitiveness compared with the EU, while Japan saw a modest 1-2% increase in capex and R&D spends.
- **Special economic zones:** These zones offered tax breaks and infrastructure support and attracted significant investment from Hong Kong and Taiwan.
- **Market growth:** China's share of global chemical sales jumped to 42% in 2023 from 24% in 2010, accounting for nearly half of the global supply.

Malaysia

The decline of Malaysia's tin ore and natural rubber industries was driven by government actions after independence in 1957.The government introduced industrial strategies and policies to boost the petrochemicals value chain and attract foreign investment, leading to rapid economic growth in the early 1990s and accelerating the development of the chemical industry. Key government measures that helped the Malaysian chemical industry include:

[37] Southeast Asia Chemicals
[38] Southeast Asia Chemicals
[39] Southeast Asia Chemicals
[40] Southeast Asia Chemicals
[41] Southeast Asia Chemicals

- **Diversification policies:** post-1957, the government focussed on shifting from the traditional (tin and rubber) industries toward manufacturing and chemicals.
- **Attracting foreign investment:** Industrial strategies and policies helped drive economic growth effectively and establish major chemical plants.
- **Establishment of PETRONAS (1974):** Under the Petroleum Development Act, PETRONAS was granted full ownership and rights to explore and exploit Malaysia's oil and gas resources. The company operates through production-sharing contracts, enabling effective resource management and driving industry growth.
- **Infrastructure development:** The Peninsular Gas Utilisation project initiated by PETRONAS in 1984 and completed in 1993, created the country's longest gas pipeline, enabling efficient natural gas transmission.
- **Creation of industrial hubs:** The development of petrochemical hubs in Kerteh, Gebeng and the Pasir Gudang/Tanjung Langsat area provided essential infrastructure and services, attracting major companies.

Indonesia

Since the 1997 economic crisis, Indonesia has prioritised foreign direct investment (FDI) to support job creation, economic growth and poverty reduction. The chemical sector has been a major focus, benefitting from these targeted investment incentives.

- **Investment incentives:** Indonesia has strengthened its efforts to attract FDI through measures such as reduced import duties and easy financing.
- **Infrastructure and jobs:** In the Banten province, investment in the chemical industry has enhanced infrastructure development and generated significant indirect jobs.

Recommendations: Policy initiatives and reforms

Recommendation IA: Strengthen domestic feedstock production

To achieve an ambitious target of achieving a 5-6% share in the global chemical value chain by 2030, with a net zero trade balance, it is essential to identify the chemicals that need to be prioritized for government interventions.

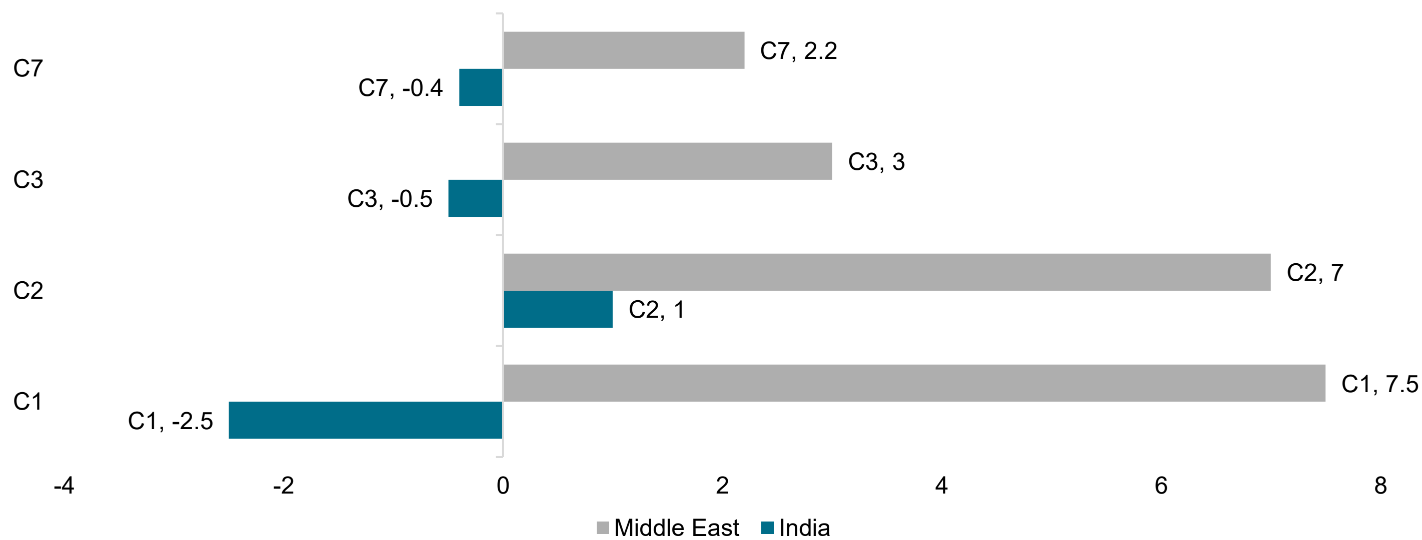
Reducing import dependency

The chemicals industry requires a significant production boost to facilitate import substitution and reduce single-source dependency. The bulk of the domestic demand for essential chemicals is met through imports, which stand at $75 billion. Also, many of these imports come from just a few supplier countries. By increasing production capacity and enhancing product quality, India can become a competitive player in the international market, particularly in segments like specialty chemicals, where it currently has a minimal presence.

The chemicals industry accounts for 30-40% of the total raw material imports within different segments:

- **Deficit in C1, C2, C3 and C7:** India imports 70-80% of high-value raw materials, especially active pharmaceutical ingredients, ethylene and propylene, for the merchant market and methanol and toluene for domestic consumption.

Figure 27: Production capacity versus demand in India and the Middle East (million metric tonne or MMT)



Note: Positive values represent excess production capacities over existing demand, whereas negative values represent a supply deficit
C1, C2, and C3 petrochemicals are derived from hydrocarbons with 1, 2, and 3 carbon atoms, respectively
Source: DCPC, Crisil Intelligence

To reduce import dependency, the government may implement the following strategies:

1. **Identify chemicals for import substitution**: This process involves analysing import data, growth rates and market shares of chemicals. This will help identify chemicals that can be produced domestically.

2. **Provide incentives to encourage domestic production**: The government can provide incentives, like Production Linked Incentives (opex subsidies), to encourage domestic production of the identified chemicals. This can help reduce import dependency and increase domestic production capacity.

3. **Improve infrastructure and logistics**: This can help reduce transportation costs and increase the competitiveness of domestic producers. It includes investing in ports, roads and warehouses, as well as streamlining customs procedures.

Imports are expected to increase in the medium term because of non-availability of raw material. Also, there is a wide gap between gas and methanol prices. Hence, purchasing methanol from the spot market is more cost-effective than producing it in-house. Similarly, there is an increase in the import of toluene because of its use as a precursor in the production of benzene, xylene and TDI.

Forward integration of oil and gas refineries into downstream petrochemical manufacturing, i.e., **crude oil to chemicals** is accelerating. This may limit feedstock availability in the merchant market. Thus, long-term supply agreements or captive production would be critical.

In 2020, the Indian government launched the **coal gasification scheme** to gasify 100 MMT of coal by 2030, thereby reducing reliance on imports, especially of the oil, gas, fertiliser and petrochemical sectors, and conserving foreign exchange.

The government has also approved a Rs 8,500 crore incentive scheme for coal gasification projects, encouraging both private companies and public sector undertakings to participate.

The government is also encouraging public and private players to set up **bamboo-to-methanol plants to produce green methanol.** Cachar Paper Mill in Panchgram (Assam) has already commissioned this project, valued at Rs 2,000 crore. It is expected to generate 18,900 jobs.

Recommendation IB: Promote backward integration

From Petrochemicals side of thing, as much as 50-60% of the feedstock (such as naphtha and natural gas) required for plastics and synthetic fibres is imported in India.

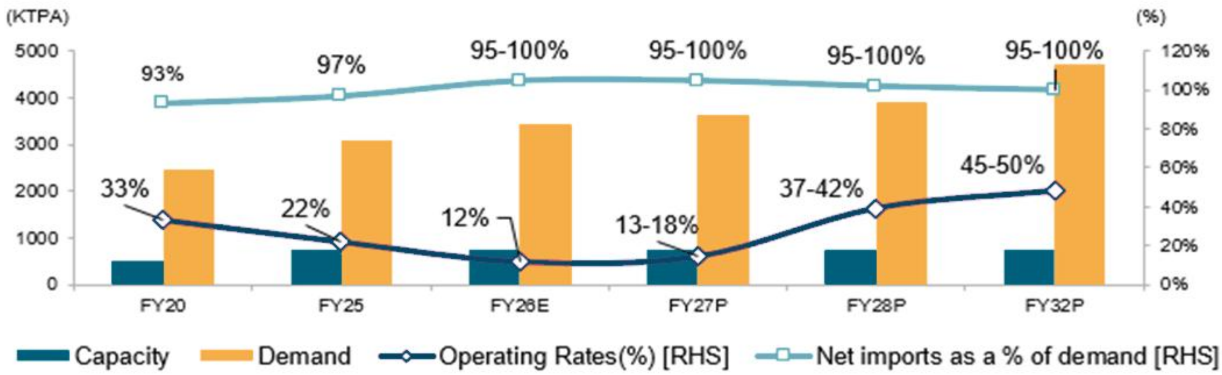
Under the coal gasification projects, India aims to gasify 100 MMT of coal by 2030, this creates a diversified feedstock system that is more resilient to global supply disruptions. The Ministry of Coal is offering a **50% rebate in revenue share** to promote coal gasification. It is also offering long-term coal allotments to gasification plants.

Mega coal to chemicals complexes is catalysing new downstream clusters in methanol-to-olefins, ammonia derivates and synthetic fuels. Co-location of downstream consumers lowers logistics costs, ensures steady feedstock supply and supports globally competitive manufacturing ecosystems.

Integrated chlor-alkali complexes linking chlorine production with downstream PVC, CPVC, chloromethanes, solvents and specialty chemicals-reduce reliance on imports and stabilise chlorine economics. This model ensures consistent feedstock availability for domestic manufacturers and supports industrial competitiveness. Growing requirements of PVC, pharmaceuticals (active intermediates) and water-treatment chemicals justify capacity expansion. This strengthens India’s role as a reliable hub for global supply chains and improves availability of high-value feedstocks in export-oriented industries.

Together, coal gasification and chlorine downstream development broaden India's feedstock base across carbon-hydrogen and halogen value chains. They reinforce global supply chain stability, support regional industrial clusters, reduce import dependence, and strengthen India's role as reliable partner for critical chemicals manufacturing.

Figure 28: Domestic demand for methanol is met largely through imports, driven by rising consumption of formaldehyde, acetic acid, pharmaceuticals and chloromethane



Source: Crisil Intelligence

Recommendation IIA: Ensure integrated infrastructure, faster approvals for PCPIR success

The government has been devising measures to increase the share of the domestic chemical industry in the global market. The challenges that the industry faces and require urgent attention include inadequate infrastructure, regulatory bottlenecks, and shortage of skilled talent. According to a report published by the Department of Chemicals and Petrochemicals (DCPC), the chemical sector should be encouraged to invest in refineries to address the surging fuel demand, increase the processing capacity of crude oil and produce feedstock for downstream industries.

PCPIRs: An overview and current standings

Petroleum, chemicals and petrochemicals investment regions (PCPIRs), introduced by the Government of India under the PCPIR policy, are large, specifically delineated industrial regions planned to promote investment in petroleum, chemicals and petrochemicals in an integrated and infrastructure-led manner.

Each PCPIR was envisaged as a mega industrial region of around 250 square kilometres (sq.km.) or more, with at least 40% of the area earmarked as a processing zone for manufacturing units and the remaining area (non-processing) allocated for residential, commercial, social and institutional infrastructure.[42]

The idea was to move away from fragmented industrial development and create globally competitive clusters with shared utilities, logistics, ports and social infrastructure, reducing costs, improving efficiency and attracting large domestic and foreign investments.

The policy was brought in at a time when India’s chemical and petrochemical demand was rising steadily, but investments were constrained by inadequate infrastructure, regulatory delays and lack of integrated planning. Through PCPIRs, the government aimed to attract large anchor investments, such as refineries and crackers, enable downstream and ancillary industries, boost exports, generate employment and ensure environmentally planned industrial growth.

Four PCPIRs were approved across India—the Dahej PCPIR in Gujarat, the Visakhapatnam–Kakinada PCPIR in Andhra Pradesh, the Paradeep PCPIR in Odisha and the Cuddalore–Nagapattinam PCPIR in Tamil Nadu. Each of these regions was expected to develop around a large anchor petrochemical or refinery complex that would drive downstream investments over time.[43]

Regional overview

The performance of PCPIRs has been uneven, with each chemical hub having its unique strengths and challenges:

Gujarat (Dahej): The Dahej PCPIR in Gujarat is widely regarded as the most successful implementation of the policy. The presence of ONGC Petro Additions Ltd (OPaL), whose petrochemical complex was commissioned in March 2017, provided the region with a strong anchor. Supported by robust port connectivity, early infrastructure development and proactive state government involvement, the Dahej PCPIR has attracted cumulative investments of more than Rs 1.2 lakh crore, as per official ministry data. Employment generation in the region is estimated at ~2.38 lakh jobs, including direct and indirect employment.44 The availability of feedstock, reliable utilities and proximity to export markets have encouraged growth of several downstream chemical and polymer units, making Dahej a functioning industrial ecosystem rather than just a notified zone.

[42] Policy Resolution for Promotion of Petroleum, Chemicals and Petrochemical Investment Regions (PCPIRs)
[43] PCPIR - Department of Chemicals and Petrochemicals
[44] PCPIR - Department of Chemicals and Petrochemicals

Another major factor was Gujarat's early and sustained infrastructure readiness. Port connectivity at Dahej was already operational and continuously expanded, road and rail connectivity were strengthened early, and utilities such as water, power and gas pipelines were developed ahead of demand. Gujarat already had a mature petrochemical ecosystem. Existing refineries, chemical manufacturers, skilled manpower, ancillary industries and service providers reduced execution risk.

Odisha (Paradip): The Paradip PCPIR in Odisha has also made tangible progress, though at a slower pace compared with Gujarat. The commissioning of Indian Oil Corporation's Paradip refinery in February 2016 acted as the anchor project for the region. According to official data, investments of around Rs 47,000 crore have been realised in the PCPIR so far, with employment generation of ~40,000 jobs.45 While the core refinery is operational, downstream petrochemical development has taken time due to infrastructure gaps and phased investment decisions. Nevertheless, the region is considered operational, with continued efforts by the state government to attract petrochemical and chemical manufacturing units around the refinery complex.

Andhra Pradesh (Visakhapatnam to Kakinada): The Visakhapatnam-Kakinada PCPIR in Andhra Pradesh, which has a large, notified area of 640 sq.km. and a strategic coastal location, has not been able to secure a strong anchor petrochemical complex under the PCPIR framework. Official figures indicate investments of ~Rs 18,000 crore and employment generation of ~1.41 lakh jobs, but much of this activity is not directly linked to an integrated PCPIR-led petrochemical value chain.46 Delays in infrastructure development, land acquisition challenges, regulatory coordination issues and the absence of a committed anchor project have limited investor confidence. Reports by government bodies have highlighted execution gaps and lack of momentum as key reasons for the slow progress of this PCPIR.[47]

Land acquisition and environmental clearances faced delays due to local resistance, coastal regulation constraints and administrative coordination issues. Policy continuity at the state level was another challenge. Changes in priorities and focus across administrations reduced momentum and delayed decision-making on large capital-intensive projects.

Tamil Nadu (Cuddalore and Nagapattinam): The Tamil Nadu PCPIR covering the Cuddalore and Nagapattinam region has seen the least progress and is effectively stalled. Although it was initially notified under the PCPIR policy, the state government cancelled the local planning area notification in 2020, which significantly weakened the institutional framework required for its development. As per parliamentary responses, investments in the region remained limited at ~Rs 8,000 crore, with employment below 14,000 jobs and no major anchor petrochemical project realised. Policy uncertainty, local opposition, environmental concerns and shifting state priorities contributed to the lack of progress, resulting in the PCPIR not evolving as originally envisaged.

The region faced strong environmental and social opposition, particularly due to its coastal ecology and existing livelihood concerns. This made land acquisition and project approvals politically and administratively difficult.

More than a decade after the policy was introduced, only two PCPIRs can be considered operational—one is partially realised, and one has effectively stalled.

The experience with PCPIRs shows that policy notification alone is not sufficient to create large industrial ecosystems. Successful PCPIRs have been those with strong anchor projects, early infrastructure development, consistent state support and proximity to ports and markets. Lagging PCPIRs have faced challenges, such as delays in land acquisition, environmental clearances, weak coordination between central and state authorities, lack of anchor investments and policy reversals. As of the latest official position, Dahej and Paradeep PCPIRs are operational, with significant investments and employment, the Andhra Pradesh PCPIR remains underdeveloped relative to its original plan, and the Tamil Nadu PCPIR is not progressing under the original policy framework.

---

[45] PCPIR - Department of Chemicals and Petrochemicals
[46] PCPIR - Department of Chemicals and Petrochemicals
[47] Powering India's participation in Global Value Chains, July 2025

Recommendations and way forward for PCPIRs and Indian chemical hubs

1. Approach to planning and implementation
    a. Formulate an overarching master plan that draws upon the most successful global models and practices in the field
    b. Design and implement a realistic and workable public-private partnership framework capable of mobilising the required financial resources for timely project delivery
    c. Develop a comprehensive feedstock security plan that covers the entire value chain, ensuring consistent and adequate raw material availability specifically for downstream manufacturing units
    d. Create a strong backbone of logistics facilities, general infrastructure, and an interconnected pipeline grid
2. Measures from government
    a. Establish a unified single-window mechanism that enables rapid and expedited approvals
    b. Offer attractive concessions to investing companies, including rebates on GST and income tax, plus exemption from customs duty on imported raw materials/feedstocks
    c. Install dedicated full-time committees and leadership for each PCPIR, along with specialised managerial and technical support teams
3. Launch focused programmes for building skilled manpower

The current institutional framework for domestic chemical hubs faces challenges in implementation, with only Gujarat having a dedicated management board. A central empowered committee and administrative body may be set up at the chemical hub level. The empowered committee will oversee strategic direction, policymaking and investment screening for chemical hubs, while the administrative body will handle day-to-day operations, investment screening, land management and coordination with service providers at the chemical hub level.

Case study on Jurong Chemical Park: A successful model

Jurong Island in Singapore is a global leader in the chemical industry. It ranks among the top 10 hubs worldwide in terms of chemical exports. With an impressive $40 billion investment to enhance its production capacity, Jurong Island has attracted more than 100 chemical companies. The success of the park can be attributed to its high production capacity, well-developed shared infrastructure and excellent strategic connectivity. "Jurong Island boasts a substantial cracker capacity of 4 MMTPA for ethylene and 2.5 MMTPA for propylene, ensuring efficient petrochemical production and a steady supply of raw materials for downstream industries.[48]

Key factors contributing to Jurong's success

1. **High production capacity**: Jurong Island has a substantial cracker capacity, ensuring efficient petrochemical production and a steady supply of raw materials for downstream industries.

2. **Well-developed shared infrastructure**: The island features well-developed shared infrastructure, including utilities and logistics, which lowers operational costs and enhances overall efficiency.

3. **Excellent strategic connectivity**: Jurong Island's strategic location and connectivity through comprehensive transport networks ensure the seamless transportation of raw materials and finished products.

4. **Effective governance and proactive role of the government**: Providing a conducive business environment and streamlining regulatory processes, the Singapore government has played a crucial role in the development of the park.

[48] *Powering India's participation in Global Value Chains, July 2025*

Replicating the Jurong model in India[49]

India can learn from the success of Jurong Island and replicate its principles to the domestic chemical industry. By investing in refineries and petrochemical complexes, building a collaborative ecosystem and developing well-planned infrastructure, the country can create a world-class chemical industry. The government can play a proactive role in providing a conducive business environment, streamlining regulatory processes and attracting investments.

Takeaways from other leading global hubs - Port of Rotterdam, Nanjing Chemical Industrial Park

The Port of Rotterdam is the largest port and one of the biggest petrochemical hubs in Europe. It hosts multiple large refineries and integrated petrochemical complexes operated by various multinational chemical and petrochemical companies.

The Nanjing Chemical Industrial Park is one of China's major state-backed chemical clusters, anchored by large state-owned enterprises and multinational companies.

Some key takeaways from the set-up and success of these industrial hubs:

- Secure and operationalise anchor refinery or cracker projects before notifying large investment regions
- Plan ports, pipelines, storage, utilities and industrial plots as one integrated system
- Front-load core infrastructure instead of waiting for demand to emerge
- Create a single empowered authority with decision-making power
- Ensure long-term land use, zoning and regulatory stability to reduce investor risk
- Build shared pipelines, utilities and effluent systems to lower entry barriers for downstream units
- Enforce cluster discipline by allowing only relevant chemical and petrochemical industries
- Focus on fewer, deeper, execution-ready clusters rather than multiple underdeveloped regions

Proposed governance structure for Indian chemical hubs[50]

The proposed governance structure for Indian chemical hubs includes a central empowered committee and administrative body. The empowered committee will oversee strategic direction, policymaking and investment screening for the hubs, while the administrative body will handle day-to-day operations, investment screening, land management and coordination with service providers at the chemical hub.

Key entities and their roles

1. **Empowered committee**: Oversees strategic direction, policymaking and investment screening for all chemical hubs.

2. **Administrative body**: Handles day-to-day operations, investment screening, land management and coordination with service providers at the chemical hub level.

3. **Anchor tenants**: Provide essential feedstock for downstream industries and work closely with chemical companies.

4. **Infrastructure and services**: Develop shared infrastructure, including utilities and logistics, to lower operational costs and enhance overall efficiency.

Recommendations

1. **Invest in refineries and petrochemical complexes**: Encourage investment in refineries to address the surging fuel demand and increase capacity to process crude oil and produce feedstock for downstream industries.

---

[49] Powering India's participation in Global Value Chains, July 2025
[50] Powering India's participation in Global Value Chains, July 2025

2. **Build a collaborative ecosystem**: Foster partnerships with technology providers and international suppliers of crude oil to strengthen crude oil supply and enhance bilateral energy cooperation.

3. **Develop well-planned infrastructure**: Invest in shared infrastructure, including utilities and logistics, to lower operational costs and enhance overall efficiency.

4. **Streamline regulatory processes**: Provide a conducive business environment and streamline regulatory processes to attract investments and facilitate the growth of the industry.

5. **Attract investments**: Attract investments from domestic and international players to enhance the production capacity and competitiveness of the industry.

By implementing these recommendations, India can make the chemical industry more competitive, sustainable and innovative and ultimately increase its share in the global market.

Recommendation IIB: Upgrade port infrastructure

India has 12 major ports and 205 notified minor ports. Most were developed several years ago and require significant upgrades. The design of existing ports is inadequate to meet the current requirements for faster turnaround and higher cargo volumes, resulting in delays in cargo movement

Key issues/pain-points[51]

I. Insufficient handling capacity

- Indian ports lack dedicated berths and specialised handling capacity for chemicals
- Compared with benchmarks, the gap is large

  i. Antwerp (Belgium): 286 MMT

  ii. Kandla: 138 MMT, Paradip: 135 MMT

With chemical volumes rising, current infrastructure cannot keep pace

II. Limited storage capacity

- Specialised tankage for hazardous and bulk chemicals is inadequate
- Antwerp offers 9.6 MMT + 6.15 million sq. m covered storage, while Indian ports often have 3-5 MMT storage capacity
- Storage shortage leads to delays, longer turnaround time and safety risks

III. Low mechanisation

- Heavy dependence on manual handling due to budget constraints
- Lack of advanced cranes, compressors and vacuum systems slows operations
- Manual processes also heighten safety risks for hazardous materials

IV. Poor last-mile connectivity

- Weak road, rail and pipeline connectivity between ports and chemical clusters

---

[51] Powering India's participation in Global Value Chains, July 2025

- In contrast, Antwerp is within 500 km of 60% of Europe’s consumer market and has seamless multimodal connectivity

- Port infrastructure needs a revamp to boost chemical exports: The industry is seeking world-class port infrastructure for better logistics performance, higher maritime trade, economic growth and higher yield to be able to create a global impact. Indian ports have a far lower handling capacity compared with global standards. This needs immediate attention in terms of expansion.
- India has 12 major ports and 205 notified minor ports. Most were set up several years ago and need to be upgraded at a considerable cost. However, the design of existing ports is inadequate to meet the current requirement for a quick turnaround and handling of increased volumes, which is causing delays in cargo movement. The turnaround time in India, therefore, remains vastly inferior. The government and the port authorities must take appropriate action to bridge such gaps.
- However, Union Budget 2025-26 marks a significant push toward modernising India's ocean freight logistics sector. Strategic initiatives such as the maritime development fund, shipbuilding clusters and tax incentives, port connectivity enhancements under the PM Gati Shakti programme were launched to boost shipbuilding, improve port connectivity and encourage green shipping practices, ultimately driving economic growth and strengthening India's position in international trade.

Recommendations

The type and extent of port infrastructure required for different chemicals varies depending on the chemical's properties, handling requirements and transportation modes.

Liquid chemicals

- Tanker berths: Dedicated tanker berths with suitable draft and mooring facilities to accommodate large tankers.
- Storage tanks: Adequate storage tank capacity to store liquid chemicals, with features such as heating, cooling and nitrogen blanketing.
- Pumping systems: High-capacity pumping systems to transfer liquids between ships, tanks and pipelines.
- Pipeline infrastructure: Extensive pipeline networks to transport liquids to and from storage tanks, processing facilities, and other ports

Dry bulk chemicals

- Dry bulk terminals: Specialised dry bulk terminals with features such as conveyor belts, silos and warehouses to handle dry bulk chemicals.
- Unloading facilities: Grab cranes, bucket elevators or pneumatic conveyors to handle dry bulk chemicals.
- Storage facilities: Adequate storage facilities such as silos, warehouses or open storage areas to store dry bulk chemicals.
- Loading facilities: Loading facilities such as conveyor belts, bucket elevators or pneumatic conveyors to load dry bulk chemicals onto ships or trucks.

Gas chemicals

- Gas terminals: Specialised gas terminals with features such as liquefied natural gas and liquefied gas chemicals.
- LNG terminals: Specialised terminals with features such as regasification facilities, storage tanks and pipelines.
- Petrochemical terminals: Specialised terminals with features such as ethylene crackers, propylene and other petrochemical facilities.

Focus on chemicals to make India a global manufacturing hub for chemical sector:

To enhance the competitiveness of India's chemical industry, the government has proposed a revised governance and operational framework for chemical parks. This framework emphasises centralised coordination, state-level autonomy and seamless integration of stakeholders, with clearly defined accountability and responsibilities.

Global best practices

India can draw inspiration from successful global chemical parks, such as:

1. **Jurong Island in Singapore**: Contributes to ~3% of Singapore's GDP and employs thousands of people.
2. **Ludwigshafen Chemical Park in Germany**: Generates ~€20 billion in annual revenue and is one of the largest chemical parks in the world.
3. **Jubail Industrial City in Saudi Arabia**: Houses over 100 companies and produces ~7% of the world's petrochemicals, generating thousands of jobs.

Institutional framework

The institutional framework for India's PCPIRs could include the following:

1. **High-powered committee**: With representatives from the Union Ministry of Ports, Shipping and Waterways, the Department of Chemicals and Petrochemicals, and senior officials from other central ministries and departments may be constituted. The committee would also seek advice from public and private terminal operators, industry members, and safety and compliance experts.
2. **Management Boards:** Special purpose vehicles (SPVs) that handle master planning, infrastructure development and investment facilitation.

Challenges and opportunities

Despite progress, India's chemical hubs face challenges, such as:

1. Operating difficulties
2. Contractual issues
3. Reluctance from international companies to enter ventures without majority shareholding

To address these challenges, it is essential to:

- Enhance coordination and optimise infrastructure development
- Streamline regulatory processes
- Prioritise sectoral growth
- Address environmental and community issues

By implementing these recommendations, India can overcome its port infrastructure challenges and emerge as a global leader in the chemical sector, driving economic growth and sustainable development. With a world-class port infrastructure, India can enhance its competitiveness, increase exports, and improve safety standards, ultimately achieving its goal of becoming a global manufacturing hub for the chemical sector.

Recommendation III: Leverage FTAs; safeguard domestic growth

The domestic chemicals industry generates more than two million jobs and plays a crucial role in the nation's economic output. However, the industry faces significant challenges, including a widening gap between imports and domestic production, which is forecasted to expand substantially. The free trade agreements (FTAs) that are already signed and that are under negotiations, particularly with the Middle Eastern countries, have brought both opportunities and challenges for the industry. This section examines the impact of the FTAs on the industry, highlighting the gaps and challenges that need to be addressed to make it competitive and self-reliant.

Gaps and challenges[52]

FTAs have a mixed impact on the chemicals industry, with several roadblocks that complicate growth and competitiveness. The key challenges faced by the industry include:

1. **Cost competitiveness and import surge**: India's chemical imports reached nearly $75 billion in fiscal 2023, with China, Saudi Arabia and the United States being major suppliers. The influx of low-cost chemical imports, particularly from the Asia-Pacific FTA partners, has put pressure on domestic players, making it difficult for them to compete with cheaper imports.

2. **Limited protection for sensitive sectors**: FTAs often include sensitive product lists, which allow some sectors protection through tariffs. However, India's sensitive lists do not adequately shield critical segments within the chemicals industry, such as petrochemical intermediates and specialty chemicals, from zero-duty imports.

3. **Impact on value-added manufacturing**: FTAs inadvertently promote raw material imports over local value-added manufacturing expansion, which curtails job creation and economic development. Although India exported around $44 billion worth of chemicals in fiscal 2024, much of this was in lower-value segments, limiting opportunities for more advanced and specialised manufacturing.

4. **Inadequate feedstock and infrastructure support**: FTAs have increased India's dependence on imported feedstock, as most domestic producers lack access to competitively priced raw materials. The lack of basic feedstock infrastructure means that the industry remains exposed to global supply chain risks, further constraining growth.

5. **Overlooked industry-specific needs in FTA negotiations**: FTAs typically focus on broader economic interests without adequately addressing the specific needs of the chemicals sector, which demands a nuanced approach.

Fostering balanced growth from future FTAs

To build a more resilient and competitive chemicals industry, India needs to negotiate FTAs that incorporate specific provisions for the sector. The following initiatives could help:

1. **Targeted FTA negotiations:** India could negotiate FTAs that incorporate industry-focused protections, such as tariff quotas or selective duty exemptions on critical raw materials and petrochemical feedstock, while retaining tariffs on imported finished products to protect domestic manufacturers.

2. **Awareness and effective utilisation of FTAs:** Improving awareness and accessibility of FTA provisions could enhance their utility and ensure that exporters are able to take full advantage of tariff reductions. Simplifying administrative processes, especially around proving the origin of exports, could lower costs and improve compliance.

3. **Promoting localised production and sustainable shipping methods**: The government may promote investments in localised production, sustainable shipping methods and robust trade infrastructure to ensure stability in the future.

Case study: The Indo-Japanese free trade agreement

The CEPA between Japan and India, signed in FY11, has played a significant role in shaping trade relations, particularly affecting India's trade balance in the chemicals sector. Since the agreement, Japan's exports to India have nearly doubled,

[52] *Powering India's participation in Global Value Chains, July 2025*

while India's exports to Japan have seen limited growth, leading to a more pronounced trade imbalance. This imbalance is notably reflected in the chemicals sector, where India's import-to-export ratio with Japan has worsened. The FTA's rules of origin and product-specific norms have created barriers for Indian chemical exports, highlighting the need for a review of the CEPA's terms to ensure that the chemicals industry can better capitalise on export opportunities to Japan.

Going forward, India must prioritize FTAs that avoid such restrictive norms and ensure more balanced, mutually beneficial market access for its chemical industry.

The government may explore to subsidise the outward freight or manage the ocean freight rate and provide freight support packages to help the industry deal with increasing freight rates. It may also introduce competitive financing or tax structures for micro, small and medium enterprises to help them maintain or grow their position in the chemical industry.

FTAs have created a mixed landscape for the Indian chemicals industry, with several challenges that need to be addressed to foster a competitive and self-reliant industry. The government needs to negotiate FTAs that incorporate specific provisions for the sector, promote localised production and sustainable shipping methods, and impose ADD on key chemicals to protect the domestic industry. By doing so, India can build a more resilient and competitive chemicals industry capable of capitalising on global supply-chain opportunities and contributing to the country's economic growth.

Recommendations

1. **Revise customs duty:** Revise customs duty on several products, including laboratory chemicals, phosphoric acid, and boric acid to support domestic manufacturing and curb competition.

2. **Subsidise freight:** Subsidise outward freight or manage ocean freight rates and provide freight support packages to help the industry deal with increasing freight rates.

3. **Competitive finance:** Make available competitive finance or tax structures for micro, small and medium enterprises to help them maintain or grow their position in the chemical industry.

4. **Promote localised production**: Promote investments in localised production, sustainable shipping methods and robust trade infrastructure to ensure future stability.

5. **Imposing ADD**: Impose ADD on several key chemicals to protect the domestic industry from cheaper imports and provide a level-playing field for domestic manufacturers.

By implementing these recommendations, India can foster a competitive and self-reliant chemicals industry capable of contributing to the country's economic growth and development.

Regulatory Framework for Dual-Use Chemicals

- The current framework is approval-centric, resulting in multiple clearances, repetitive documentation and lengthy approval timelines.
- Excessive compliance requirements, overlapping regulatory oversight and procedural delays increase operational and legal risks for legitimate users.
- Regulatory scrutiny focuses more on permissions than on actual industrial end-use, with limited incentives for voluntary compliance and self-disclosure.
- A more facilitative framework is proposed through voluntary disclosure windows, safe-harbour protection, digital reporting systems, risk-based monitoring, standardised end-user declarations and corrective-action mechanisms before penalties.

These measures would improve transparency, reduce compliance burdens and strengthen regulatory oversight.

Conclusion

The Indian chemical industry is a vital component of the country's economy, contributing significantly to its growth and development. The industry has the potential to become a global manufacturing hub, driven by increasing demand from end-user industries, government support and a favourable regulatory environment. However, the industry faces several challenges, including inadequate infrastructure and significant environmental and safety issues.

The government and industry stakeholders must work together to address these challenges, implementing a comprehensive strategy that promotes domestic production, enhances competitiveness and fosters innovation, which can be achieved by investing in research and development, developing infrastructure and providing incentives to support the growth of the industry. The industry must also adopt sustainable practices, reduce its environmental impact and ensure the safety of its workers and the communities.

The Indian chemical industry has a diverse range of products, including petrochemicals, specialty chemicals and inorganic chemicals. The industry is expected to log a CAGR of 6-8% between fiscals 2024 and 2032, driven by the growth of the automotive, construction and pharmaceutical sectors. The industry is also expected to benefit from the government's initiatives to promote domestic production, enhance competitiveness and foster innovation.

To achieve the goal of making India a global manufacturing hub for the chemical sector, the government and industry stakeholders must work together to implement a comprehensive strategy that addresses the existing challenges. The recommendations outlined are poised to significantly help India to achieve economic growth, create job opportunities and increase its global competitiveness.

Key recommendations

1. Promote domestic production and reduce import dependency

The government and industry stakeholders must work together to reduce dependence on imports and enhance competitiveness. By reducing its reliance on imports, India can conserve foreign exchange, mitigate the impact of global price volatility and ensure a stable supply of essential chemicals. This can be achieved through the promotion of domestic production, encouraging investments in the chemical sector and implementing policies that support the growth of the industry.

2. Investing to improve competitiveness

I. **Develop infrastructure**: The government must invest in infrastructure development, including the construction of new ports, roads and railways, and upgrade the existing infrastructure to promote growth. Apart from these, focus on establishing integrated facilities must be on our list to increase our global competitiveness with little reliance on imports

II. **Provide incentives**: The government must provide incentives, such as production-linked incentive schemes, to support growth and encourage investment.

III. **Adopt sustainable practices**: The industry must adopt sustainable practices, such as the use of renewable energy, waste reduction and recycling, to reduce its environmental impact.

By developing a competitive chemical industry, India can enhance its global reputation, attract foreign investments, and become a preferred destination for chemical manufacturing and sourcing. This can lead to increased market share and improved efficiency and productivity.

3. Leverage FTAs while safeguarding domestic industry growth

The Indian chemicals industry faces challenges from increasing imports and evolving trade dynamics. A balanced approach that safeguards domestic industry while promoting global competitiveness will be critical to positioning India as a resilient and globally integrated chemicals manufacturing hub.
To make India a global manufacturing hub for the chemical sector, it is essential to promote and incentivise the production of certain chemicals which have high demand, growth potential and strategic importance.

Table 7: Priority chemicals for enhancing domestic manufacturing capabilities

Chemicals	Domestic capacity (FY25) (KTPA)	Utilisation levels (FY25)	Import value (FY25) ($ million)	Import dependency (FY25)	Import dependency (FY30)	Share (%) of countries in India's import basket (FY25)
Phenol	280	131%	263.48	41%	31%	Thailand – 47% Singapore – 14% Korea – 12% South Africa – 8% US – 7%
Methanol	746.64	15-20%	917.67	85-90%	85-90%	Oman – 50% Saudi Arabia – 22% Qatar – 13% Iran – 5% Bahrain – 4%
Acetic acid	196	80-85%	477.43	85-90%	85-90%	China – 51% Malaysia – 23% Singapore – 14% Taiwan – 7% Oman – 2%

Source: Crisil Intelligence

Phenol's demand is driven by end-user industry growth along with capacity additions of its downstream products such as polycarbonates and BPA. Domestic consumption was at 596 KTPA as of fiscal 2025. Import dependency was reduced to 40% as of fiscal 2025 and is expected to decline to 30% by fiscal 2030 owing to capacity additions by existing as well as new players.

Methanol is one of the largest consumed organic chemicals in India. Domestic consumption stood at 3,309 KTPA for fiscal 2025 and import dependency was at 85-90% as of fiscal 2025; the latter is expected to remain the same till fiscal 2030. Manufacturers opt for imports owing to unfavourable cost economics. No significant methanol capacity additions are expected in the next five years. But, by leveraging coal gasification, India can reduce methanol imports and enhance domestic production. Moreover, India is also aiming for 100 million tonne (MT) coal gasification by 2030 with investments worth over Rs 4 lakh crore, which would help in reducing import dependency.

Acetic acid is one of the major organic chemicals imported in India. Demand for acetic acid stood at ~1,380 KTPA as of fiscal 2025. Import dependency was 85-90% for the fiscal and is expected to remain the same till fiscal 2030 as no capacity addition is planned. There is less incentive for the manufacturer to produce acetic acid because of the high production cost due to dependency on methanol (the primary raw material), for which India is again dependent on imports.

TEXTILES

RMG

Ready-made garments

MMF

Man-made fibres

Policy

Competitiveness roadmap

Table of contents

Textiles

Executive Summary

Textile sector at a glance

2% GDP contribution	**$37.7B** FY25 exports	**46M+** People employed
80% MSME capacity	**4.1%** Global share	**$100B** FY30 target

MMF scale-up · Cotton productivity · MSME modernisation · FTA-led outreach · Sustainability

Sector overview

India's textile and apparel industry (T&A) is one of the country's most important manufacturing sectors, contributing approximately 2% to national GDP, 11% to manufacturing GVA, and 9% of merchandise exports. The sector is also the second-largest employer after agriculture, providing livelihoods to more than 45 million people and supporting widespread MSME-led industrial development. In fiscal 2025, India exported textile products worth USD 37.7 billion and accounted for 4.1% of global textile and apparel exports, making it the sixth-largest textile exporter globally. The sector therefore plays a critical role in advancing India's manufacturing, export, employment, and inclusive growth objectives.

Global opportunity

The global textile industry is expected to reach approximately USD 1.8 trillion by 2027, supported by rising disposable incomes, urbanisation, growth in e-commerce, and increasing demand for apparel, home textiles, and technical textiles. While natural fibres continue to occupy a significant share of global consumption, demand is increasingly shifting towards man-made fibres (MMF), particularly polyester, owing to their durability, versatility, and suitability for performance apparel and technical applications. As global consumption patterns evolve, countries with strong capabilities across both cotton and MMF value chains are expected to be best positioned to capture future growth opportunities.

India's competitive position

India possesses several natural and structural advantages, including a strong raw material base, manufacturing capabilities for complete value chain, and a sizeable domestic market. The country is among the world's largest cotton producers and remains the largest exporter of cotton yarn. However, achieving the government's target of USD 100 billion in textile exports by fiscal 2030 will require India to expand beyond its traditional strength in cotton textiles and develop greater competitiveness in MMF-based segments that are witnessing faster global growth.

Several structural factors are expected to support the growth of India's textile industry over the coming years. Rising incomes, expanding urbanisation, increasing adoption of e-commerce platforms, and growing demand for value-added apparel are expected to drive domestic consumption. At the same time, increasing global demand for technical textiles, sustainable products and MMF-based garments presents significant export opportunities. Government initiatives such as the Production Linked Incentive (PLI) Scheme for Textiles, PM MITRA Parks, the Samarth skilling programme, the National Technical Textiles Mission and the recently announced Mission for Cotton Productivity are expected to further strengthen manufacturing capabilities and improve sector competitiveness.

Lessons from Global Leaders

The experiences of leading textile-exporting countries provide valuable lessons for India.

Bangladesh has emerged as one of the world's leading garment exporters through competitive labour costs, dedicated export-oriented industrial zones, strong infrastructure support, and preferential market access arrangements that have enabled rapid export growth.

Vietnam has strengthened its position through extensive trade integration, strong foreign direct investment inflows, specialized industrial parks, and close integration with global supply chains. The country has successfully leveraged trade agreements and a favorable investment environment to become a major global textile manufacturing hub.

China continues to dominate the global MMF ecosystem through long-term industrial planning, strong policy support, large-scale manufacturing capacities, extensive R&D investments, and integrated supply chains spanning raw materials to finished textile products.

The experiences of these countries underscore the importance of scale, trade competitiveness, integrated manufacturing ecosystems, technology investments, and policy support in building globally competitive textile industries.

Key Challenges Hindering Competitiveness

Despite its strong foundations, India faces several structural challenges that constrain its global competitiveness.

First, the domestic textile industry remains heavily reliant on cotton, even as global demand increasingly shifts towards MMF-based products. Limited availability and higher costs of key MMF feedstocks such as PTA and MEG affect the competitiveness of downstream manufacturers.

Second, manufacturing capacities in critical segments such as weaving and processing remain fragmented, with a large proportion of production concentrated among MSMEs that often face constraints relating to technology adoption, scale, and productivity.

Third, Indian exporters continue to face market access disadvantages relative to competing countries such as Bangladesh and Vietnam, which benefit from wider preferential trade arrangements in major export markets.

Fourth, labour productivity in the textile sector remains significantly below the overall manufacturing average, while gaps in skilling, technology adoption, and innovation continue to affect competitiveness. Private sector investment in research and development also remains limited relative to leading global peers.

Strategic Priorities for Accelerating Growth

To strengthen India's global position and accelerate export growth, the report identifies the following priorities:

- Improve raw material competitiveness by addressing MMF feedstock constraints, improving cotton productivity and quality, and rationalising duties.
- Promote scale through infrastructure support for MSMEs, technology upgradation, larger weaving and processing capacities, and greater foreign investment.
- Expand market access through deeper trade integration and targeted FTAs.
- Enhance productivity through workforce skilling, labour welfare measures, and technology adoption.
- Strengthen emerging segments such as technical textiles, MMF-based products, sustainable textiles, and premium Indian weaves.

Way Forward

India possesses raw material base, a complete value chain, entrepreneurial ecosystem and policy support necessary to emerge as a leading global textile manufacturing destination. However, achieving the target of USD 100 billion in textile exports by fiscal 2030 will require a strategic shift towards MMF-led growth, stronger integration with global value chains, enhanced productivity, improved market access, and sustained investment in innovation and technology. A coordinated policy approach focused on competitiveness, scale, and value addition can transform the sector into a major engine of exports, employment generation, and industrial growth over the coming decade.

Introduction

Textile is one of the oldest industries and encompasses all segments—from cultivation and production of raw fibres such as natural cotton and silk or synthetic fibres such as polyester—as well as the designing, manufacturing and distribution of final products such as yarn, fabric and garments. It is one of the most significant global sectors, covering both small-scale and large-scale enterprises involved in processing and manufacturing of various textile products. These enterprises contribute notably to industrial output, exports and employment.

Against this backdrop, this report aims to evaluate the government policies, initiatives, frameworks, and incentives that have facilitated the growth of the global textile manufacturing sector, with a particular focus on identifying countries that have emerged as leaders in this space. By examining the strategies and best practices of nations with high production volumes, significant export market share, and extensive global coverage, this report seeks to inform the development of targeted interventions that can help India's textile manufacturing sector become globally competitive. Specifically, the report will assess the key strategic priorities that India needs to address in order to drive growth, enhance productivity, and increase its market share in the global textile industry. By doing so, the report aims to provide a roadmap for India's transformation into a global manufacturing hub for textiles.

Overview of Indian textile industry

The textile and apparel industry accounts for 2% of India's gross domestic product (GDP)[53] and 11% of manufacturing GVA[54]. It is also a major export contributor, representing 9% of total merchandise exports[55]. In fiscal 2025, India exported textile items[56] worth $37.7 billion.

As the second-largest employment generator after agriculture, the textile industry provides jobs to over 45 million people[57], including a significant number of women and rural population. Furthermore, nearly 80% of the industry's capacity is spread across micro, small, and medium enterprise (MSME) clusters[58] throughout the country, promoting inclusive growth.

The industry is, therefore, well-aligned with the government's key objectives, including Make in India, Skill India, women's empowerment, rural youth employment and inclusive growth.

On the global stage, India is the sixth-largest exporter of textiles and apparel[59], with a 4.1% share of the global market in calendar year 2024. This significant presence in the global export market underscores the importance of the textile industry to India's economy and highlights its potential for continued growth and development.

The Indian textile and apparel industry is vibrant and diverse, with a value chain spanning the entire production process—from fibre to finished apparel. The value chain includes an upstream segment, comprising cotton fibre, man-made fibre (MMF), cotton yarn, and man-made yarn and filament; a mid-stream segment, that includes cotton, synthetic, and blended fabric; and a downstream segment, comprising readymade garments (RMG), home textiles and technical textiles. The industry's product portfolio is remarkably diverse, ranging from handmade craftsmanship to contemporary and modern fashion, offering a broad range of products.

India is a major cotton producer, accounting for approximately 22% of global output in the 2023/24 marketing year, which runs from August 1st to July 31st[60]. However, the global textile market is shifting towards man-made fibers (MMF).

Over the past three years, India has experienced a decline in cotton production, whereas the production of MMF has shown an upward trend.

Cotton’s virtues such as softness, breathability and versatility make it a preferred choice for apparel and home textiles. However, changing fashion trends and growing demand for durable, wrinkle-resistant and quick-drying fabrics is driving the rise of MMF such as polyester.

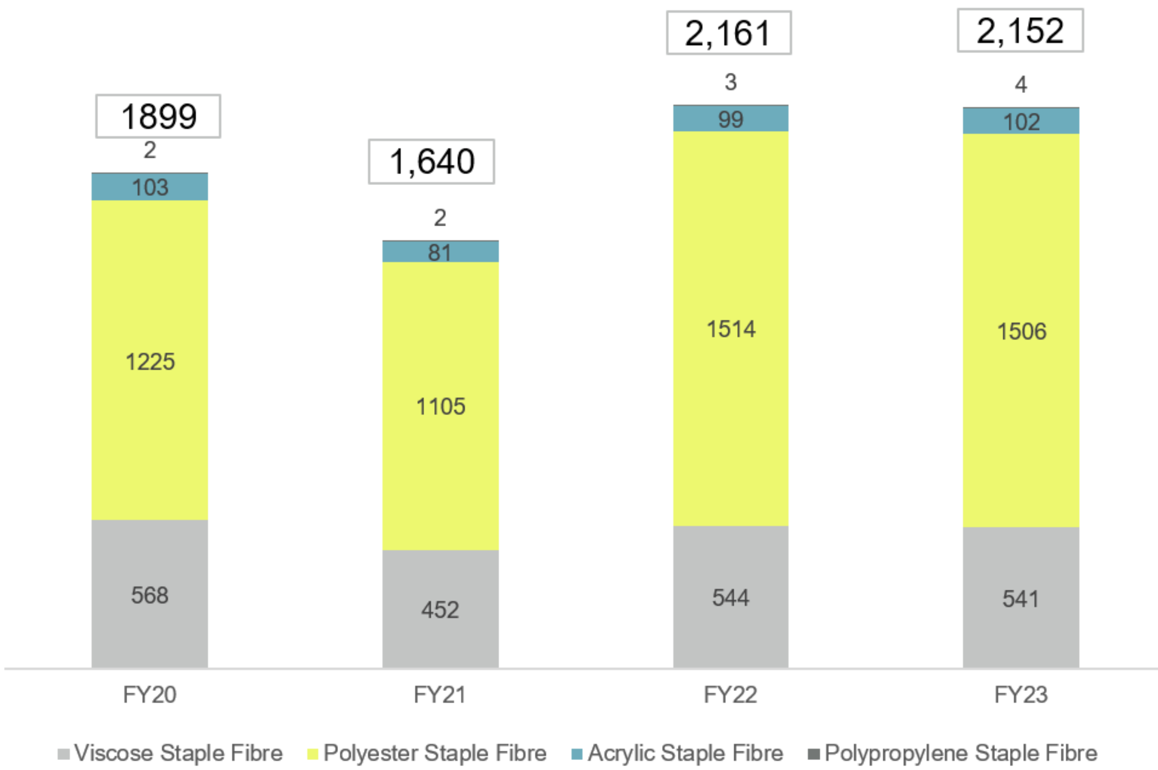
Recognising this shift, the Indian government has introduced several schemes to promote domestic MMF manufacturing, thereby strengthening the country's competitiveness.

---

[53] Ministry of Statistics and Programme Implementation (MOSPI)
[54] Ministry of Statistics and Programme Implementation (MOSPI)

[55] Directorate General of Foreign Trade (DGFT)
[56] Directorate General of Foreign Trade (DGFT)
[57] Press Information Bureau
[58] Economic Survey 2024
[59] Trade statistics for international business development
[60] U.S. Department of Agriculture

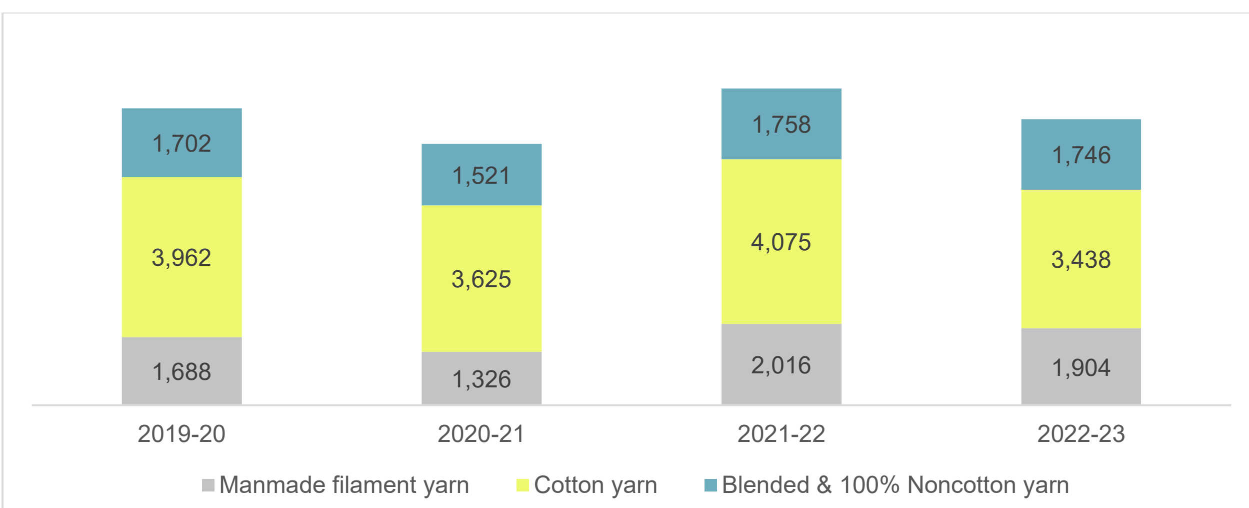
Figure 29: Production of man-made fibre in million kgs



Source: Ministry of Textile, Office of the Textile Commissioner, Crisil Intelligence

Cotton yarn production in India declined 5% annually from 3,962 million kgs in fiscal 2020 to 3,438 million kgs in fiscal 2023. In contrast, production of manmade filament yarn and blended/non-cotton yarn grew 2% annually, reaching 3,650 million kgs. Despite this decline, India remains the largest exporter of cotton yarn, accounting for 29% of global exports in CY 2023. Meanwhile, demand for polyester yarn is rising owing to its versatility and use in technical textiles, performance wear and sportswear.

Figure 30: Production of filament yarn and spun yarn in million kgs

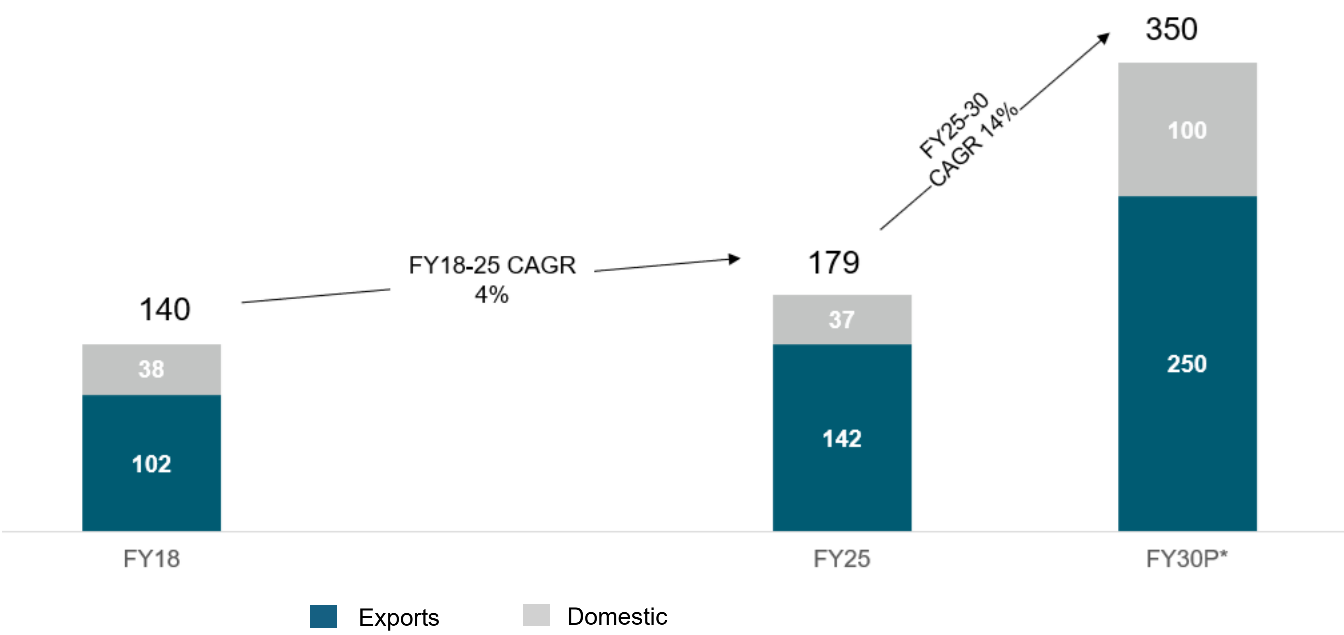


Source: Ministry of Textile, Office of the Textile Commissioner, Crisil Intelligence

Although woven fabric production has increased, India continues to rely on imports owing to quality and cost concerns. In contrast, the knitting fabric segment is more self-sufficient, with local production meeting a significant portion of domestic demand.

The Indian textile and apparel industry comprises both, domestic and export segments. Historically, the domestic segment has grown faster than exports, which have been impacted by the global slowdown, Covid-19 pandemic and high export tariffs levied by the European Union (EU), compared with the zero-import duty for other exporting countries, such as Bangladesh. The domestic industry is divided into ready-made garments (RMG), technical textile and home textiles, with RMG as the largest segment, followed by technical textile. For exports, the industry is RMG-dominated, followed by home textiles.

Figure 31: Indian textile and apparel market – overall market in $ billion



Source: DGCIS, Crisil Intelligence
P- Target set by Government of India*

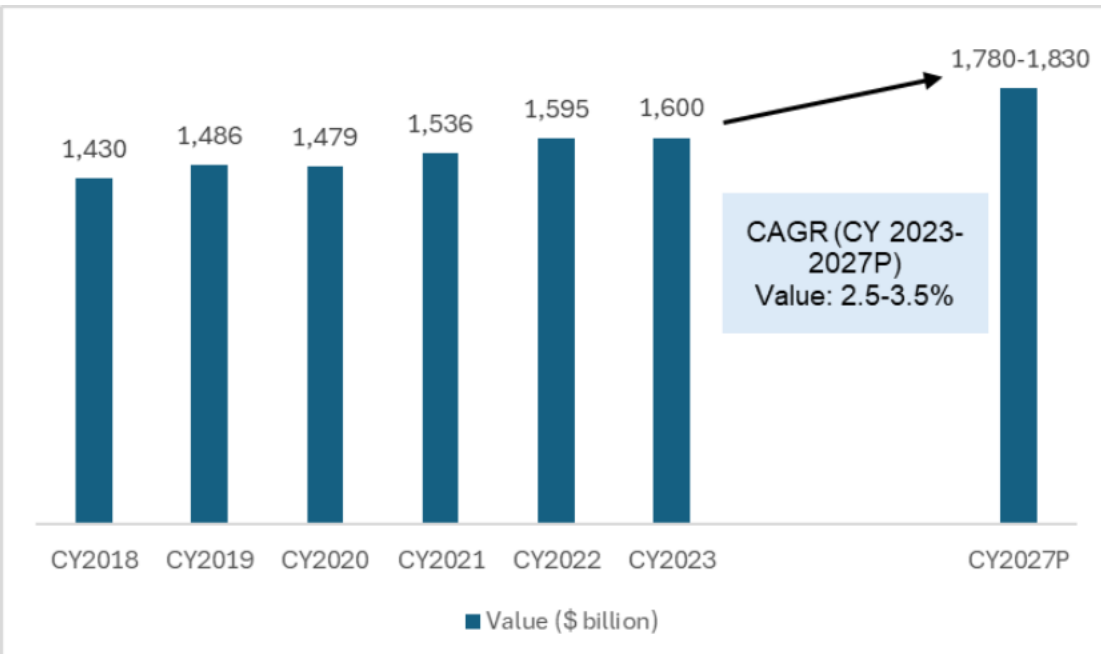
India's textile industry is well positioned globally, particularly in cotton production. However, it faces several challenges that must be addressed to achieve the export target of $100 billion by fiscal 2030 (up from $37.7 billion in fiscal 2024). These challenges include issues related to global demand dynamics, supply chain disruptions, production limitations, competitive disadvantages, and structural inefficiencies. To meet this target, India needs a strategic, multi-layered approach that addresses both industry-specific and broader trade-related challenges.

Global textile industry overview

The global textile industry encompasses a range of products, including upstream segments such as fibres, yarns, and fabrics, as well as downstream segments comprising garments, home textiles and technical textiles. The industry experienced consistent growth from 2018 to 2023, except for Covid-19-linked decline in 2020. The market recovered with 3.8% year-over-year growth in 2021, a 3.9% increase in 2022 and a 0.3% increase in 2023.

The global textile industry is expected to grow at a CAGR of 2.5-3.5% from 2023 to 2027, reaching $1,780-$1,830 billion in revenue terms by 2027. This growth will be driven by fast fashion, the expansion of e-commerce platforms, urbanisation and growing disposable incomes, that are transforming the market and driving demand.

Figure 32: Global textile market



Source: Crisil intelligence and Grandview Research

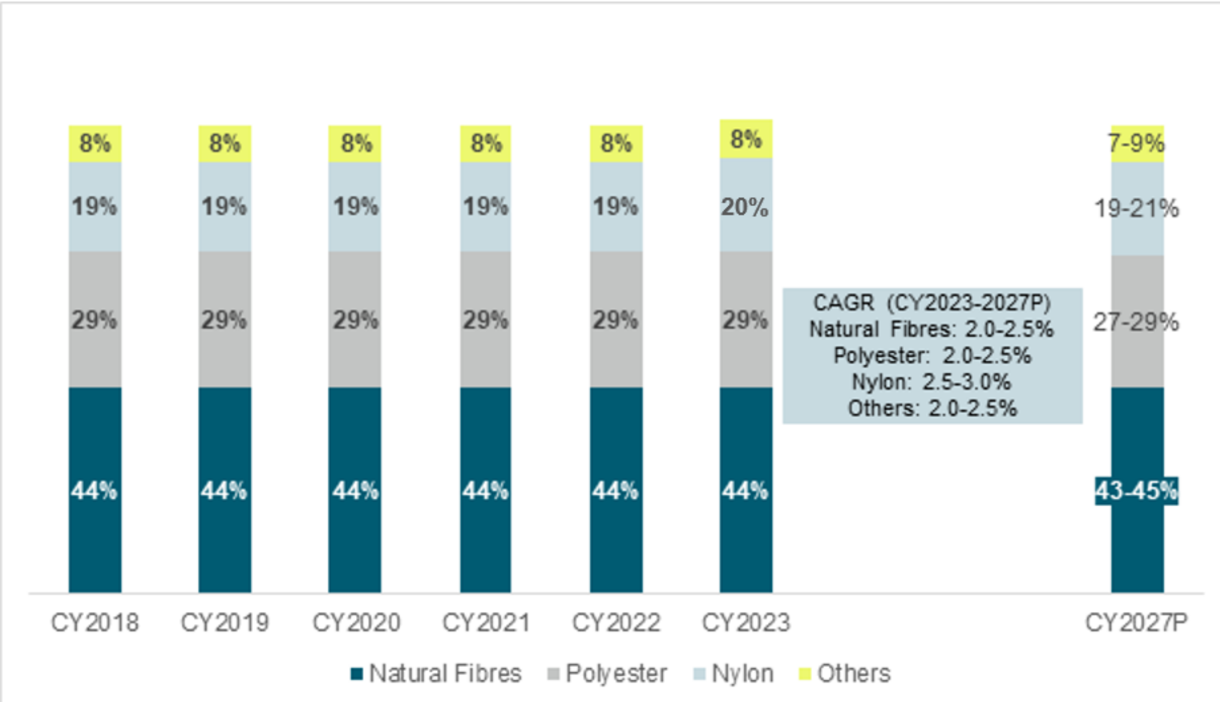
Between 2018 and 2023, natural fibres accounted for ~44% of the textile market in value terms, driven by their versatility, sustainability and environmental appeal. Natural fibres are likely to maintain their leading position going forward.

With a market share of 29%, polyester ranked second in value terms between 2018 and 2023. Its durability, resistance to wrinkles and fast-drying properties made it an ideal material for a wide range of applications in apparel, home textile and technical textile.

At 20%, nylon held the third-largest market share, owing to its durability, elasticity and moisture-wicking properties. Its applications range from women's stockings and parachutes to industrial uses, where its superior strength and stretchability, compared with polyester, makes it a preferred choice, supporting expectations of higher future growth.

In addition to these leading fibres, other segments, such as polyethylene (PE), polypropylene (PP), aramid and polyamide, also hold a significant market presence. Polyethylene's unique properties, including its high resistance to acids and alkalis at elevated temperatures and low moisture absorption, have driven its rising demand. The market share of different fibres is expected to remain largely unchanged by 2027.

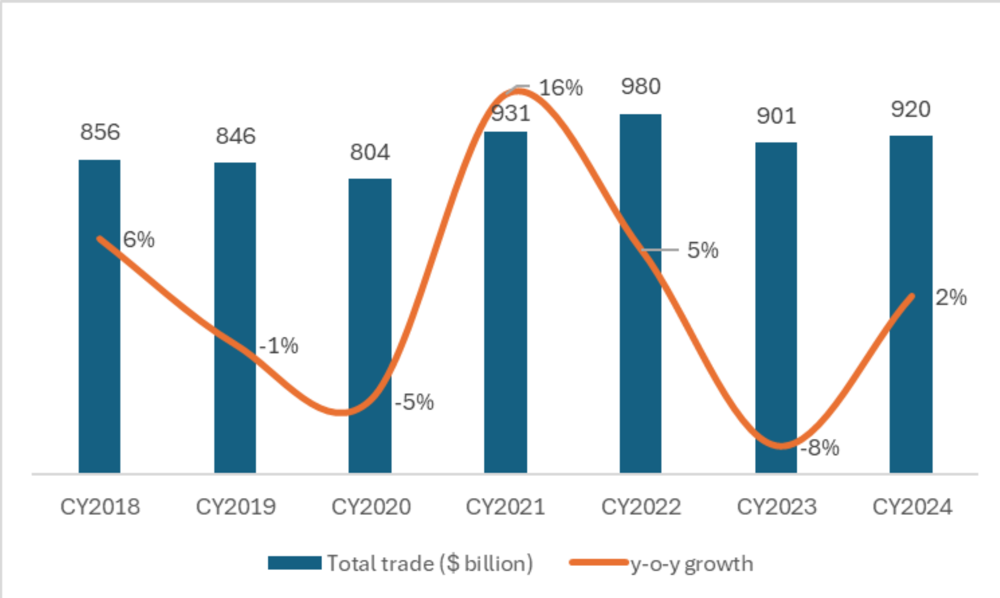
Figure 33: Fibre-wise segmentation of global textiles by value (%)



Source: Crisil intelligence and Grandview Research

The global textile trade logged a CAGR of 1% from 2018 to 2023, reaching $901 billion. Although the Covid-19 pandemic caused a dip in 2020, the trade rebounded in 2021 with a 16% year-on-year increase. However, growth slowed in 2022 and 2023 owing to inflation and weak consumer sentiment, resulting in an 8% decline in 2023. Additionally, within the textiles sector, apparel dominated the global textile trade, followed by fabrics and home textiles.

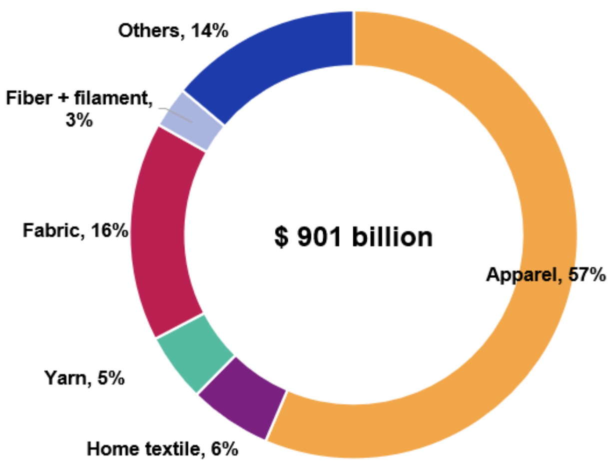
Figure 34: Global textile trade (CY2018-2024)



Note: Trade numbers have been calculated based on global export data; Harmonized System (HS) codes used for analysis include: 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 65, 4203, 4303, 4304

Source: ITC Trade, Crisil Intelligence

Figure 35: Breakup of global textile trade (CY2023)



Source: ITC Trade, Crisil Intelligence

The Asia Pacific region—led by China, India, Bangladesh and Vietnam— remains the largest supplier of downstream textile products, driven by well-established manufacturing capabilities, large labour pools and raw material availability. The US and the EU, on the other hand, serve primarily as major consumption markets.

Textiles value chain

Cotton

Ginning

The textile value chain begins with the planting of cotton in March, April and May, followed by harvesting in September and October. The freshly harvested cotton is then sent to ginning units, where it is processed. Ginning of cotton involves separating raw cotton from seeds to produce lint, the fibre used in spinning. This process is crucial, as it prepares the cotton for the subsequent stages, ensuring that the quality of the fibre is preserved. Ginning plays a vital role in determining the final quality of the yarn, as it removes impurities and short fibres, thereby creating a cleaner and more uniform product that is essential for efficient spinning.

Spinning (cotton)

Following ginning, the cotton lint is spun into yarn, the fundamental building block of textiles. In this stage, cotton fibres are twisted together to create yarns of varying thicknesses and strengths, depending on the intended use.

Weaving and knitting

The yarn is then woven or knitted into fabric, which forms the intermediate stage of the textile value chain. This fabric can vary widely in terms of texture, weight and appearance, depending on the weave or knit pattern used. The fabric is then dyed, printed or finished according to the requirements of the final product, with additional processes such as bleaching or mercerising enhancing its characteristics. This stage is critical as it determines the aesthetic and functional qualities of the final garment.

Garmenting

Finally, the fabric is transformed into RMGs, the end products that reach consumers. In this stage, the fabric is cut, stitched and assembled into various clothing items, ranging from basic apparel to intricate fashion garments. The RMG segment is where the creative and technical aspects of fashion design come together, producing finished products that meet market demands in terms of style, comfort and durability. This final stage is the most labour-intensive and involves various skill levels, from basic sewing to advanced tailoring and quality control, ensuring that the garments meet industry standards and consumer expectations.

MMF (polyester)

Raw material

Polyester is produced through the continuous polymerisation of purified terephthalic acid (PTA) and mono ethylene glycol (MEG). PTA is obtained from paraxylene, which is derived from naphtha, a hydrocarbon produced through crude oil distillation. MEG is produced from ethylene. Ethylene is produced via steam cracking of hydrocarbons (like naphtha or ethane).

Fibre and yarn

PTA and MEG are combined to produce polyester staple fibre and polyester filament yarn. Polyester staple fibre is further converted into 100% polyester spun yarn or combined with materials such as cotton, viscose, wool and other materials to produce blended yarn. On the other hand, polyester filament yarn is made from long, continuous strands of polyester.

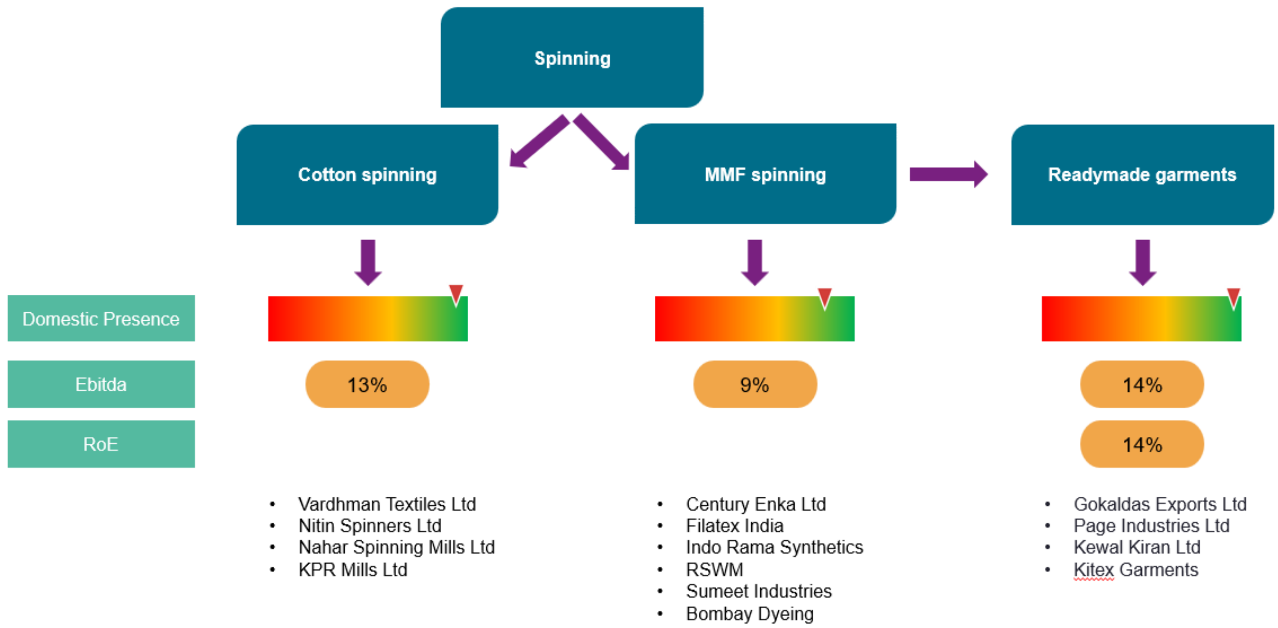
Weaving and knitting

Polyester yarns are then knitted or woven to create blended fabrics, which can be a mix of polyester and other materials, or 100% polyester fabrics. The fabric is then treated with dye, print or finish to meet the final product's requirements.

Garment/ made-ups

Fabric thus generated through weaving and knitting is used to make a wide range of products, including garments like sportswear, activewear and dresses, as well as home textiles like bedspreads, curtains, carpets and tablecloths.

Figure 36: Domestic presence and profitability across textile value chain



Note: Positioning of red arrow indicates the presence in the domestic market
Note: The list of companies is representative, not exhaustive.
Note: EBITDA and RoE are average for FY21, FY22, FY23
Source: Crisil Intelligence, Company Reports

Strategic alignment – RMG and MMF

The RMG segment is a key pillar of the domestic textile industry, accounting for 50-60% of the domestic market and 42% of the country's total textile exports, which amounted to $37.7 billion in the fiscal year 2024, according to Crisil Intelligence.

In the upstream segment, the domestic textile industry is currently dominated by cotton. However, the global shift towards MMF-based textiles has highlighted the need for India to enhance its MMF production capacity. To achieve the government's vision of $100 billion textile exports by fiscal 2030, it is essential to scale up MMF production capacity over the next five years.

Raw material availability – RMG

RMG companies produce apparel, such as shirts and t-shirts, in standard sizes, which are then sold to retailers. In India, the majority of apparel is typically made from cotton, polyester or a blend of both. Natural fibres constitute approximately 65% of the total fibre production in India, with cotton being the predominant fibre, accounting for more than 75% of the natural fibre. Meanwhile, polyester dominates the MMF and filament segment, making up over 80% of the total MMF production (refer to Annexure V).

Table 8: Key RMG raw materials and major producing countries

Raw materials	Cotton	Polyester
Raw material intensity	High	High
Producer 1	China	China
Producer 2	India	India
Producer 3	Brazil	Indonesia

Note: Raw material intensity refers to the proportion of raw material costs to the total cost of the final product
Source: Crisil Intelligence

The table highlights the availability and intensity of raw materials for the textile industry, focusing on two key fibres: cotton and polyester. Cotton has high raw material intensity, indicating its significant availability and utilisation in the global textile industry. China, India and Brazil are the leading producers of cotton, with these countries having vast agricultural areas dedicated to cotton cultivation. These nations not only supply cotton to their domestic industries but also play a critical role in the global cotton trade, making them critical players in the global textile value chain.

The table also indicates that polyester, much like cotton, has a high raw material intensity. This reflects the significant global demand for synthetic textiles, which are predominantly made from polyester fibres. The high intensity of polyester production is driven by its widespread use in various applications, from everyday apparel to industrial fabrics, due to its durability, versatility and cost-effectiveness. Leading producers such as China, India and Indonesia have capitalised on this demand by establishing robust polyester manufacturing industries, supported by readily available petrochemical resources.

India's prominent role in both cotton and polyester production positions it as a versatile player in the global textile industry, capable of catering to diverse market needs. However, domestically, cotton-based textiles have maintained their dominance.

Table 9: Countries from where India procures raw materials

Raw Materials	Cotton	Polyester
Supplier country 1	India	India
Supplier country 2	Australia*	China
Supplier country 3	Brazil*	Indonesia
Domestic availability	Yes	Yes
Import share	5-10%	5-12%

Geopolitical relationship	Positive	Neutral

Source: Crisil Intelligence
**Based on quantity imported in fiscal 2025*

India is one of the largest producers of cotton globally, with a significant portion of its textile industry being self-sufficient in cotton procurement. Extensive cotton cultivation across states such as Gujarat, Maharashtra and Telangana ensures that more than 90% of the cotton used in the domestic textile industry is sourced domestically.

In terms of polyester production also, the country is largely self-sufficient, with major players such as Reliance Industries Ltd, Indo Rama Synthetics (India) Ltd, Filatex India Ltd, Sanathan Textiles Ltd and Bombay Dyeing Manufacturing Company Ltd leading the charge. The country produces a wide range of polyester fibres, which are crucial for both the domestic textile industry and export markets.

According to the Asia petrochemical industry conference (APIC) Country Paper 2025, India's polyester production capacity, which includes polyester staple fibre and partially oriented yarn, stood at ~6.2 million tonne in fiscal 2024. However, the actual production was ~4.8 million tonne, resulting in a capacity utilisation rate of ~ 77%, down from 80% in fiscal 2023. The primary reason for the decrease in utilisation was a slump in demand from the downstream garment and home textile segments.

The availability of raw materials such as cotton and polyester is crucial for India's RMG sector. Having a stable and indigenous supply of these inputs ensure that the domestic RMG industry can operate efficiently and without disruptions that could arise from heavy reliance on imports.

This strong raw material base not only supports domestic manufacturing but also enhances India's competitiveness in the global market. To be sure, India's position as a leading producer and exporter of cotton, particularly cotton yarn, solidifies its importance in the global textile supply chain.

Also, the ability to supply high-quality downstream textiles at competitive prices makes the country a preferred partner for many global brands.

As a result, the RMG sector in India continues to thrive, contributing significantly to the economy via exports and providing largescale employment.

Raw material availability – MMF

India's MMF industry is driven by polyester and viscose, which together account for ~97% of total fibre consumption.
The major raw materials to make polyester are paraxylene, PTA and MEG, with the Indian MMF sector relying majorly on imports of PTA and MEG.

The top three source countries for each of the raw materials for the global textile industry are:

Table 10: Top raw material sources for global textile industry

Raw materials	Paraxylene	PTA	MEG
Raw material intensity	High	High	Medium
Producer 1	South Korea	China	Saudi Arabia
Producer 2	Japan	South Korea	USA
Producer 3	China	Thailand	Canada

Source: Crisil Intelligence

India's limited PTA and MEG capacities can be attributed to high barriers to entry due to the capital-intensive nature of setting up manufacturing facilities. As a result, the market is dominated by a few large players, including Reliance Industries Ltd, MCPI Pvt Ltd and Indian Oil Corporation Ltd in PTA production, and Reliance Industries Ltd, India Glycols Ltd and Indian Oil Corporation Ltd in MEG production.

Second, India's dependence on crude oil imports, a key feedstock for PTA and MEG production, exposes the industry to significant risks, including price volatility and exchange rate fluctuation. The uncertainty and volatility of crude oil prices, combined with the depreciation of the rupee, can increase the cost of feedstock procurement, affecting the competitiveness of domestic production.
India imports PTA and MEG from multiple countries, primarily due to cost and logistical considerations.

Table 11: Countries from where India procures raw materials

Raw materials	PTA	MEG
Supplier country 1	China	Kuwait
Supplier country 2	Taiwan	Saudi Arabia
Supplier country 3	Thailand	Singapore
Domestic availability	Yes	Yes
Import share	~25%	~35%

Geopolitical relationship	Positive	Neutral

Source: Crisil Intelligence

Domestic production meets about 75% of India's PTA demand and ~65% of its MEG demand, with the remainder met through imports

The presence of a large-scale petrochemical industry in China and Taiwan, mainly in the aromatics value chain, has resulted in the countries becoming major exporters. Furthermore, availability of cost-effective raw materials (crude oil and natural gas) has resulted in Kuwait and Saudi Arabia becoming India's major trade partners.

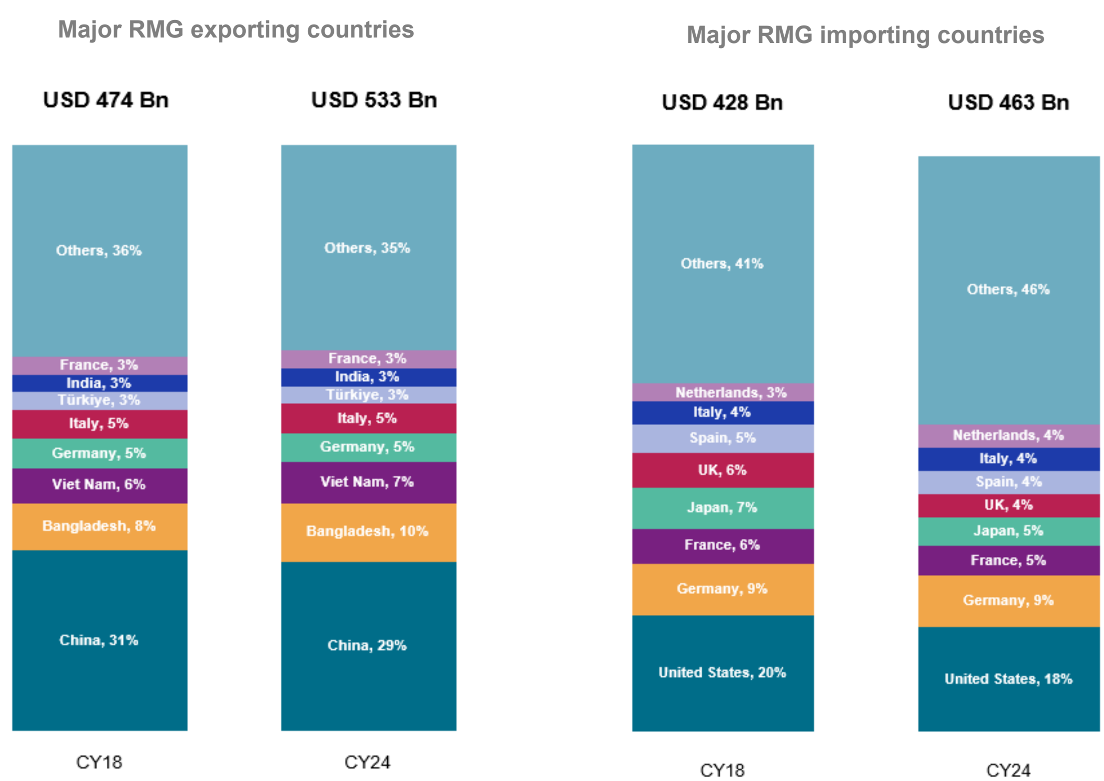
Global trade – RMG

China is the world's largest exporter of RMG, accounting for ~29% share, owing to its robust domestic manufacturing capabilities. However, its share in the global RMG export market has declined due to ongoing supply chain derisking by manufacturers and a ban on Xinjiang cotton.

Asian countries, particularly Bangladesh and Vietnam, play an important role in the global RMG industry. These countries are leveraging their large labour base, cost-effective production capabilities and growing industrial capacities to become dominant exporters in the RMG market. Over recent years, their influence has only grown, reflecting a broader trend, where Asian economies are increasingly becoming the world's manufacturing hubs, supplying garments to developed markets.

On the other hand, developed countries such as the US, Germany and other European nations continue to be the largest consumers of these garments. These countries import vast quantities of RMGs, driven by strong consumer demand and reliance on global supply chains that source affordable and diverse fashion products from Asian manufacturers. These dynamics underscore a global trade pattern, where production is concentrated in developing economies and consumption is predominantly in wealthier, developed markets.

Figure 37: World Trade



Note: HS codes 61 and 62 considered
Source: Trade Map, Crisil Intelligence

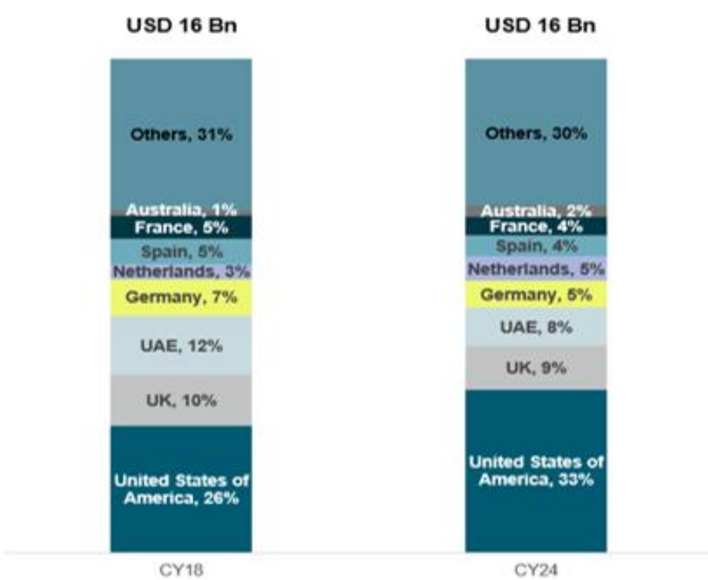
The market share trends illustrated in the charts suggest that Asian manufacturers, particularly those in Bangladesh and Vietnam, are increasingly capturing a larger slice of the global market. This shift reflects their growing competitiveness and rising demand for their products in global markets. Concurrently, the stable yet slightly diversifying import patterns of developed countries indicate that while these continue to rely heavily on imports from a few key Asian suppliers, there is also a gradual exploration of new sourcing options to meet their domestic demand.
In terms of global demand, the steady increase in export as well as import of RMGs points to a robust and expanding market. The growing middle class in developing countries, along with a sustained appetite for fast fashion in developed economies, continues to drive this demand.

As Asian countries strengthen their position as the world's garment manufacturers, these are likely to continue benefiting from these global consumption trends, strengthening their roles in the international trade landscape.

As illustrated in the below chart, the major export destinations for the Indian RMG industry shifted somewhat between 2018 and 2024. Still, the US remains the largest market, increasing its share from 26% in 2018 to 33% in 2024, underscoring the continued strong demand for Indian garments in the US market. The UAE also remains a significant market, although its share decreased slightly to 8% from 12%. This shift might reflect changes in trade policies, consumer demand, or increased competition from other RMG exporting countries.

The data also shows a moderate increase in the share of exports to Australia and the Netherlands, indicating that India's RMG industry is successfully penetrating new markets or expanding its presence in existing ones. The stability or slight increase in exports to these markets reflects a strategic broadening of the country's export base, which could help mitigate risks associated with overreliance on a few key markets.

Figure 38: Major export destinations for Indian RMG industry



Note: HS codes 61 and 62 considered
Source: Trade Map, Crisil Intelligence

This diversification is crucial for sustaining growth and resilience in the face of global economic uncertainties and shifting trade dynamics.

As India continues to navigate the complexities of global trade, maintaining and expanding its foothold in diverse markets will be key to ensuring the long-term vitality of its RMG sector.

Global trade – MMF

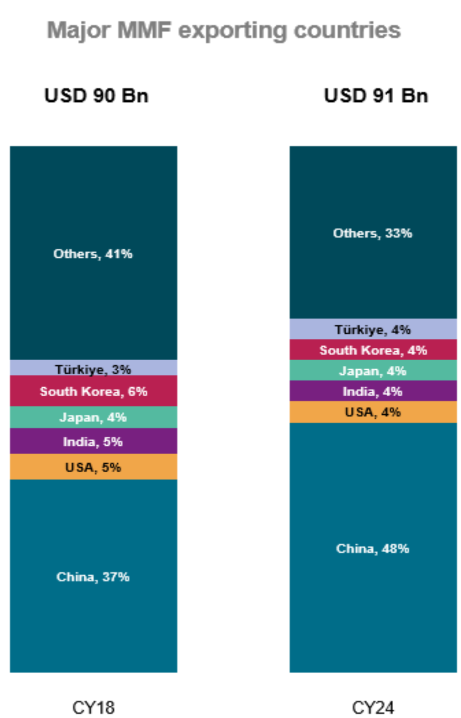
China is the largest exporter of MMF, accounting for ~48% of global exports, supported by strong domestic manufacturing capabilities. Favourable government policies resulted in faster capacity additions, boosting overall production capacities. Presence of all major global RMG players outsourcing and manufacturing in China has further bolstered production volume. The US is the second-largest exporter of synthetic fibres, with higher focus towards polyester and nylon. Robust raw material support, owing to the availability of crude oil and petrochemical products, along with lower power costs, creating a favourable production environment for the US.

Presence of major exporters, including India and Indonesia, facilitates easier and cost-effective availability of input material.

On the import front, major outsourcing destinations such as Vietnam (8%) and Bangladesh (5%) are among the largest importers of synthetic fibres. The expansive garment manufacturing industry in these countries results in sustained requirement for synthetic fibres. The absence of manufacturing and technological know-how and extremely competitive markets further restrict the growth of domestic manufacturing.

Italy (3%) maintains steady import levels to meet domestic demand for luxury. Also, despite domestic production, the US (4%) and China (4%) continue to import, depending on availability of cost-effective products globally.

Figure 39: Global trade dynamics pertaining to the MMF industry

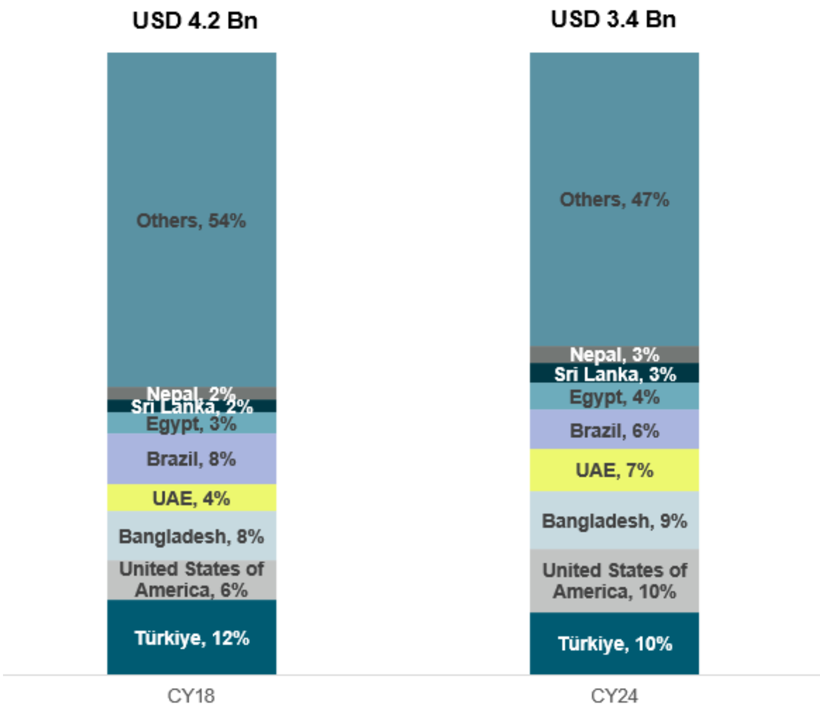


Note: HS codes 54 and 55 considered
Source: Trade Map, Crisil Intelligence

Indian MMF exports have remained steady due to favourable global demand-supply dynamics. Presence of domestic textile and intermediaries' industry, along with competitive manufacturing cost, makes the country a strong competitor for global exports. In 2024, overall exports declined, owing to lower global demand resulting from growing recessionary pressures. Increasing dumping from China further resulted in lower competitiveness of domestic products and reduction in overall capacity utilisation.

India-UAE free trade agreement (FTA) and the government's PLI scheme are expected to boost cost-effective production of synthetic fibres in India. Indian manufacturers can leverage competitive production costs, efficient supply chains and the ability to produce grades that meet diverse market requirements to meet the growing international demand.

Figure 40: Major export destinations for Indian MMF industry



Note: HS codes 54 and 55 considered
Source: Trade Map and Crisil Intelligence

Technology readiness - RMG

Technology Readiness		
Local Availability of Tech	**Foreign partnerships**	**Tech Know-How**
Garment producers have healthy production capabilities to compete with global peers. However, SMEs in the industry lack long-standing partnerships with global brands resulting in relatively low visibility for business.	Indian players struggle on account of lack of adequate trade pacts with global brands as well as major export markets.	India possesses the technical know-how in garment manufacturing and has also upgraded to value added products in contrast with basics produced by some competitors

Note: The green logo denotes that the parameter is available in India, while the red logo denotes that it is not
Source: Crisil Intelligence

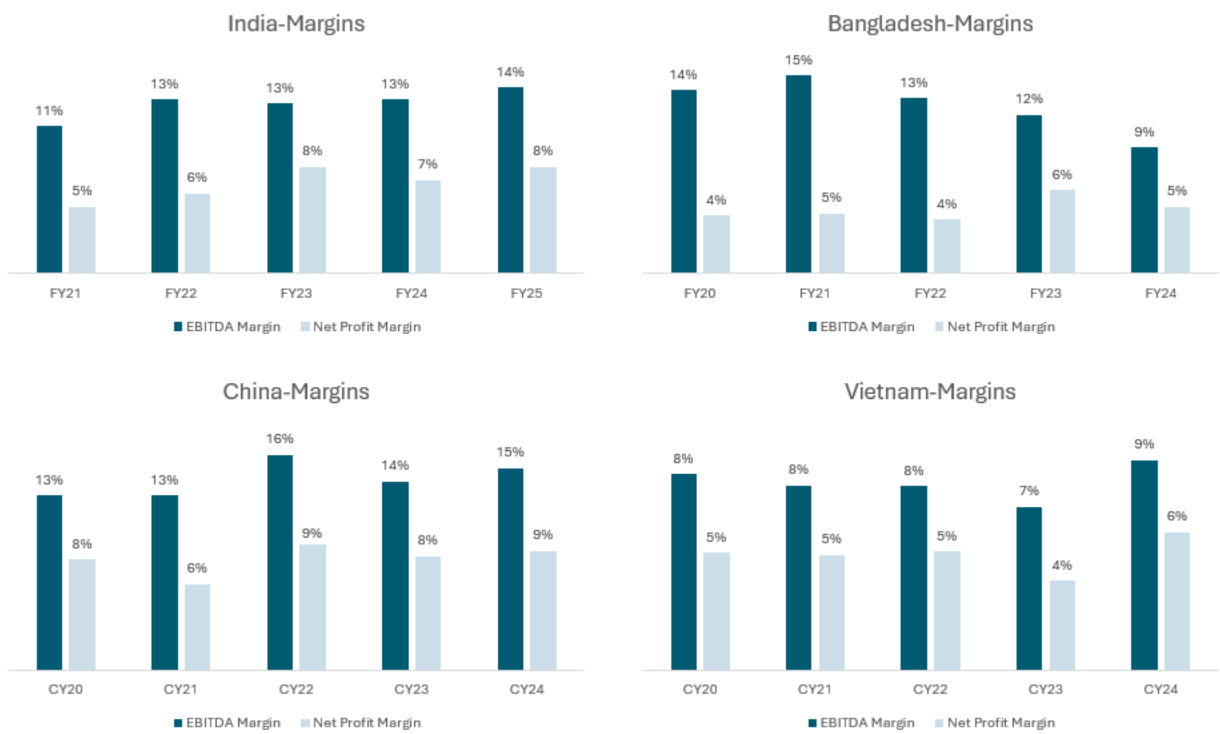
Technology Readiness - MMF

Technology Readiness		
Local Availability of Tech	**Foreign partnerships**	**Tech Know-How**
Major players in the MMF segment have a healthy production edge, largely competitive with global peers. However, the SME segment lacks efficiency, leading to wastage.	Recent FTA agreements with countries have opened new markets for the Man-Made Fibres industry. Indian players, however, lack global partnerships and lack Foreign Direct Investment in manufacturing.	India possesses sufficient know-how to produce fibres and yarns.

Note: The green logo denotes that the parameter is available in India, while the red logo denotes that it is not
Source: Crisil Intelligence

Financial viability - RMG

Figure 41: Profitability Benchmarking of India's RMG Sector Against Key Global Peers

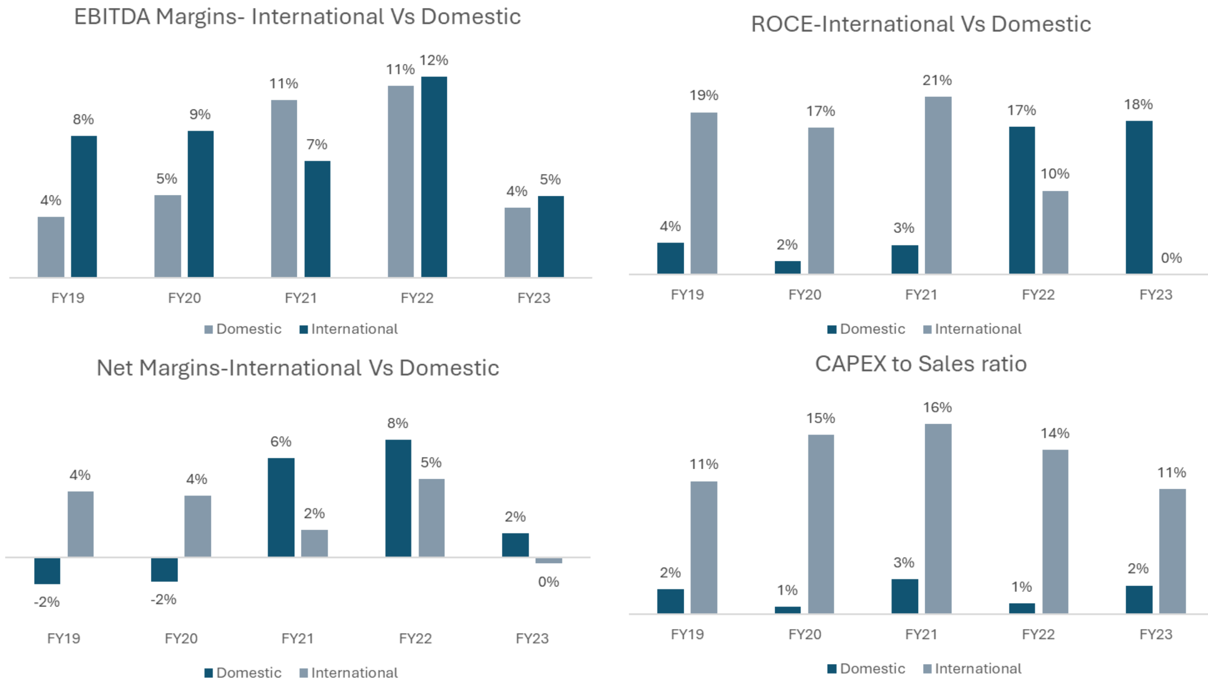


Source: Crisil Intelligence, company reports
Note:The financial year for India is April-March, while for Bangladesh, it is July-June.
The list of companies used for this analysis is available in Annexure 1

The margins of domestic RMG companies are at par with those of international players. However, the margins of Vietnamese RMG companies are lower owing to their concentration on low-margin export markets and lack of high-premium products, which limits their ability to command higher prices.

Financial viability - MMF

Figure 42: Profitability Benchmarking of India's MMF Sector Against Key Global Peers

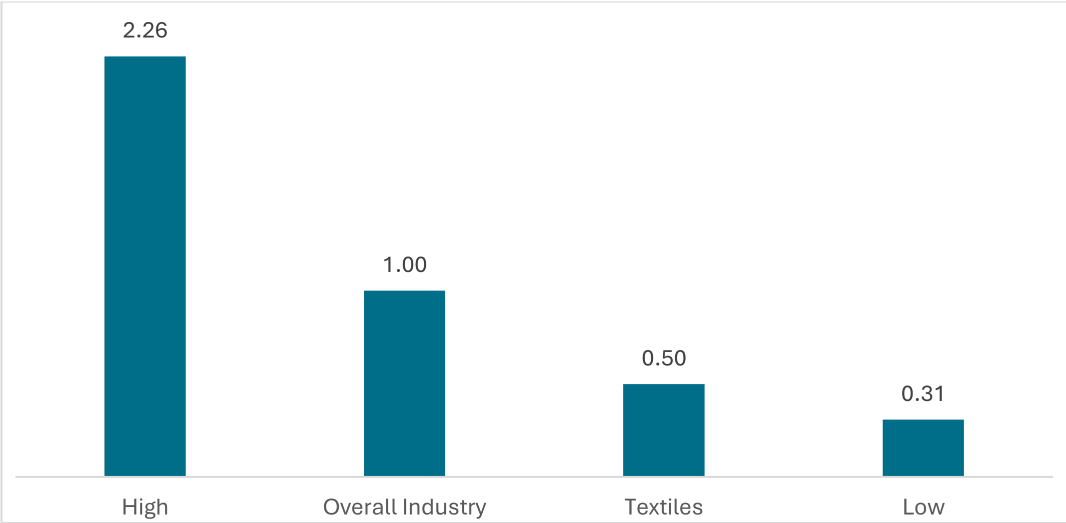


Source: Crisil Intelligence, company reports
Please note that international players considered are Xinfengmin, Hengyi and Tongkun and domestic players considered are Century Enka, Indo Rama and Filatex India.

In the MMF segment, the overall financial profile of the international players is significantly better than that of the domestic players. Indian players incur higher costs, primarily due to two reasons – import dependence on raw materials and low-capacity utilisation of domestic players. Despite having a robust fibre and yarn industry, India lacks raw material capacities for some key raw materials such as PTA-MEG. Global oversupply of raw materials at competitive prices is the key reason for lack of domestic capacities for feedstock, resulting in import reliance, inflating costs for downstream players. Despite being a net-exporter of fibres, India faces consistent pressure from international players (mainly China), resulting in lower capacity utilisation impacting returns. Higher economies of scale and backward integration have enabled global players to have a favourable and competitive cost structure vis-à-vis Indian players. Furthermore, the presence of SMEs and lower focus towards technology/machinery upgradation have resulted in higher wastage and lower efficiency for Indian manufacturers, thereby increasing costs.

Employee productivity

Figure 43: Gross value added per person engaged across sectors



Note: The numbers represent the ratio of gross value added per person engaged in the textiles sector relative to that of other sectors
Source: Crisil Intelligence, Annual Survey of Industries 2022

The chart presents a comparison of employee productivity across different sectors by examining the ratio of gross value added (GVA) per person engaged. In this comparison, the textile sector's employee productivity is notably lower than the overall industry average. The ratio for textiles stands at 0.50, which is half of the overall industry benchmark of 1.00. This indicates that, on average, each worker in the textiles sector contributes significantly less to the GVA compared with their counterparts in other industries. The high-value sector, represented by a ratio of 2.26, shows more than double the productivity of the average industry worker, further highlighting the productivity gap between textiles and more capital-intensive or technology-driven industries.

Several factors contribute to the relatively low employee productivity in the textile industry. One primary reason is the labour-intensive nature of textile production, particularly in segments like garment manufacturing, where a large portion of the work is manual. Unlike high-value sectors that often rely on advanced machinery, automation and high levels of capital investment, the textile industry, especially in developing countries, tends to depend heavily on low-cost labour. This reliance on manual processes can limit the efficiency and speed of production, leading to lower productivity per worker.

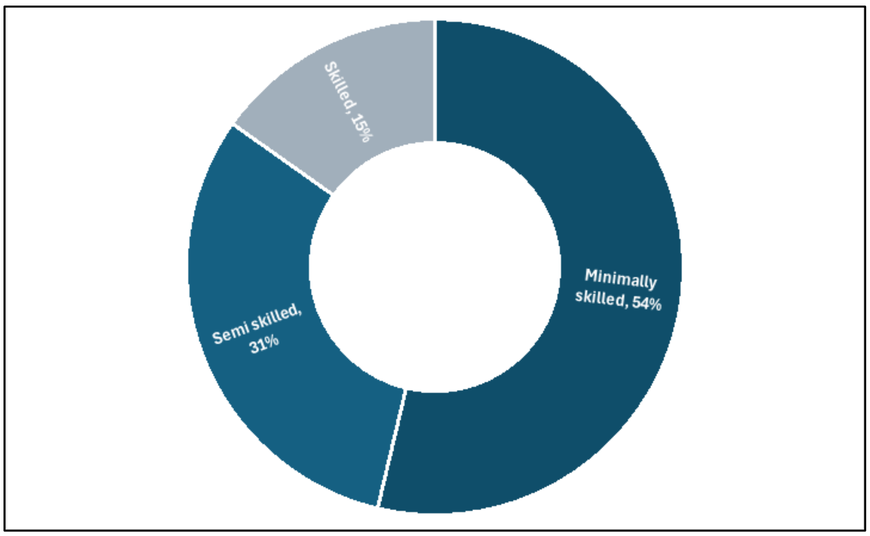
Additionally, the textile industry often faces challenges such as fluctuating raw material costs, outdated technology and stiff competition in global markets, which can further suppress productivity. Investments in modernising equipment and training workers are often limited, especially in smaller firms, resulting in inefficiencies. The sector's dependence on seasonal demand and the variability in orders also contribute to inconsistencies in production levels, making it difficult to maintain a high and steady productivity rate. This combination of factors explains why the employee productivity in textiles remains below the overall industry average.

Skill requirement

The readymade garments industry relies heavily on a workforce distributed across three skill levels as can be seen from the chart below: minimally skilled, semi-skilled and skilled workers. The majority, comprising 54% of the workforce, falls into the minimally skilled category. These workers typically handle basic, repetitive tasks such as cutting fabric, performing simple sewing operations, operating basic machinery and packing garments.

Semi-skilled workers, who make up 31% of the workforce, perform more complex tasks that require a degree of technical expertise. Their responsibilities might include operating advanced sewing machines, assembling garment components, conducting quality control, and assisting with machinery setup. The smallest segment, skilled workers, represents 15% of the industry's workforce. These individuals take on the most complex and critical roles, such as pattern making, advanced tailoring, supervising production lines and ensuring quality standards. They often lead specialised processes and provide training to less skilled workers, reflecting their significant experience and expertise.

Figure 44: Skill-level distribution: Indian textile sector



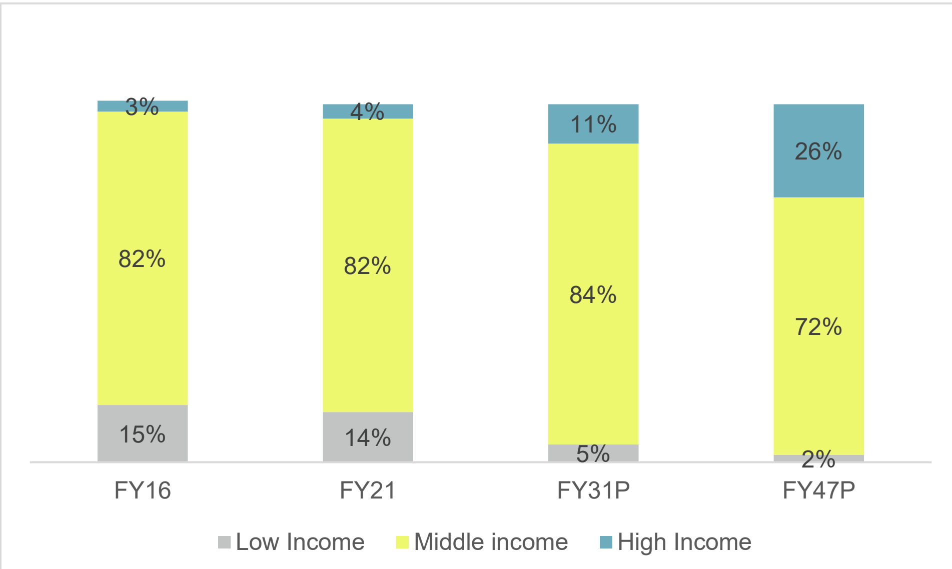
Source: Crisil intelligence and National Skill Development Corporation

Growth drivers

Key growth drivers for the Indian textile sector are:

- **Favourable demography**
  India's middle and high-income classes are expected to clock significant growth over the next decade. By fiscal 2031, the share of middle- and high-income groups is expected to reach ~95% from 86%, supported by growth in per capita income. This growth will lead to increased domestic consumption of textiles and apparel, as rising disposable incomes fuel demand for high-quality clothing and textiles.

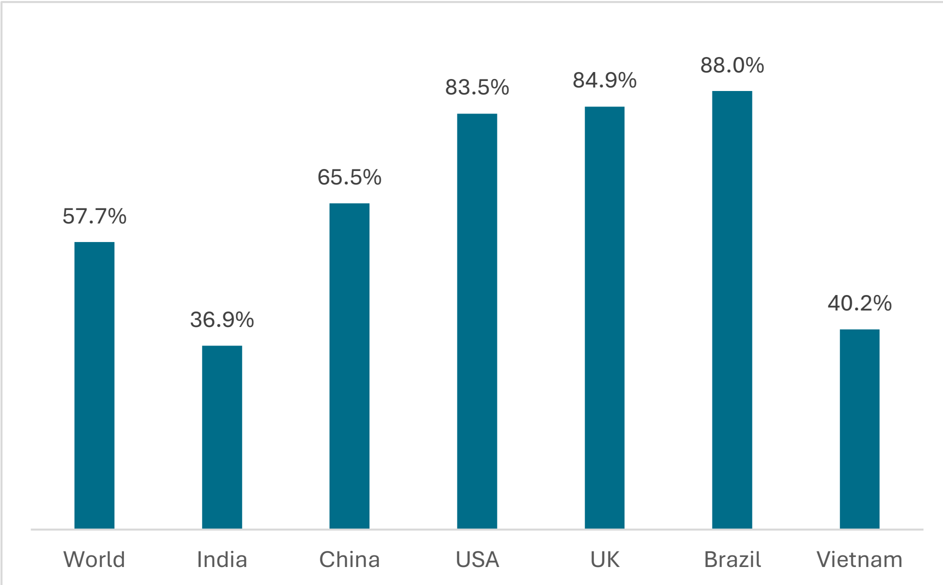
Figure 45: Income-based split of the population



P: Projected
Note: The low-income group comprises those earning less than Rs 125,000 per annum; middle-income group comprises those earning between Rs 125,000 and Rs 30 lakh per annum; and high-income group comprises those earning more than Rs 30 lakh per annum
Source: People Research on India's Consumer Economy (ICE) 360° survey, Crisil intelligence

- **Urbanisation**
  As per the World Bank, India's urban population has grown substantially, from 32.8% of the total population in 2018 to 36.9% in 2024. Despite this growth, the country still lags other major economies in terms of urbanisation, presenting a significant opportunity for further development. As urbanisation accelerates, Indian fashion is poised to undergo a transformation, with western casual wear becoming increasingly popular. Urban areas can expect a surge in demand for fashionable clothing, while traditional and ethnic wear will continue to be preferred for special occasions, resulting in a growth in overall apparel demand.

Figure 46: Urban population as a percentage of total population of key economies (CY 2024)



Source: World Bank and Crisil Intelligence

- **Government and policy support**
  The Indian government has implemented several initiatives to support the textile sector, including the Production-Linked Incentive (PLI) scheme and the PM MITRA Parks Scheme. These schemes aim to increase manufacturing, attract investments and create large-scale infrastructure, making Indian textiles more competitive globally. The government has also launched the Samarth scheme, a skill development programme, to ensure a steady supply of skilled labour for the manufacturing sector and sustainable growth.

- **Rise of e-commerce**
  According to a report by ANAROCK and ET Retail, the Indian e-commerce market is expected to witness substantial growth, rising from $125 billion in 2024 to $345 billion in 2030, and eventually reaching $550 billion by 2035. As the market expands, companies will be able to reach a wider audience, offering a variety of products at competitive prices, leading to an increase in demand for apparel in Tier 2 and Tier 3 cities, as well as in Tier 1 and metro cities, providing a significant boost to the entire apparel sector.

- **Diversification of product portfolio**
  The Indian textile industry is undergoing a significant transformation, driven by a strategic focus on diversification and expansion of its product offerings. Manufacturers are broadening their product ranges to include technical textiles, functional textiles, and value-added products, in addition to traditional segments such as apparel and home textiles. The government's initiatives, including the National Technical Textiles Mission, are also facilitating this diversification by providing support for research, development and promotion of technical textiles, thereby enabling the industry to explore new opportunities.

- **Focus on sustainable manufacturing practices**
  The global market is witnessing a significant shift towards sustainable products, with a growing demand for eco-friendly processes and the use of recycled materials. In line with this trend, the Indian government is also promoting sustainable practices to enhance competitiveness. As a result, the textile

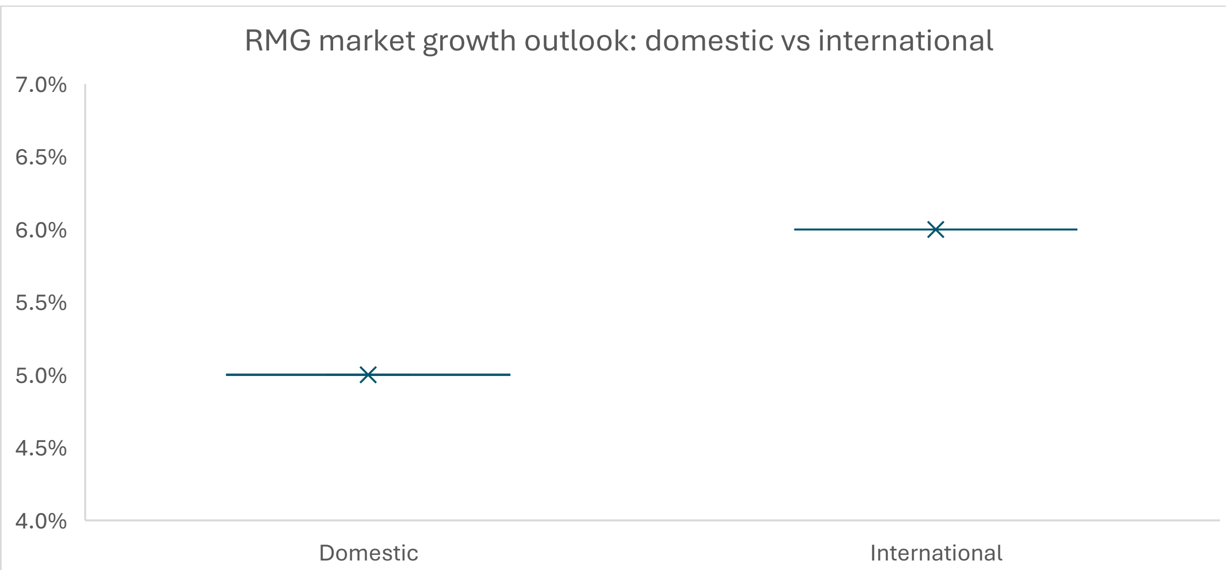
industry is placing increasing emphasis on sustainability and environmentally friendly practices, which can provide Indian textile players with a competitive advantage in the global market.

- **Strong raw material base and integrated value chain**
  The Indian textile industry benefits from a rich raw material base and a fully integrated value chain. The country ranks as the second-largest producer of cotton and silk, the largest producer of jute, and a leading producer of polyester and viscose. This strong raw material availability ensures a steady supply and cost competitiveness. In addition, India's end-to-end integration, from raw materials to finished goods, reduces import dependency and enhances production efficiency. These strengths enable the industry to respond swiftly to global demand shifts, driving sustained growth, expansion, and competitiveness in international markets.

RMG outlook

We expect the domestic RMG sector to log a CAGR of approximately 5% (see the graphic below) between fiscals 2023 and 2030. Exports are projected to see a slightly higher growth rate of around 6%. This growth in the export market is expected to be supported by improved market access, including the India-UK CETA and the India-EU FTA, which is expected to provide additional market access once implemented.

Figure 47: RMG sector CAGR between FY23 and FY30



Source: Crisil Intelligence and company reports

Moreover, India's emphasis on cotton textiles contrasts with the global shift towards synthetic materials such as polyester. This mismatch in production focus has led to slower growth in the exports, with the country not being able to meet the rising demand for synthetic textiles while remaining a dominant player in cotton textiles. However, the global market's preference for synthetic fibres, driven by their versatility and lower costs, poses a challenge for India's RMG sector to capture a larger share of international trade. To enhance growth, the country may need to diversify its textile offerings and adapt to global market trends, ensuring its RMG industry remains competitive both domestically and internationally.

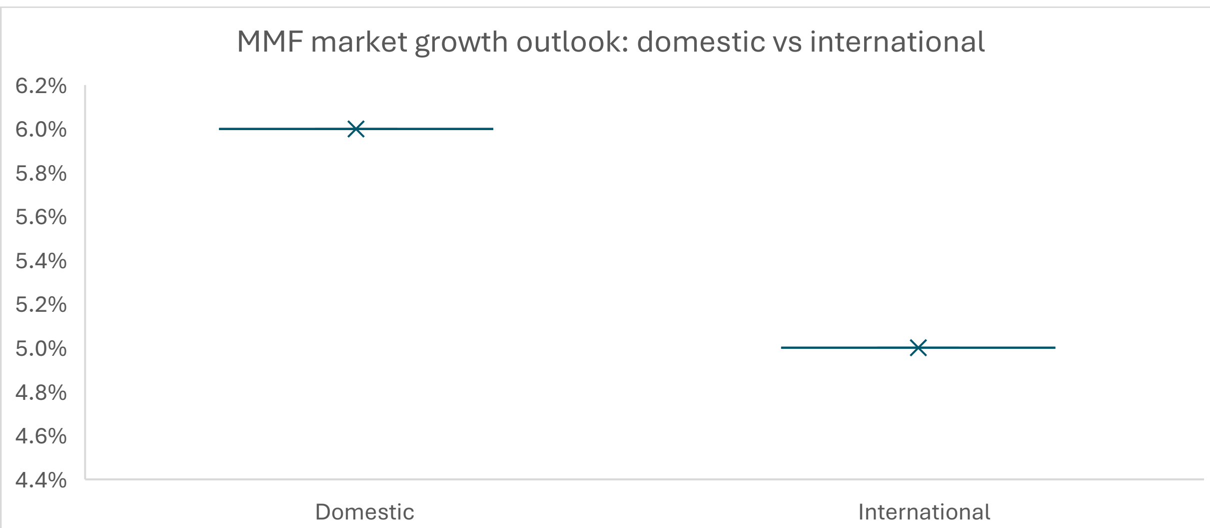
Several demand drivers are poised to boost the growth of the domestic RMG industry in the future. Rising disposable incomes and urbanisation are creating a more fashion-conscious consumer base, leading to an increase in demand for diverse and high-quality garments. Additionally, the growth of e-commerce platforms has made it easier for consumers to access a wide range of apparel, driving up demand further.

On the global front, the shift towards sustainability is expected to benefit India's RMG sector, as international buyers are increasingly seeking suppliers who can offer eco-friendly materials and adopt ethical manufacturing practices, areas in which India is already making significant strides. Moreover, the country's young population and growing middle class, coupled with the government's Make in India initiatives, are likely to spur domestic production and consumption, supporting the long-term growth of the RMG industry both domestically and internationally.

MMF outlook

According to our estimates, the domestic MMF market size at $ 6.8 billion is expected to clock a CAGR of 6-7% between fiscals 2023 and 2030, driven by growth in domestic consumption and increasing MMF penetration. The domestic market is poised to outdo export growth due to several factors. For one, there is a growing shift in consumer preference towards MMF over natural fibres such as cotton, driven by the rising cost of natural fibres and increasing demand for more durable, versatile and affordable textiles. Additionally, the country's large and rapidly expanding middle class is fuelling demand for a wide range of clothing and home textiles, which heavily utilise MMF. Moreover, government initiatives, such as the Production Linked Incentive (PLI) scheme, are encouraging domestic manufacturing and innovation in the textile sector, further boosting the MMF market. With its strong position in global textile exports and robust domestic consumption, the domestic MMF sector is poised to grow faster than the global average.

Figure 48: MMF Industry CAGR between FY23 and FY30



Source: Crisil Intelligence, Company Reports

Benchmarking against competing countries

China, India, Bangladesh and Southeast Asian countries, such as Vietnam, Indonesia, Cambodia and Sri Lanka, are leading readymade garments manufacturing countries, driven by availability of labour and demand from the US and the UK. China leads by rapid investments and intense competition and fragmentation across large numbers of segments in natural fibre as well as synthetic textiles. Indian textiles rely on self-sufficiency in cotton, while other countries leverage availability of low-cost manpower to be cost competitive in the international markets.

India is growing rapidly, supported by a favourable regulatory environment, thrust on synthetic textiles production and entry into value addition, while competitors benefit from government policies, trade pacts, geographical advantages and labour cost.

Table 12: Share of key exporting countries in the global RMG trade

Exporters	2004	2010	2015	2019	2023	2024
China	22%	35%	37%	29%	30%	29%
Bangladesh	3%	4%	6%	9%	9%	10%
Vietnam	2%	3%	5%	6%	6%	7%
India	3%	3%	4%	3%	3%	3%
Indonesia	2%	2%	2%	2%	2%	2%

Source: ITC Trade Map, Crisil Intelligence
Note: Figures correspond to calendar years

Bangladesh

Textiles production is pivotal to Bangladesh's economy, making the country one of the largest textile and garment exporters in the world. The industry accounts for more than 85% of Bangladesh's total exports, driven by its large-scale production of RMG. Bangladesh has leveraged its competitive advantage of low labour costs and a large workforce to attract international brands and retailers. The sector has also benefited from favourable trade agreements, such as the Generalised System of Preferences (GSP) in the European Union, which allows for duty-free access to key markets.

Fiscal incentives

The government offers cash incentives on 43 export product categories, ranging from 0.5% to 15% of export value; readymade garments (RMG) receive a base incentive of 4%. Specific incentives include:

- A 1% cash incentive to all RMG exporters based on free-on-board (FOB) value
- An additional 4% incentive for exports to new markets beyond the EU, US, and Canada
- An additional 4% incentive for SME exporters with export volumes below $5 million
- An additional 2% incentive for exports to the EU
- Extra incentives for products manufactured using local fibres

These incentives are being gradually phased out as Bangladesh transitions out of Least Developed Country (LDC) status by 2026. To offset this, the government is offering electricity tariff waivers of up to 10%, duty exemptions on capital machinery imports, and low-interest loans for green energy initiatives.

The Duty Drawback Scheme refunds duties paid on imported raw materials, helping exporters lower their production costs.

Tax benefits

- Corporate tax rate: Revised in 2022 to 15% for listed textile companies, versus 27.5% for non-listed and 20% for listed companies (general)
- VAT exemptions: In place since 2016 on select textile products and raw materials; a VAT exemption on domestically produced recycled fibre was under consideration as of April 2024 (traders currently pay 7.5% on purchase and 15% at point of sale)
- Port services exemption: 100% VAT exemption on port services for fully export-oriented industries and EPZs, covering both imported and locally manufactured goods (granted by the National Board of Revenue)

Infrastructure development

- **Special economic zones (SEZs):** Managed by BEPZA to attract foreign investment, offering a 5–7 year tax holiday, duty-free import/export, double taxation relief, 100% foreign ownership, no investment ceiling, and full profit repatriation
- **Garment Palli:** A BGMEA-developed integrated garment park covering the entire value chain—from sourcing to shipment—improving productivity and reducing costs
- **Ports and Logistics:** Modernisation of Chittagong (handles 90%+ of trade) and Mongla ports, backed by $650 million in World Bank funding (June 2024) for the Bay Terminal deep seaport
- **Compliance and Sustainability:** Effluent treatment plants mandatory in large units; Bangladesh has 90 green-certified garment factories, the highest globally (USGBC)

Trade agreements and market access

Bangladesh enjoys duty-free, quota-free access to the EU under the GSP and Everything But Arms (EBA) schemes, with readymade garments accounting for nearly 90% of the EU's imports from Bangladesh. As a member of SAARC and BIMSTEC, the country also benefits from reduced regional trade barriers. In addition, Bangladesh has negotiated bilateral trade agreements with major economies such as China and India, securing preferential access and reduced tariffs for its textile exports.

Financial Assistance and Subsidies

- Export development fund: Managed by the Bangladesh Bank, this fund offers low-interest loans to exporters for financing raw materials and equipment
- Subsidies for raw material: The government provides subsidies for importing essential raw material, such as cotton and dyes, to lower production costs and enhance competitiveness

Capacity Building and Skill Development

- Training programmes: In collaboration with the International Labour Organisation (ILO) and BGMEA, the government runs training programmes that enhance technical skills, improve management practices, and raise awareness of occupational safety and quality control.
- Textile institutes: Specialised institutions, such as the Bangladesh University of Textiles and the National Institute of Textile Engineering and Research, play a key role in building a skilled workforce.
- Sustainable production practices: The Better Work Bangladesh programme further supports this effort by improving labour standards and overall business competitiveness.

Environmental and Compliance Support

- ETPs: The government provides financial support for setting up ETPs, which are mandatory for large textile units.
- Sustainable production practices: Initiatives such as the Green Textile Initiative offer incentives for adopting eco-friendly production methods.
- Partnership for Cleaner Textiles (PACT): An IFC-led programme supporting factories across the value chain in adopting cleaner practices, with BGMEA as the implementing partner and global brands such as Levi's, Puma, and Tesco as partners

Vietnam

Vietnam's textile industry, comprising over 6,000 textile and garment manufacturing companies as of June 2022, is one of the country's leading export industries, employing more than 2.5 million workers. In 2020, Vietnam surpassed Bangladesh to become the second-largest exporter of readymade garments globally. A combination of labour availability, low labour costs, and free trade agreements (FTAs) with key trading partners drives the growth of the Vietnamese textile industry.

Export incentives

- Cash incentives: Provided to export-oriented enterprises, particularly in the textile and garment sectors, to reduce costs and enhance global competitiveness
- Duty Drawback Scheme: Refunds duties paid on imported raw materials, lowering production costs and improving the competitiveness of Vietnamese textiles

Tax benefits

Corporate tax rate: Vietnam offers a corporate tax rate of 20%. Companies that make new investments in key sectors such as technology, garments, footwear and automobiles, or produce goods that are not currently manufactured in Vietnam or meet EU quality standards, are eligible for substantial tax incentives

Infrastructure development

- Special Economic Zones (SEZs): Offer preferential tax rates and exemptions, import duty exemptions, reduced land lease rates, and support services; Vietnam has four key economic regions (north, south, central, and Mekong Delta), with the south hosting multinationals such as Nike and Adidas
- Industrial parks: Provide dedicated facilities for textile units, enhancing operational efficiency and supporting growth

Trade agreements and market access

- Preferential trade agreements: Vietnam benefits from various FTAs, including the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the EU-Vietnam Free Trade Agreement (EVFTA), which eliminate tariffs on garments and textiles, enhancing market access
- Regional trade agreements: As a member of ASEAN and the Regional Comprehensive Economic Partnership (RCEP), Vietnam enjoys reduced trade barriers and regional cooperation
- Bilateral trade agreements: Significant bilateral trade agreements with the EU, Japan and South Korea provide preferential access and reduced tariffs for Vietnamese textiles

Financial assistance and subsidies

- Export Development Fund: The Vietnam Development Bank offers export financing and credit facilities to support textile and garment businesses
- Support for SMEs: The Small and Medium Enterprises Development Fund (SMEDF) provides financial support, training, and market access programmes to boost the productivity and competitiveness of small and medium enterprises (SMEs)

Skill development

- Training programmes: Industry–global brand collaborations focus on advanced manufacturing and management skills
- Textile institutes: Technical universities and vocational colleges offer specialised training in textile and garment technology

Policy frameworks and Initiatives
Vietnam's textile industry has attracted significant FDI, with foreign-backed companies accounting for ~60% of fabric and garment exports and ~70% of yarn exports. Investments originate from China, Singapore, Japan, South Korea, and Taiwan—with Chinese companies being the largest contributors (over half of textile FDI and roughly one-third of spinning capacity).

Vietnam's appeal stems from its proximity to key transport corridors, extensive shoreline, economic and political stability, and business-friendly incentives such as tax cuts and streamlined procedures. It has invested heavily in infrastructure (ports, railways, roads, SEZs, industrial parks) and signed 18 FTAs, including the CPTPP, EVFTA, and RCEP, offering investors preferential market access.

Legal reforms under the Law on Investment 2020 and Law on Enterprises 2020 have made investing safer and easier, with key provisions:

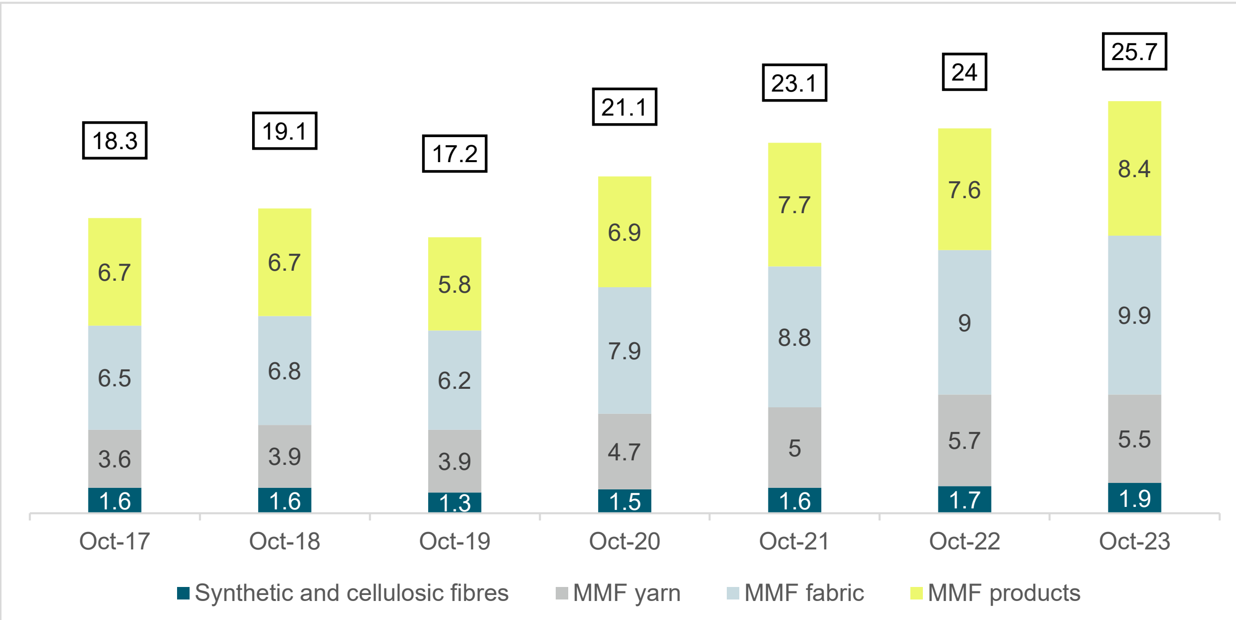
- Asset protection: Lawful assets cannot be nationalised or confiscated through administrative measures
- Choice of incentives: Existing incentives are retained if new laws are less favourable
- Efficient registration: Investment certificates issued within 5 working days of approval
- Growth support: Incentives apply to both new and expansion projects
- Project flexibility: Investors may adjust, transfer, merge, or divide projects
- Long-term stability: Project durations of up to 70 years (within economic zones) and 50 years (outside)
- Vietnam has also signed over 80 double taxation avoidance agreements (DTAAs) as of 2024, easing the tax burden on foreign investors. Reflecting this, the Asia Manufacturing Index ranks Vietnam second, ahead of India, as a preferred manufacturing destination in Asia.

Vietnam has also signed over 80 double taxation avoidance agreements (DTAAs) as of 2024, easing the tax burden on foreign investors. Reflecting this, the Asia Manufacturing Index ranks Vietnam second, ahead of India, as a preferred manufacturing destination in Asia.

China

According to the International Cotton Advisory Committee (ICAC), China has emerged as the dominant driver of synthetic and cellulosic fibre production, accounting for approximately 70% of the world's total man-made fibres (MMF) in 2023. China's MMF exports, spanning fibres, yarn, fabric, and finished products, have grown significantly, recording a 6% compound annual growth rate (CAGR) between 2017 and 2023.

Figure 49: Total Chinese MMF exports in million tonne



Source: Trade Data Monitor and Crisil Intelligence

Note: 12-month totals ending in September of each year. For example, Oct-17 represents exports from October 2017 to September 2018

The significant growth in China's MMF production can be attributed to a range of supportive policies, including:

China's five-year plan

China's five-year plan serves as a roadmap for national development, providing strategic direction for key industries, including textiles. The 12th Five-Year Plan, for instance, aimed to drive innovation in the textile industry by achieving breakthroughs across 50 technologies, spanning spinning, weaving, printing, dyeing, textile processing, and environmentally friendly methods.

During the 14th Five-Year Plan period, the Ministry of Industry and Information Technology (MIIT) and the National Development and Reform Commission (NDRC) issued the "Guiding Opinions on the High-quality Development of China's Chemical Fiber Industry," setting ambitious goals for the chemical fibre (MMF) industry by 2025:

- Increasing industrial added value by 5% annually while maintaining a stable global market share
- Boosting R&D investment to 2% of total expenditure and enhancing the development of high-performance fibres
- Improving the green manufacturing system, with output of bio-based and degradable fibre materials growing by over 20% annually

Collectively, the five-year plan provides a comprehensive blueprint that helps the sector prioritise efforts, allocate resources, and make informed decisions about future growth.

Pre-tax super deduction of R&D expenses

Under China's pre-tax super deduction policy, eligible companies can deduct 200% of their research and development (R&D) expenses from their income, effectively reducing their tax liability. The policy applies broadly across most industries, with limited exceptions on a negative list. This enables the MMF segment to invest in cutting-edge research, enhancing competitiveness and driving technological advancement.

Reduced corporate income tax

As part of China's Western Development Policy, domestic companies investing in chemical fibre manufacturing in selected western regions, including Xinjiang, are eligible for a reduced corporate income tax rate of 15%, compared to the standard rate of 25%. This preferential rate applies to investments made between January 1, 2021, and December 31, 2030.

Export tax rebate

China's export tax rebate policy refunds the value-added tax (VAT) and consumption tax (CT) paid during production and distribution, making Chinese goods more competitive internationally by eliminating double taxation on exports. Current rebate rates on textile products range between 13% and 16%, offering significant support to textile exports.

Tax incentives to encourage equipment upgrades

In 2015, the government introduced the "Circular on Further Improving the Enterprise Income Tax Policies relating to the Accelerated Depreciation of Fixed Assets," allowing textile companies to apply accelerated depreciation on purchased fixed assets from January 1, 2015. Companies could choose between two options:

- Shortened depreciation period: Depreciate newly purchased assets over a shorter timeframe, subject to a minimum of 60% of the standard period
- Accelerated depreciation method: Apply either the double declining balance method or the sum-of-the-years'-digits method to depreciate assets faster

This policy encouraged companies to upgrade equipment and remain competitive, ultimately benefiting the wider industry.

Policy framework and industry support mechanism

The following initiatives are aimed at supporting the Indian textile industry:

1. **PLI scheme for textiles**
   - The PLI scheme for textiles aims to boost the production of MMF apparel, fabrics and technical textiles in India
   - The scheme has approved 96 applications, with a proposed investment of Rs 32,085 crore and a projected turnover of Rs 2,32,158 crore. As of July 2025, the scheme generated investments of Rs 7,343 crore, with a turnover of Rs 4,648 crore and exports of Rs 538 crore in the textile sector

2. **Pradhan Mantri Mega Integrated Textile Region and Apparel park (PM MITRA parks)**
   PM MITRA parks will help India's textile industry scale up and create a modern, integrated value chain
   Update on PM Mitra parks:
   - Madhya Pradesh: As of September 2025, 1,294 acres of land has been allocated to 91 companies, with expected investments exceeding Rs 20,000 crore and creation of over 72,000 jobs
   - The PM Mitra Park in Telangana, developed at a cost of ₹1,695 crore, was inaugurated as the country's first functional PM MITRA Park in May 2026.

3. **Samarth scheme**
   - The scheme aims to provide demand-driven, placement-oriented skilling programmes, creating jobs in the organised textile and related sectors
   - As of August 2025, according to the Ministry of Textiles, the scheme had trained 4.57 lakh beneficiaries, with 3.55 lakh (78%) of them having secured placements.

4. **Rebate of State and Central Taxes and Levies (RoSCTL**) on exports of apparel, garments and made-ups, effective until September 30th, 2026
   The RoSCTL scheme enables Indian exporters to remain competitive in the global market by reimbursing state and central taxes/levies embedded in the exports of made-up articles and garments, ensuring a level playing field

   Other subsegment-specific schemes include:
   - **Mission for Cotton Productivity**
     It empowers farmers with advanced scientific and technological tools to enhance cotton yields, fibre quality and resilience to climate and pest-related stresses, ultimately boosting their overall productivity
   - **National Technical Textiles Mission (NTTM)**
     NTTM was launched in 2020 with a financial outlay of Rs 1,480 crore, focusing on research, innovation and development to boost the technical textiles sector
     As of March 2025, NTTM had received a total allocation of Rs 517 crore since its inception. Furthermore, 168 research projects with a combined value of approximately Rs 509 crore have been approved under NTTM
   - **National Handloom Development Programme (NHDP)**
     NHDP is a comprehensive initiative that aims to promote the integrated development of the handloom sector in India, including financial assistance for loom upgradation, marketing support, and access to domestic and export markets
   - **National Handicrafts Development Programme**
     It is a supportive initiative that provides a range of benefits to handicraft clusters and artisans, including basic inputs, infrastructure support and capacity enhancement, to help them access and serve target markets.

Recommendations: Policy initiatives and reforms

Recommendations for Enhancing Raw Material Cost Competitiveness

Adequate availability of quality raw materials, such as natural fibres and man-made fibres, at internationally competitive prices is a prerequisite for achieving the target of increasing the textile business size to $350 billion by 2030, from the current level of $179 billion.

In the case of cotton, the Minimum Support Price (MSP) often leads to domestic cotton prices being higher than international cotton prices, particularly when there is increased production of cotton in the global market. Furthermore, Indian cotton faces additional challenges, including having one of the lowest cotton yields and a lack of quality cotton.

On the other hand, the production of man-made fibres (MMF) is also hindered by significant challenges. India has domestic production capacity for PTA and MEG; however, supply-demand imbalances and import dependence affect the cost competitiveness of polyester production. Additionally, the inverted duty structure in MMF negatively impacts MMF yarn and fibre producers.

Given these challenges, it is essential to address these issues to create a level playing field with other competing countries, such as China, Bangladesh and Vietnam, in terms of availability and pricing. Without this, the Indian industry will struggle to compete globally.

Recommendation – I: Addressing the inverted duty structure between feedstock and downstream industry in the polyester-based MMF industry

The introduction of the revised GST rates in September 2025 aimed to rectify the inverted duty structure in the MMF sector. Previously, the GST was 18% on polyester fibre, 12% on polyester yarn, and 5% for subsequent stages, resulting in significant input tax credit accumulation for yarn and fabric manufacturers. The revised GST rates for all stages are 5%, including fibre, yarn and fabric, easing working capital pressure on manufacturers. However, the revision did not completely address the inverted duty structure as the main raw materials, PTA and MEG are still taxed at 18%, while downstream products are taxed at 5%, leading to a higher inversion of duty, resulting in a significant accumulation of funds at the hands of yarn and filament manufacturers. This will cause higher blockage of working capital for MMF yarn players and hinder the industry's ability to expand.

Suggestions to implement recommendations:

Addressing the inverted duty structure: A revision of the duty structure to lower GST on essential raw materials like PTA and MEG can significantly ease cash flow constraints for industry players. This move is expected to provide crucial support to the sector and encourage the production of polyester fibre.

Recommendation – II: Enhanced Accessibility to MEG

The manufacturing of polyester requires PTA and MEG. Specifically, approximately 0.86 kg of PTA and 0.34 kg of MEG are required to produce 1 kg of polyester. India have a significant PTA production capacity of approximately 6.5 MMTA, with Reliance Industries, Indian Oil Corporation Limited (IOCL), and MCPI as major producers. In view of the planned substantial expansion, with 5.5 MMTA of new capacity expected to be added in the next 2-3 years, India may achieve self-sufficiency in PTA production, nearly doubling its current capacity. As a result, no adjustment to the import duty on PTA is required.

Details on upcoming project:

Promoter	Project details	Capacity addition	Current status
GAIL Ltd	GAIL acquired the purified terephthalic acid (PTA) manufacturing facility of JBF Industries Limited through a resolution plan sanctioned by the National Company Law Tribunal (NCLT). Following the acquisition, the entity was renamed as GAIL Mangalore Petrochemicals Limited	1.2 million metric tonnes	Project expected to be completed in 2026
Indian Oil Corporation Limited	The project involves setting up a Paraxylene and Purified Terephthalic Acid (PX-PTA) facility at Paradip, in the Jagatsingpur district of Odisha	1.2 million metric tonnes	Project expected to be completed by December 2026
Reliance ltd	A single-train Purified Terephthalic Acid (PTA) plant project at Dahej is under implementation by Reliance Industries	3.2 million metric tonnes	Project expected to be completed by June 2027

Source: Company reports, Crisil Intelligence

The global MEG market's oversupply situation has resulted in Indian producers exercising caution, with no imminent plans for substantial capacity expansion. Therefore, to foster growth in the polyester industry, governments may implement policies that improve access to MEG for Indian polyester producers, thereby supporting the sector's expansion.

Suggestions to implement recommendations:

Removal or reduction of customs duty on MEG:

With approximately 35% of the country's MEG requirements being met through imports due to insufficient domestic capacity, and no new substantial capacities on the horizon, the government may consider eliminating or reducing the 5% customs duty on MEG imports. This move would help reduce the manufacturing costs of polyester and enable domestic polyester manufacturers to produce yarn at competitive rates, thereby boosting the industry's global competitiveness.

Recommendation – III: Accelerate adoption of recycled content in MMF garmenting

Indian polyester manufacturers must prioritise scaling up recycled inputs like recycled polyethylene terephthalate (rPET) and chemically or mechanically recycled chips. This strategic move will not only shield them from raw-material volatility but also ensure they meet the EU's rapidly rising sustainability standards. The Ecodesign for Sustainable Products Regulation (ESPR), which took effect on July 18, 2024, sets requirements for products sold in the EU to contain more recycled content, use fewer hazardous substances, and have a lower carbon footprint. The ESPR provides a framework for product-specific ecodesign requirements, which may include recycled-content requirements for textiles and apparel. Hence, it is important to provide policy support to accelerate the adoption of recycled materials in MMF garments.

Suggestions to implement recommendations:

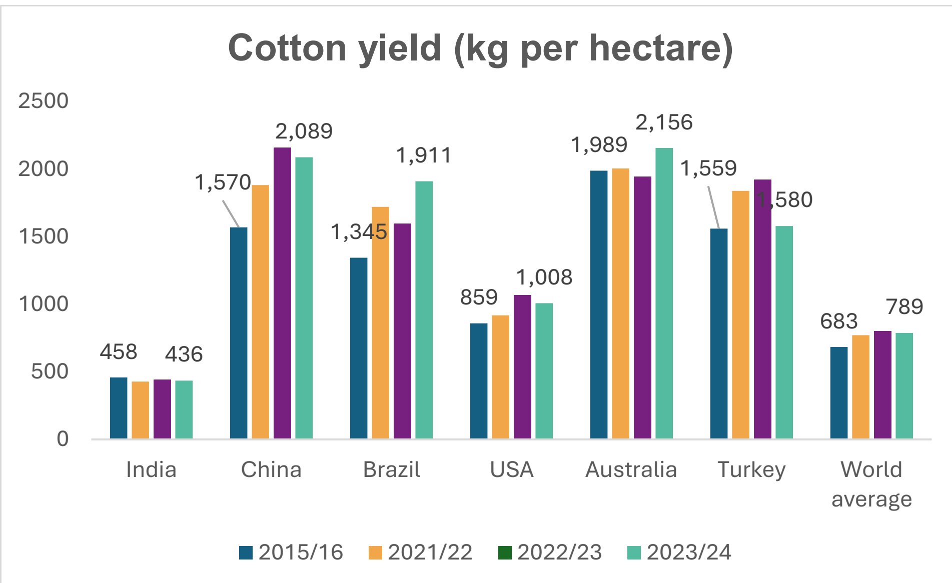
- **Improving waste collection:** India's recycling ecosystem can be strengthened by introducing a digital marketplace that connects informal waste aggregators with formal recycling units. This can be complemented by establishing centralised sorting hubs, which can help ensure a stable and traceable feedstock supply, ultimately enhancing the overall efficiency of the recycling process

- **Introducing minimum amount of recycled materials in MMF garments:** In the long run, the government may introduce regulations requiring MMF garment manufacturers to incorporate a minimum amount of recycled materials into their products. Certifications like the Global Recycled Standard (GRS) and Recycled Claim Standard (RCS) may be used to validate recycled content claims, ensuring transparency and accountability

Recommendation – IV: Improving cotton productivity

India's cotton yield is significantly below that of several major cotton-producing countries and the global average due to the use of outdated cotton seeds that are ineffective against the pink bollworm (Pectinophora gossypiella), erratic weather, increasing seed costs and a lack of awareness among small-scale farmers. Additionally, the country's small landholdings make it difficult to utilise various farm equipment, further exacerbating the issue.

Figure 50 Global peer benchmarking of cotton productivity



Note: The data is based on the cotton marketing season, which commences in August and ends in July.
Source: Crisil Intelligence, USDA

Current initiative

The Union Budget for fiscal 2026 introduced a five-year Cotton Mission to tackle the issue of stagnant cotton productivity, with a focus on extra-long staple varieties. The mission will provide technical support to farmers, with a total outlay of Rs 2,500 crore over five years. The mission's three key objectives are:

- Improving cotton yield and productivity through strategic interventions such as research and human resource development
- Modernising ginning and pressing units
- Promoting sustainable natural fibres such as banana, milkweed and bamboo, to diversify the country's fibre base

Suggestions to implement recommendations:

- **Providing new cotton seed technology:** In 2002, India introduced Bt cotton, a genetically modified (GM) crop developed by Monsanto in collaboration with Maharashtra Hybrid Seeds Company. Marketed under the brand name Bollgard, this crop was specifically designed to combat American bollworm (Helicoverpa armigera), a pest that had been causing significant damage to cotton crops. In

2006, India approved the use of Bollgard II, which has two genes for protection. This superior technology further enhances the crop's ability to control bollworm, tobacco budworm and other cotton pests, making it the dominant cotton variety grown in the country. Despite its initial success, Bt cotton is now facing significant challenges. The effectiveness of Bollgard II cotton seeds against bollworms has decreased, resulting in decreased yields. Additionally, the emergence of secondary pests, such as aphids and whiteflies, has become a significant problem. The increased cost of Bt cotton seeds is also a major concern for small-scale farmers, who are struggling to maintain profitability amid declining yields and increasing pest pressure.

- The Indian cotton industry is at a critical juncture, and it is essential to address these challenges to ensure the long-term sustainability of cotton production. The country may accelerate the development, evaluation and adoption of next-generation cotton seed technologies, including indigenous insect-resistant, disease-tolerant and climate-resilient varieties, subject to applicable regulatory approvals. This is necessary to improve crop yields, reduce losses and enhance the competitiveness of India's cotton industry.

- **Training farmers:** Despite training efforts, farmers remain skeptical about adopting new practices. To overcome this, alternative approaches can be explored, such as partnering with local leaders, engaging progressive farmers as mentors, and demonstrating the benefits of new techniques. Additionally, mobile-based tools can be utilised to educate farmers on best practices such as soil testing and herbicide use as well as innovative methods such as plastic film mulching, furrow irrigation, seedling transplanting and precision seeding. Special emphasis should be placed on crop protection from insects and effective agricultural management practices during the training. A nationwide initiative can be implemented, comprising campaigns and training programmes for farmers on regenerative practices.

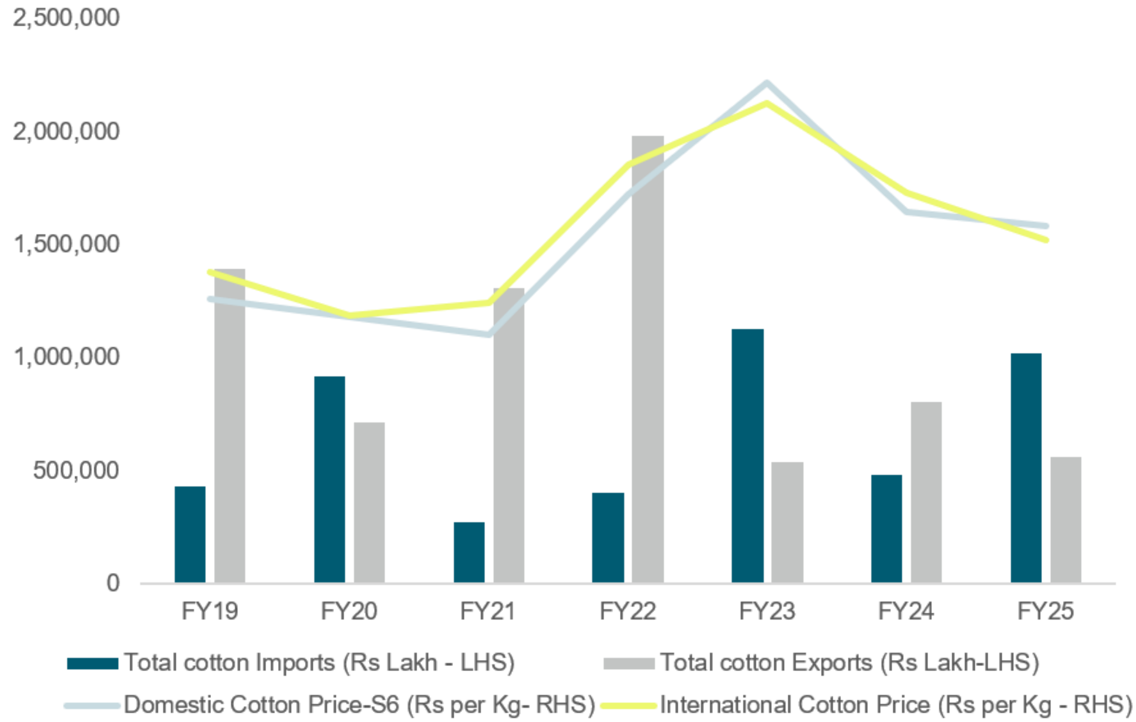
- Increasing use of artificial intelligence in cotton farming for weather prediction and pest monitoring: Erratic climate change poses a significant threat to cotton production as rising temperatures, droughts and unpredictable weather patterns can lead to reduced yields and lower crop quality. However, advances in machine learning can help mitigate these impacts by providing accurate weather predictions. By leveraging historical data, satellite imagery and sensor data, machine learning models can help farmers make informed decisions about planting, harvesting and irrigation, ultimately contributing to more sustainable and resilient cotton production. Artificial intelligence (AI) can also be used for real-time monitoring of pests, enabling farmers to make informed decisions about pest management

Recommendation–V: Removal of import duty on cotton

In February 2021, the Government of India had announced an 11% duty on imported cotton. As of now, the Government temporarily exempted custom duties on imports of raw cotton from 1 June 2026 to 31 October 2026. The measure aims to augment the availability of cotton for the domestic textile industry, reduce input costs, improve the competitiveness of the textile and apparel sector.

Due to the minimum support price (MSP), domestic cotton prices do not move in tandem with international cotton prices. When domestic cotton prices are lower than international cotton prices, the import duty has a minimal impact on the textile industry. However, when domestic cotton prices are higher than international cotton prices, the domestic value chain gets impacted, including the profitability of spinners and the competitiveness of the textile sector. When domestic cotton prices exceed international prices, the imports surge and exports decline. This makes cotton more expensive for Indian textile manufacturers as they must choose between high-priced domestic cotton and imported cotton with an 11% duty. In contrast, countries such as Bangladesh and Vietnam, which rely on imported cotton, do not have import duty on cotton, giving them a competitive edge.

Figure 51: Cotton price comparison: domestic vs international



Source: Industry, Ministry of Commerce and Industry, Crisil Intelligence

Suggestions to implement recommendations:

To address this issue, the government may consider removing the import duty on cotton, thereby bringing domestic players on a par with international players, or allow a certain quantity of cotton to be imported duty-free, which could help fulfil the demand that is not being met by domestic producers and ensure a stable supply of raw materials.

Recommendation–VI: Improving quality of cotton

India's cotton ginning segment has undergone significant modernisation, driven by various state and central government subsidies. Although a substantial number of Indian ginning factories have upgraded their facilities, many still face challenges in maintaining optimal production practices. Specifically, due to cost constraints, a large number of ginning factories fail to clean the kapas (raw cotton) before ginning. According to a research paper titled "Technological Evolution and Current Practices in the Indian Ginning Industry," published in 2024, a staggering 64% of factories do not clean the kapas at all before ginning, while 23% rely on manual cleaning methods. Ginners also tend to avoid using lint cleaners, which can improve the grade and appearance of cotton lint by removing small impurities and short fibers after ginning. The quality issues arising during ginning are permanent and cannot be corrected in the later stages of cotton textile value chain.

Suggestions to implement recommendations:

- Monitoring and Compliance for Modernised Ginning Units: Ginners who have benefited from subsidies for modernisation should be obligated to employ kapas cleaners and lint cleaners. Compliance can be ensured by requiring ginners to submit regular digital reports detailing kapas cleaner and lint cleaner usage statistics, and quality reports.
- Standardised testing framework: Presently, India lacks a standardised testing framework for ginned cotton. Implementing a standardised database with uniform testing parameters, methods, and a centralised data upload system will ensure consistency and accountability among ginners. This will motivate ginners to enhance their cleaning and handling practices. Additionally, it will facilitate a shift towards quality-based cotton procurement, moving away from traditional bulk pricing methods

This measure is expected to yield cleaner lint, thereby strengthening the competitive position of Indian cotton textiles in the global market.

Recommendations to improve the scale of operations

Recommendation I: Infrastructure and policy support for textile firms

According to Economic Survey 2024, approximately 80% of textile and apparel producers are micro, small and medium enterprises (MSMEs), which typically operate on a relatively small scale. These MSMEs often lack access to advanced machinery and technology, certification centres and digital infrastructure, hindering their ability to participate in e-commerce and access global markets. Hence, it is essential to address this issue.

Current initiatives

The government has launched the PM MITRA parks scheme, which aims to increase infrastructure support for MSMEs. Each of the seven PM MITRA parks will span a minimum of 1,000 acres and provide plug-and-play infrastructure, a vital component for MSMEs. This infrastructure will include dedicated facilities, transport networks and e-commerce support, enabling MSMEs to operate efficiently. By bridging the gap between small-scale manufacturers and large, export-oriented competitors, the PM MITRA scheme is expected to enhance the competitiveness of MSMEs and facilitate their growth. Upon completion, each park is envisaged to generate 100,000 direct jobs and 200,000 indirect jobs, thereby making a significant contribution to employment creation. Furthermore, it is estimated that each PM MITRA park will attract investments of approximately Rs 10,000 crore, providing a substantial boost to the industry.

Suggestions to implement recommendations

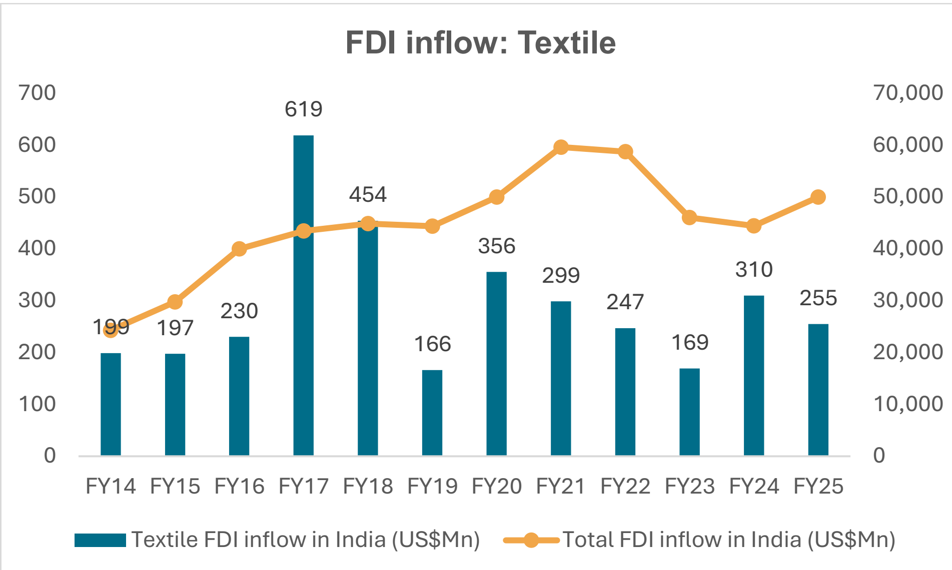
Promoting modernisation and innovation: To enhance productivity, competitiveness and product quality, it is important to address technological gaps among textile firms. Government support may be provided to facilitate the replacement of outdated machinery, adoption of automation and advanced production technologies, and integration of resource-efficient and environmentally sustainable practices.

Facilitating access to information and certifications: Cluster-level certification centres may be established as a one-stop support mechanism for MSMEs to meet domestic and international market requirements. These centres could provide guidance and assistance in obtaining the certifications, testing and compliance-related documentation required for textile exports, thereby reducing procedural difficulties and facilitating smoother access to global markets.

Recommendation II: Attracting foreign direct investments

The textile sector accounts for only ~0.67% (average of past 12 years) of India's total FDI inflows. Despite a 7% CAGR in overall FDI inflows over fiscals 2014-2025, the textile sector's FDI growth was limited to 2% during the period. Key challenges facing the sector include lack of trade agreements, underdeveloped infrastructure and regulatory hurdles.

Figure 52: FDI inflow trends pertaining to the Indian textile sector



Source: Department for Promotion of Industry and Internal Trade, Crisil Intelligence

Current initiatives

India allows 100% FDI in the textile sector under the automatic route. Single-brand retail also permits 100% FDI, subject to certain conditions. In contrast, multi-brand retail has a 51% FDI limit, with specific requirements.

Suggestions to implement recommendations:

- **Reduction of stamp duty and registration fees**
  Stamp duty and registration charges vary significantly across Indian States and can add materially to project establishment costs. This disparity makes property purchases in India relatively expensive compared with countries such as Mexico, which has abolished traditional stamp duties in favor of localized acquisition taxes. To attract foreign investors and remain competitive, it is crucial for India to revisit its stamp duty structure and consider reducing these charges for investors.

- **Streamlining approvals**
  To promote foreign investment in India, it is crucial to simplify the process of setting up a factory. Currently, companies must navigate a complex web of approvals from various departments, including the municipal corporation, state pollution control board, and others. This process is not only time-consuming but also costly. A potential solution is to create a centralised online platform that offers a one-stop solution for all approvals where land registration is electronically linked to all relevant state departments. This would enable companies to obtain all necessary approvals through a single online application, reducing the complexity, time and cost associated with setting up a factory in India.

- **Removal of exit barriers**

  According to a study by the Quality Council of India, which was conducted for the Economic Survey, the time taken to close a company in India is excessively long, requiring approximately 1,570 days (4.3 years) to complete, even in the absence of any complications. Much of this time, nearly three years, is spent navigating clearances and refunds from government agencies, such as the income tax department, GST administration, and provident fund authority. This emphasises the need for reform and simplification of exit procedures to facilitate easier business closure and promote a more business-friendly environment.

  Several measures can be taken to address the exit barriers, such as introducing a single-window clearance for winding up companies with no liabilities and streamlining the process of repatriating foreign funds when a company ceases operations.

- **Support for foreign companies investing in PM MITRA parks**

  To promote technology transfer and reduce dependence on imports, the government may support foreign firms that establish joint ventures with Indian companies in PM MITRA Park. This will encourage foreign companies to share advanced technology and set up production units in the park, specifically in segments where India currently relies heavily on imports.

By implementing these measures, India can fortify its presence in the textile industry, elevate its global standing and attract substantial foreign investment, thereby achieving sustained growth and ultimately transforming the sector to make it more competitive globally.

Recommendation – III: Creating large-scale capacities in the weaving and processing sub-sectors

India's textile sector uses outdated weaving and processing technologies, particularly the unorganised power loom segment. This practice hinders its fabric quality and productivity. To bridge the gap with competing countries such as China, it is essential to shift from obsolete shuttle looms to advanced shuttle-less looms. Shuttle-less looms, such as rapier and air-jet looms, are faster and more efficient, thereby increasing production and improving fabric consistency.

Suggestions to implement recommendations:

- **Promoting adoption of shuttle-less looms:**

The Ministry of Textiles may undertake a market research study to identify potential buyers with consistent demand for high-quality fabrics. The findings of the study could be leveraged to identify existing textile clusters with the potential to cater to such demand and facilitate their technological upgradation through appropriate support. This would enable the clusters to enhance their product quality, productivity and competitiveness in line with market requirements.

The Ministry may also play a facilitative role in establishing linkages between identified buyers and textile clusters, including facilitating discussions on bulk procurement commitments that provide greater market certainty to clusters while offering reliable sourcing opportunities to buyers. Such an approach could help foster sustainable, long-term partnerships between buyers and clusters.

At the cluster level, the respective associations may be encouraged to aggregate and manage bulk fabric orders, thereby streamlining the sales process, improving bargaining power, and ensuring that weavers receive a fair price for their products.

Recommendation – IV: Promoting research and development (R&D) in the private sector

The Indian textile sector lags in technology due to inadequate investment in R&D by the private sector. Compared with Chinese peers, India's private sector lags in R&D investments, with top textile companies allocating a mere 0.21% of sales towards R&D, significantly lower than the 2.25% spent by top Chinese textile companies (as per Annexure IV). To drive innovation and competitiveness, it is essential to incentivise and encourage private sector investment in R&D. Their participation in R&D is crucial for the sector to progress, address environmental concerns and capitalise on emerging opportunities and challenges.

Suggestions to implement recommendations:

To encourage design innovation, some support may be provided to companies purely on outcome basis that invest in design development and achieve commercial success with these designs.
This approach will lead to a reduction in the share of low-value-added products in India's export basket, thereby increasing the dependence of international retailers on Indian suppliers and making it more difficult for them to diversify to alternative suppliers.

Recommendation – V: Improving cost competitiveness

The textile industry in India is characterised by high logistics costs, exacerbated by the geographical dispersion of the sector. For example, cotton produced in Gujarat, Andhra Pradesh and Maharashtra is often transported to Rajkot and Coimbatore for spinning. The yarn is then sent to Pali, Erode or Bhiwandi in Maharashtra for weaving, knitting and processing. The finished fabric is transported to major consumption hubs such as Mumbai, Delhi, Bengaluru and others, where it is converted into ready-made garments. This complex supply chain highlights the interconnectedness of the sector and the dependencies that exist across the entire value chain.

Suggestions to implement recommendation:

- **Lower charges for textiles cluster using dedicated freight corridor (DFC)**
  The DFC offers a significant opportunity for textile clusters to reduce logistics costs, as rail transport is cheaper and more environment-friendly than road transport. To promote the use of DFC, the government may offer lower charges for specific textile clusters transporting goods using this corridor.

Recommendations to expand market outreach in the downstream sector

Recommendation – I: Enhancing market access through trade agreements

To expand India's export reach, FTAs play a critical role in reducing trade barriers. Recent agreements, such as the FTA with Australia, have demonstrated early success in boosting exports. Similar agreements with other key markets, can help Indian exporters gain duty-free or preferential access, thereby making Indian textiles more competitive globally.

Table 13: India's key FTAs and country-wise RMG export growth rate

Countries	FY22 (YoY RMG growth in quantity)	FY23 (YoY RMG growth in quantity)	FY24 (YoY RMG growth in quantity)	FY25 (YoY RMG growth in quantity)	Trade agreements
Japan	1%	12%	-1%	14%	In 2011, India and Japan signed a Comprehensive Economic Partnership Agreement (CEPA), allowing for duty-free import of Indian garments to Japan. Despite this, textile and apparel trade growth between the two countries has been modest. However, on January 27, 2021, the textiles committee, Ministry of Textiles, government and Japan's Nissenken Quality Evaluation Center signed a memorandum of understanding (MoU) to enhance the quality of Indian textiles and meet the requirements of Japanese buyers through various initiatives, including testing, inspection and conformity assessment, as well as training, capacity building, R&D and consultancy services
Australia	25%	2%	24%	36%	The India-Australia Economic Cooperation and Trade Agreement came into effect on December 29, 2022, providing immediate duty-free access to 96.4% of India's exports to Australia in value terms, including textiles and apparel, which were previously subject to a 5% import duty
Mauritius	-17%	38%	1%	7%	The Comprehensive Economic Cooperation and Partnership Agreement entered into force on April 1, 2021. Under this agreement, over 300 domestic goods from various sectors, including agriculture, textiles (comprising 27 product lines), electronics and others, will gain market access in the African nation at concessional customs duty rates
UAE	13%	4%	-8%	6%	The India-UAE CEPA, signed on February 18, 2022 and effective from May 1, 2022, has India securing immediate duty elimination on over 80% of its tariff lines, accounting for 90% of the country's exports in value terms, with most of these lines pertaining to labour-intensive sectors, such as textiles, which previously attracted tariffs ranging from 5% to 10%
UK	14%	-7%	-5%	13%	On May 6, 2025, the government officially announced the successful completion of the India-UK FTA. This agreement provides extensive market access for goods across sectors, encompassing India's export interests. With the elimination of tariffs on ~99% of tariff lines, covering ~100% of trade value, the India-UK FTA is expected to significantly enhance the competitiveness of Indian textile goods in the UK market relative to those of other countries.

Source: Directorate General of Commercial Intelligence and Statistics (DGCI&S), Crisil Intelligence

Table 14: Share of key FTA countries in India's RMG export basket (volume-wise)

Countries	FY21	FY22	FY23	FY24	FY25
Japan	1.16%	0.95%	1.15%	1.18%	1.18%
Australia	1.48%	1.50%	1.64%	2.10%	2.50%
Mauritius	0.23%	0.15%	0.23%	0.24%	0.22%
UAE	10.58%	9.92%	10.03%	9.83%	8.96%
UK	7.6%	7.03%	7.03%	6.93%	6.86%

Source: DGCI&S, Crisil Intelligence

Table 15: Duty-free access for RMG

	Exporting countries			
Importing countries	India	China	Vietnam	Bangladesh
US	No	No	No	No
EU-27	No@	No	No*	Yes
UK	Yes	No	No*	Yes
Canada	No	No	Yes	Yes
South Korea	Yes	No*	Yes	No*
Australia	Yes	Yes	Yes	Yes
UAE	Yes	No	No	No
Russia	No	No	No*	No
Mexico	No	No	No*	No
Malaysia	No*	Yes	Yes	No*
Panama	No	No	No	No
Brazil	No	No	No	No
Kuwait	No	No	No	No
Switzerland	Yes	Yes	Yes	Yes
Israel	Yes	Yes	Yes	Yes
Saudi Arabia	No	No	No	No

Note: Bangladesh is enjoying duty-free access in UK, EU, Japan, Canada, Korea and Australia owing to its LDC status

* *Exporting countries are subject to lower tariffs on RMG exports than other countries due to preferential treatment from importing countries*

"Yes" indicates availability of duty-free/preferential tariff access for RMG products under applicable FTAs, GSP/LDC schemes or other preferential arrangements, subject to product-specific tariff lines and rules of origin.

@FTA has been completely negotiated but yet to be ratified

Source: ITC Trade Map

Green	India has an advantage over China, Bangladesh and Vietnam
Grey	No advantage to any of the four exporting countries
Dark orange	India has a disadvantage over China, Vietnam or Bangladesh
Blue	India and Bangladesh have an advantage over China and Vietnam
Light orange	India and Vietnam have an advantage over China and Bangladesh

Suggestions to implement recommendations:

- **Leveraging India's strengths in cotton:** FTAs should also focus on promoting India's core strengths, such as cotton textiles, to maximise export opportunities. Collaborative initiatives within FTAs to promote Indian cotton as a high-quality, sustainable option could create additional demand in international markets
- **FTAs with high-potential markets:** While traditional markets such as the EU and the US remain crucial, India may strive to sign FTAs with these countries and simultaneously explore new trade opportunities with high-growth markets such as Mexico, Canada, Malaysia, Brazil, Panama, Russia, Kuwait and Saudi Arabia (Annexure II)
- **Market development**: Expanding into new markets can be achieved through:
    - Identifying the specific types of garments needed in those countries by examining their import data on apparel
    - The industry association engaging with various clusters to design and manufacture the required products for export to the identified countries.
    - Organising trade shows and exhibitions in the target countries to showcase offerings and attract potential buyers

Recommendation – II: Focus on sustainability practices

The mounting environmental concerns have made regulatory support for sustainable production a necessity, with policies such as the Eco-Design for Sustainable Products Regulation (ESPR) and the Corporate Sustainability Due Diligence Directive (CSDDD) playing a key role. Moreover, a significant number of retailers in the US and EU are using sustainability criteria to evaluate suppliers, and major buyers are increasingly requiring certifications that demonstrate compliance with environmental and social standards.

Suggestions to implement recommendations

- **Promoting sustainable practices:** The government's support for sustainable practices in the textile industry can be instrumental in driving industry-wide change. By offering support, the government may encourage industry players to adopt environmentally friendly methods, including Closed-Loop Recycling, green technology adoption, development of advanced sustainable fibers like bamboo fibre, banana fibre, and hemp, and the use of recycled materials. Textile industry associations should provide regular updates on the latest sustainable practices and requirements, monitor trends in sustainable exports, and collaborate with international organizations to support businesses in their green transition

- **Certification for sustainable practices in India:** To comply with international sustainability standards, Indian textile exporters must obtain certifications such as OEKO-TEX Standard 100, which ensures that textiles are chemical-free, Global Organic Textile Standard or GOTS, which is necessary for the export of organic textiles, and Registration, Evaluation, Authorisation and Restriction of Chemicals or REACH, which tests the safety conformity of textiles under EU law. These certifications are crucial for accessing international markets, as most US and EU retailers use sustainability criteria when selecting suppliers.

Adopting sustainable production practices is crucial to achieve long-term success. A collaborative framework is also necessary to bring together industry stakeholders, including government, consumers, manufacturers and investors, to promote eco-friendly practices and reduce India's environmental footprint. Prioritising sustainability will enable India to tap into the conscious consumer market and become a reliable and sustainable player in the global market, boosting its competitiveness.

Improving efficiency of labour in the textile sector

Recommendation – I: Improve labour productivity and welfare

The informal nature of India's textile industry creates substantial obstacles in enforcing labour rights and limits the acquisition of skills required for advanced technologies. The industry is also under pressure from high attrition, as migrant labourers carry out the bulk of the manufacturing.

Current initiatives

- The government has launched several key initiatives to support labour welfare in the textile sector, including:
- The Samarth scheme: The scheme offers industry-driven training programmes aligned with the National Skills Qualifications Framework to boost job creation in the organised textile sector.
- Pradhan Mantri Shram Yogi Maandhan (PM-SYM) Pension Scheme: The PM-SYM scheme is a voluntary and contributory pension scheme covering unorganised workers, including handloom

workers, and provides a minimum assured pension of Rs 3,000 per month after the age of 60. The scheme has a 50:50 contribution structure between the beneficiary and the central government

- Pradhan Mantri Suraksha Bima Yojana (PMSBY): Introduced in 2015, the scheme offers affordable insurance coverage to individuals between 18 and 70 years of age. It provides coverage of Rs 2 lakhs for accidental death or full disability, and Rs 1 lakh for partial disability, benefiting the common people, including power loom workers

Suggestions to implement recommendations

- **Certification for responsible trade practices:** The apparel industry has faced criticism for its role in exploiting workers in developing countries, where low production costs often compromise safety conditions. In response, international brands are now proactively investigating their entire supply chains, driving a shift towards greater transparency, due diligence and accountability. To promote responsible business practices, the Indian government may introduce voluntary certifications for companies that demonstrate ethical practices and prioritise labour welfare, enabling importers to identify and partner with ethical suppliers that adhere to stringent human rights standards

- **Providing hostels/dormitories to workers:** The provision of hostels or dormitories is a critical requirement in labour-intensive industries such as the garments sector, which largely relies on migrant workers. These hostels provide shared accommodation, usually situated near the workplace, and are essential to ensure the well-being and productivity of workers. India has made some progress in this regard with the launch of the Affordable Rental Housing Complexes in 2020.

  The proposed SAFE Accommodation Scheme for Workers is currently under development. The scheme seeks to address the need for safe, affordable, and dignified accommodation for workers, particularly migrant labour employed in manufacturing clusters. This scheme may be launched on priority with the objective of facilitating labour mobility, improving workers' well-being, and enhancing industrial productivity.

- **Training and development:**

  To boost worker capabilities and elevate output quality, targeted skill development initiatives can be introduced. As the industry adopts cutting-edge technologies, it is imperative that the traditional textile workforce acquires new skills and enhances their existing ones to remain relevant. Furthermore, education and training systems require a significant overhaul to align with evolving industry needs.

  Key areas identified for skilling and upskilling include:

  - **Technical design:** Technical designers play a vital role in translating creative concepts into feasible, functional, and manufacturable products. They serve as liaisons between designers and factories, ensuring a seamless transition from design to production
  - **Sustainable manufacturing:** Workers require knowledge and expertise in sustainable manufacturing practices to minimise environmental impact
  - **Digital technologies:** Developing expertise in integrating digital technologies, such as digital printing and AI-driven design, smart fabrics, and wearable technology with traditional textile manufacturing is crucial for driving enhancements in fibre quality, production efficiency, and automation
  - **Advanced fibre technologies:** Developing expertise in the production of advanced fibres that are high-performance, reliable, and eco-friendly is essential
  - **Artificial Intelligence and Blockchain:** Developing expertise in artificial intelligence (AI) and blockchain technologies is crucial. AI can play a pivotal role in demand forecasting, inventory management, and improving customer experiences, while blockchain technologies can improve traceability across the value chain

Effective training strategies:

- Industry-academia Collaboration: Foster partnerships between industry and academic institutions to provide real-time curriculum updates that align with industry needs
- Hands-on training through apprenticeships: Promote apprenticeships and certification programs in the aforementioned areas through the National Apprenticeship Promotion Scheme (NAPS)
- Public-private partnerships: Collaborate on setting up training centers near manufacturing clusters, aligning curriculum with industry requirements, and encouraging young talent to pursue textiles as a high-growth, technology-driven career path
- Integrating industry-led upskilling initiatives with policy support and infrastructure will help build a skilled and agile workforce capable of meeting the evolving demands of global buyers.

Recommendation on policy support for branding of Indian textiles

Recommendations - I: Support for global branding in apparel

India is a major apparel manufacturer for global brands such as Decathlon, H&M, and Zara. These retailers sell the products at a premium, leveraging their established brand value. Despite being a significant player in the apparel manufacturing industry, India lacks large, globally recognised brands, with a few exceptions such as FabIndia and Peter England etc. To overcome this, Indian manufacturers must prioritise investing in brand development in international markets. By shifting their focus to brand development, Indian manufacturers can transition from being mere contract manufacturers to building global brands, reaping the benefits of increased customer loyalty and premium pricing

Current Initiatives

- The Export Promotion Mission offers financial support, including interest subvention, export factoring, collateral guarantees, credit cards, and credit enhancement for market diversification, as well as non-financial support to enhance market readiness and competitiveness, covering areas such as export quality and compliance, international branding, packaging, trade fairs, logistics, and trade intelligence and capacity-building initiatives
- The government promotes “Brand India” in textiles through initiatives such as Kasturi Cotton and Silk Mark, which ensure quality, transparency, and purity in Indian cotton and silk products

Suggestions to implement recommendations

The government may offer support for developing global apparel brands. This initiative may support Indian apparel companies in building and promoting their global brands by providing funding for:

- **Facilitating bilateral market access:** The Indian government may leverage bilateral and diplomatic channels to ease market entry for Indian apparel brands in international markets. This could include negotiating preferential access, simplifying regulatory and certification requirements, and creating platforms for Indian brands to establish a presence in partner countries.
- **Strengthening export logistics and supply chain support:** The government may assist Indian apparel brands with logistics and supply chain infrastructure for international expansion, including support for warehousing, distribution networks, and streamlined export-import processes, thereby reducing the operational burden of entering and scaling in overseas markets.
- **Fostering collaborations between Indian weaves and brands:** The initiative may facilitate partnerships between Indian brands and traditional Indian weaves. By leveraging India's unique Geographical Indications (GI) tags, such as Kotpad handloom fabric, Kanchipuram Silk, Lucknow Chikankari, and Kashmir Pashmina, Indian brands can create exclusive, fashion products. This

collaboration will not only promote Indian weaves globally but also provide Indian brands with a unique selling proposition.

Strengthening specific segments of the textile industry

Recommendation – I: Diversification into technical textiles

Technical textiles, comprising specialised textile products designed for applications across sectors such as automotive, healthcare, agriculture and personal protection, constitute a rapidly expanding market. These products offer enhanced functional properties, including high strength, durability, and resistance to chemicals and ultraviolet radiation. Given its manufacturing capabilities and growing domestic demand, India has considerable potential to expand its footprint in this segment and emerge as a leading global supplier.

The domestic technical textile market has clocked a 7% CAGR, increasing to $26.8 billion in fiscal 2024 from $19 billion in fiscal 2019, according to the Ministry of Textiles. Additionally, technical textile exports have risen to $2.59 billion in fiscal 2024 from $1.99 billion in fiscal 2019, as reported by the Directorate General of Commercial Intelligence and Statistics.

Current initiatives
The Ministry of Textiles has set ambitious targets for India's technical textile sector, aiming for a domestic market size of $40 billion by 2030, while also targeting total exports of $10 billion by 2030. The government has introduced various initiatives for the growth and development of technical textiles. One such initiative is the National Technical Textiles Mission (NTTM), which has a capital outlay of Rs 1,480 crore and aims to establish India as a global leader in technical textiles by focusing on four key areas. The mission was extended till fiscal 2026. Refer to annexure II for more details on this initiative.

Secondly, the government has approved a PLI scheme for textiles, with an outlay of Rs 10,683 crore. It aims to promote the production of man-made fibre (MMF) apparel, MMF fabrics and technical textiles in the country. This initiative is designed to enable the textile sector to achieve scale and become competitive.

The government has taken a significant step towards promoting technical textiles by identifying 116 products for mandatory use across 10 ministries and departments, with 73 products notified as of June 2025, focusing on high-impact sectors such as healthcare, agriculture, infrastructure and defence to maximise the benefits of technical textiles.

All these initiatives have significantly strengthened India's domestic production of technical textiles.

However, despite the progress made, the technical textile industry in India still faces several challenges. These include:
- Over-reliance on imported machinery, which hinders domestic production and increases dependence on international suppliers, thus undermining the industry's self-sufficiency
- High dependence on the import of essential raw materials, particularly specialty fibres, which disrupts the supply chain, increases costs and poses a significant risk to the industry's sustainability
- Limited access to cutting-edge technical expertise, which restricts innovation and competitiveness, making it challenging for Indian technical textile manufacturers to stay ahead of the curve in the global market
- The research-commercialisation gap, where scientific research is not translated to practical applications and transferred to MSMEs, limiting the impact and potential of research breakthroughs

Suggestions to implement recommendations

- **Fostering international partnerships:** Partnering and collaborating with foreign governments and institutions will facilitate the transfer of world-class technical expertise and enhance the knowledge base of the domestic technical textiles industry. Key players in the technical textiles sector have undertaken several notable collaborations in the past, including:
  - In 2019, the Indian Technical Textile Association (ITTA) signed an MoU with the Taiwan Technical Textiles Association (TTTA) to promote the technical textile industry in the two countries. The MoU enables joint ventures in technical textile manufacturing and technical knowledge sharing between companies in both countries
  - Messe Frankfurt India and the Austrian Fibers Institute had partnered to host the Dornbirn Global Fiber Congress in November 2025, which had provided a unique platform for the technical textiles industry to explore the latest advancements in fibre technology, sustainable materials and innovative applications.

To propel the growth of India's technical textile industry, the Ministry of Textiles may prioritise strategic partnerships with countries, renowned for their expertise and technological advancements. By adopting a collaborative approach, the Ministry may facilitate knowledge sharing and innovation through joint ventures, technology exchange MOUs, and other cooperative agreements. Additionally, the Ministry may actively attract top technical textile manufacturers, proactively identifying and inviting industry leaders to establish operations in India, and creating a conducive environment for collaborative production. This multi-pronged approach will enable India to harness global best practices, accelerate industry growth, and emerge as a significant player in the global technical textile market

- **Transparency in R&D:** India's technical textile sector can benefit from R&D, but only if the results are disseminated to the industry. To achieve this, the replication of new developments, as well as training and skilling related to these developments, are essential. Moreover, research institutes must provide transparent reports, enabling the industry to adopt and implement the findings effectively. A joint effort between the government, researchers and relevant ministries is necessary to set up knowledge-sharing platforms for researchers and industry players to exchange research papers, best practices and new developments. This can be achieved through collective service centres that provide shared access to design expertise, product development facilities, testing equipment, thereby accelerating the adoption of new technologies in the technical textile domain

Recommendation–II: Promoting Indian weaves in the global market

Indian weaves, known for their intricate designs and cultural heritage, are gaining popularity in the slow fashion and luxury sectors. The global luxury market is showing more interest in traditional Indian textiles and craftsmanship. One such example is khadi, a well-known Indian fabric, whose exports have increased significantly from Rs 1.9 crore in fiscal 2017 to Rs 6.5 crore in fiscal 2019, a growth that can be attributed to:

- Partnerships with organisations such as the Federation of Indian Export Organisations (FIEO), World Trade Centre (WTC) and the Indian Trade Promotion Organisation (ITPO) to promote khadi in overseas markets through exhibitions and workshops
- Collaborations with the National Institute of Fashion Technology (NIFT) and other institutions to design innovative, export-quality khadi products
- Engagement with renowned fashion designers to enhance the competitiveness and appeal of khadi products in domestic and international markets
- Promotion of the eco-friendly nature of khadi, which aligns with the global sustainability trend
- Positioning KHADI as a high-end and luxury fashion product

Current initiatives

Several initiatives have been undertaken by the government and industry to support weavers, including:

- **Credit requirements:** The Weaver Mudra Scheme provides credit at a concessional 6% to handloom weavers, with margin money assistance also being provided at 20% of the loan amount, subject to a maximum of Rs 25,000 per individual weaver
- **Education and training:** The Ministry of Textiles has signed memoranda of understanding (MoUs) with the Indira Gandhi National Open University (IGNOU) and the National Institute of Open Schooling (NIOS) to provide educational facilities for weavers and their families
- **Raw material procurement:** The Yarn Supply Scheme facilitates the availability of yarn to eligible handloom weavers and organisations at mill-gate prices, with the objective of ensuring regular and timely access to essential raw materials.
- **Promoting artisans:** Artisans and weavers associated with handicrafts and handlooms can register on the Government e-Marketplace (GeM) to sell their products directly to various organisations without incurring registration fees. Furthermore, the government has launched initiatives such as Know Your Weaves, Shilp Didi Mahotsav 2024 and Urban Haats to promote the sale of Indian weaves
- The National Institute of Fashion Technology (NIFT), a renowned institution for design, management and technology, has been roped in as a knowledge partner to drive design development and strategic positioning of handlooms and handicrafts, thereby enhancing their market visibility and appeal.

Suggestions to implement recommendations:

- **Supporting artisan communities:** Government and industry initiatives to support artisans and preserve traditional skills are vital for boosting exports and improving the employment landscape. Programmes that facilitate connections between artisans and international markets, as well as establish premium branding for Indian weaves, can significantly drive demand. A notable example of such an initiative is Bharat Tex, which showcased sustainable textiles and highlighted traditional crafts, thereby promoting India's rich textile heritage. Through platforms such as Bharat Tex, artisans can showcase their skills and products, ultimately enhancing the global visibility and appeal of Indian textiles

- **Sustainable production:** Promoting sustainable and eco-friendly production processes for these weaves aligns with global trends toward sustainability, further enhancing India’s appeal in the luxury textile market

  In conclusion, by addressing the challenges and implementing strategic measures, India can successfully transform its textile industry, thereby enabling it to achieve the ambitious export target of $100 billion by 2030. A multi-faceted approach, which includes diversification into technical textiles, preservation of traditional weaves, resolution of structural issues in the MMF sector, addressing gap in natural fibre and strengthening of trade agreements, will enhance India's global competitiveness and establish it as a leading textile exporter. Moreover, the textile industry is a significant employment generator, providing direct and indirect livelihood to a vast number of people. Transforming the textile sector by implementing strategic measures will create new employment opportunities and also enhance the livelihood of the current workforce.

Annexures

Annexure I:

Country	Companies
Bangladesh	Desh Garments, Hwa Well Textiles BD Ltd, Evince Textiles
China	Shenzhou International Group Holdings Ltd, Luthai Textiles, Huafang Co Ltd
Vietnam	Song Hong Garment, TNG Investment and Trading JSC, Viettien Garment and Thanh Cong Textile Garment
India	Arvind Ltd, Bang Overseas Ltd, Cantabil Retail India Ltd, Celebrity Fashions Ltd, Gokaldas Exports Ltd, Indian Terrain Fashions Ltd, Kewal Kiran Clothing Ltd, Kitex Garments Ltd, Lovable Lingerie Ltd, Monte Carlo Fashions Ltd, Page Industries Ltd, Pearl Global Industries Ltd, Zodiac Clothing Company Ltd

Annexure II:

Ranking of high potential market for RMG exports

Rank	Country	CAGR in imports of apparel (CY18-24)	Share in global apparel imports (CY24)	Estimated GDP per capita growth rate (CY25-30)
1	Poland (EU)	12%	3%	6%
2	Mexico	12%	2%	4%
3	Romania (EU)	8%	1%	6%
4	Croatia (EU)	8%	0%	5%
5	Slovak Republic (EU)	6%	0%	5%
6	Russia*	8%	2%	3%
7	Hungary (EU)	3%	0%	6%
8	Czech Republic (EU)	5%	1%	4%
9	Malaysia	4%	0%	5%
10	Ireland (EU)	6%	1%	3%
11	UAE	3%	1%	5%
12	Panama	3%	0%	5%
13	Israel	6%	1%	3%

Rank	Country	CAGR in imports of apparel (CY18-24)	Share in global apparel imports (CY24)	Estimated GDP per capita growth rate (CY25-30)
14	Brazil	3%	0%	4%
15	Greece (EU)	4%	1%	4%
16	Korea	3%	3%	4%
17	Portugal (EU)	3%	1%	4%
18	Saudi Arabia	4%	1%	3%
19	Thailand	4%	0%	3%
20	Netherlands (EU)	3%	4%	3%
21	Canada	2%	2%	4%
22	Switzerland	3%	2%	3%
23	Australia	3%	2%	3%
24	Denmark (EU)	2%	1%	3%
25	Kuwait	5%	0%	2%

**Data for 2015-2021*
Note: Competitiveness is based on a weighted average of two factors: 40% apparel import growth and 60% estimated per capita GDP growth
Source: ITC Trademap, Crisil Intelligence, IMF World Economic Outlook

Annexure III:

Components of National Technical Textiles Mission

Component	Particulars	Mission	Action	Total capital outlay allocated under the scheme*
1	Research, innovation, and development	Promote research and development activities in technical textiles	Research topics include specialty fibres, geotextiles, medical textiles, defence textiles, sports textiles and environmentally friendly textiles, for which proposals have been invited. Guidelines have been established to: • Support the indigenous development of machinery and equipment for technical textiles in India	Rs 1,000 crore

			• Foster startups and young scientists in technical textiles application areas	
2	Promotion and market development	Enhance the application of technical textiles across various industries to boost the average growth rate by implementing strategic market development initiatives	• The Ministry has organised conferences and workshops to promote technical textiles, creating awareness and driving market development in the country • To ensure quality for both domestic consumption as well as imports, the ministry has issued quality control orders for 57 items, including geo-tech, protective, agro, and meditech textiles as of September 2024	Rs 50 crore
3	Export promotion	Aims at establishing export promotion council for technical textiles	Manmade and Technical Textiles Export Promotion Council has been designated to promote the export of technical textiles	Rs 10 crore
4	Education and skill development	Imparting advanced technical education and skilling in technical textiles, catering to the manufacture as well as the application areas	Guidelines have been issued to support academic institutes in developing technical textiles' programmes, including: • New undergrad and postgrad degree programmes • Update programmes with technical textiles courses • Grants for lab upgrades and faculty training • Internship support through the General Guidelines for Grant for Internship Support in Technical Textiles (GIST) to enhance education and	Rs 400 crore

			industry exposure for students	

*Initially allocated for FY 2021 to FY2024 and extended till FY 2026

Under component I–Research, development and innovation of NTTM

Particulars	Jun-23	Sep-23	Jan-24	Nov-24
Number of projects sanctioned till date	109	126	137	168
Valuation of projects sanctioned (Rs crore)	325	371	474	509

Annexure IV:

Indian companies							
	Arvind Ltd	Garware Technical Fibres Ltd	Pearl Global Industries Ltd	Vardhman Textiles Ltd	Filatex India Ltd	Welspun Living Ltd	Raymond Lifestyle Ltd
Rs crore	FY25	FY25	FY25	FY25	FY25	FY25	FY25
R&D expenditure	19.2	7.5949	9.8906	8.15	1.4816	39.76	0.248
Revenue from operating income	8329	1540	4,506	9,785	4252	10,697	6176
R&D expenditure as % of operating revenue	0.23	0.49	0.22	0.08	0.03	0.37	0.004
Chinese companies							
	Huafang Co Ltd	Xinfengming Group Co Ltd	HLA group Corp Ltd	Zhejiang Hangmin Co Ltd	Jiangsu Hongdou Industrial Co Ltd	Lancy Co Ltd	Lu Thai Textile Co Ltd
CNY million	CY24	CY24	CY24	CY24	CY24	CY24	CY24
R&D expenditure	141.69	1,209.25	288.13	181.71	17.2	108.62	206.82
Revenue from operating income	2,934	67,091	20,957	11,468	1,960	5,691	6,091
R&D expenditure as % of operating revenue	5	2	1	2	1	2	3

Source: Company data, Crisil Intelligence

Annexure V:

Staple fibre and filament yarn production in fiscal 2023 (million kg)

Natural fibre	
Silk	37
Jute and mesta	1,690
Wool	34
Cotton	5,712
Man-made fibre and filament	
Filament production	1,904
Polyester filament yarn	1,769
Man-made staple fibre	2,152
Polyester staple fibre	1,506

Source: Cotton Corporation of India, Central Silk Board, Ministry of Textiles, Department of Agriculture

TELECOM AND NETWORK EQUIPMENT MANUFACTURING

TANE market

Network infrastructure focus

India scale-up

PLI and localisation

Export roadmap

Radio infra and OFC

Table of contents

Telecom and Network Equipment

Executive Summary

Telecom and network equipment at a glance

1,200M+
India telecom subscribers

$25B
Indian TANE market, fiscal 2025

$50B
Expected market by 2032

10%
Expected CAGR

80%
Global market with top OEMs

98%
Private TSP demand share

Component localisation | Testing beds | Skill development | Cluster model | Export promotion

Sector Overview

India’s telecom and network equipment (TANE) manufacturing sector stands at a critical inflection point as the country pursues its vision of becoming a globally competitive manufacturing hub while strengthening digital infrastructure and technological self-reliance. As the backbone of telecommunications networks, TANE encompasses radio access network (RAN) equipment, routers and switches, optical fibre infrastructure, microwave apparatus, and associated networking systems that enable connectivity, digital services, and emerging technologies such as 5G, IoT, smart cities, and future 6G applications.

India is currently the world’s second-largest telecommunications market with more than 1.2 billion subscribers, approximately 85% telecom penetration, and nearly 75% internet usage. The telecom sector contributes an estimated 6–6.5% to national GDP and has attracted nearly USD 40 billion in foreign investment between 2000 and 2025. Recognizing the sector’s transformative potential, the National Telecom Policy 2025 (NTP-25) targets doubling the sector’s contribution to GDP, doubling exports of telecom products and services, creating one million new jobs, and significantly increasing investment and R&D expenditure by 2030.

While telecom services have expanded rapidly, domestic manufacturing of telecom equipment remains underdeveloped, resulting in substantial import dependence for critical network infrastructure. Strengthening the TANE ecosystem therefore represents a key opportunity to enhance economic resilience, generate skilled employment, deepen value addition, and improve India's position in global value chains.

The growth outlook for the industry remains robust, driven primarily by India's ongoing 5G rollout, rapid digitalisation, increasing data consumption, expansion of broadband infrastructure, emergence of smart city applications, industrial automation, IoT adoption, cloud computing, and growing enterprise connectivity requirements.

The Indian TANE market is estimated at approximately USD 25 billion in FY2025 and is projected to nearly double to about USD 50 billion by FY2032, growing at a compound annual growth rate (CAGR) of 10%.

Several demand-side indicators reinforce this outlook:

- 5G subscriptions are projected to increase from 2.27 billion in 2024 to 6.35 billion by 2030.
- Mobile data traffic is expected to grow from 124 EB per month to 303 EB per month by 2030.
- IoT connections are projected to expand from 13.2 billion to 34.7 billion over the same period.
- Continued fibreisation and broadband expansion will further increase demand for network infrastructure equipment.

Globally, the telecom equipment market is expected to grow from approximately USD 498 billion in FY2023 to USD 714 billion by FY2030, reflecting a CAGR of 5.28%. India is therefore positioned within a rapidly expanding global industry with significant export potential.

Current Structure of the Indian TANE Industry

Despite strong domestic demand, India continues to rely heavily on imports for network infrastructure equipment and critical components. TANE exports remain modest at USD 0.6–1.0 billion annually, representing only about 0.2–0.3% of India’s total exports. In contrast, imports have remained elevated at USD 4–5 billion annually.

The industry has achieved meaningful progress under the Production Linked Incentive (PLI) Scheme, particularly in product segments such as optical fibre cables, customer premises equipment, routers, and switches. Domestic companies including Tejas Networks, HFCL, and VVDN Technologies have emerged as important players. Additionally, global manufacturers such as Nokia, Ericsson, Samsung, and Sanmina have expanded manufacturing operations in India.

However, domestic value addition remains limited because much of the manufacturing activity continues to be assembly-oriented, with high dependence on imported semiconductors, RF modules, integrated circuits, processors, and other critical components. Localisation levels for several telecom products remain below 15%, demonstrating the need for deeper ecosystem development.

Lessons from Champion Countries

The study identifies China and Hungary as benchmark countries whose experiences provide valuable insights for India's telecom manufacturing strategy.

China has emerged as the global leader in telecom equipment manufacturing, driven by the scale and technological capabilities of companies such as Huawei and ZTE, which together have enabled Chinese OEMs to capture more than 42% of the global base station market. The country's success is underpinned by sustained investments in research and development, strong government support through industrial policies, dedicated Special Economic Zones (SEZs), rapid deployment of 5G infrastructure, a deeply integrated component manufacturing ecosystem, and extensive skilling and talent development initiatives. These interventions have enabled China to develop a highly competitive and self-reinforcing telecom manufacturing ecosystem spanning design, component production, assembly, and exports. By March 2026, China had deployed approximately 4.96 million 5G base stations, representing nearly 65% of global installations. The country has further strengthened its position through the strategic use of joint ventures, technology transfer, localisation requirements, and cluster-based manufacturing models, which have helped cultivate globally competitive telecom champions and establish China as a dominant player across the telecom equipment value chain.

Hungary represents a contrasting model of telecom equipment manufacturing that is centred on high-value production, advanced manufacturing capabilities, and strong integration with European markets. The country has emerged as one of Europe’s leading telecom equipment export hubs and hosts Nokia’s largest 5G manufacturing facility, underscoring its importance within the regional telecom ecosystem. In 2024, Hungary’s telecommunications equipment exports increased by 31.4% to reach approximately USD 5.5 billion, reflecting the sector’s growing competitiveness. This success has been supported by a combination of policy and structural advantages, including one of the lowest corporate income tax rates in Europe at 9%, sustained investments in telecommunications infrastructure, supportive spectrum management policies, the availability of a highly skilled technical workforce, and deep integration with European supply chains. Together, these factors have enabled Hungary to attract global telecom manufacturers and establish itself as a key production and export base for advanced telecom equipment

Key Challenges Limiting Global Competitiveness

Despite favourable demand conditions, several structural bottlenecks continue to constrain India's competitiveness.

First, high import dependence persists across critical electronic and telecom components, resulting in limited domestic value addition and higher production costs. Localisation levels for key telecom products remain low, particularly in high-value technologies such as 4G and 5G radio access equipment.

Second, domestic manufacturers face limited market access. Nearly 98% of telecom equipment demand originates from private telecom service providers, which continue to prefer established global OEMs owing to technological maturity, scalability, and certification standards.

Third, Indian manufacturers operate with lower profitability and weaker economies of scale compared with global competitors, limiting their ability to invest in innovation and capacity expansion.

Fourth, skill gaps and lower labour productivity continue to hinder the sector’s development. Productivity in telecom equipment manufacturing remains substantially below both the national manufacturing average and the electronic components sector, while employability challenges persist across technical disciplines.

Strategic Recommendations

The report proposes a targeted policy framework to transform India from an assembly-based manufacturing destination into a globally competitive telecom equipment ecosystem.

i. **Deepen Localisation Through Component Manufacturing**
A localisation-linked incentive framework is likely to encourage manufacturers to progressively source a greater share of bill-of-materials (BOM) components domestically. Focus may initially be placed on non-semiconductor, plastic, insulation, and electro-mechanical components, before gradually extending to higher-value components.

ii. **Promote Joint Ventures and Technology Transfer**
Drawing lessons from China's telecom industry, India may actively promote joint ventures between global OEMs and domestic firms to facilitate technology transfer, enhance local capabilities, and accelerate ecosystem development. Successful models such as Reliance Jio's partnership with Sanmina demonstrate the potential of this approach.

iii. **Develop Industrial Clusters**
Cluster-based manufacturing ecosystems similar to those observed in China and Taiwan can generate scale economies, facilitate supplier integration, strengthen innovation networks, and improve competitiveness. Emerging telecom manufacturing hubs such as Madhya Pradesh's Telecom Manufacturing Zone provide a potential template.

iv. **Focus on High-Potential Export Segments**
India should prioritise export promotion for radio infrastructure equipment, including antennas, remote radio heads, baseband units, optical fibre cables, and microwave apparatus. Global imports in antennas, RRH, and BU alone exceeded USD 219 billion in 2024, while India’s exports in these categories were less than USD 1 billion, indicating substantial untapped potential.

v. **Strengthening Testing, Certification, and Skill Development**
The establishment of centralised testing facilities, internationally aligned certification systems, and stronger industry-academia partnerships can improve product credibility, workforce readiness, and innovation outcomes.

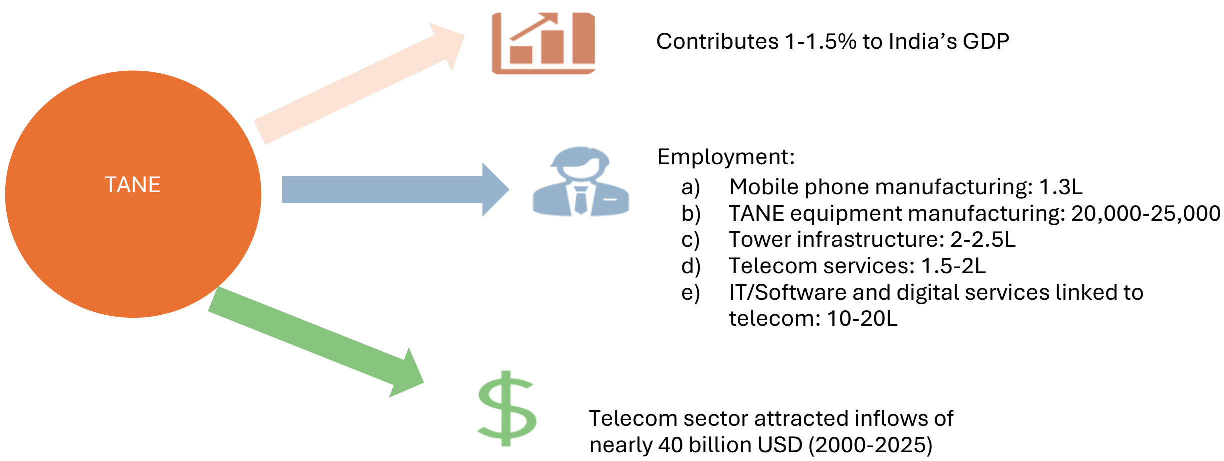
Conclusion

India possesses strong domestic demand, policy support, demographic advantages, and increasing manufacturing capabilities that position it favourably to emerge as a major global telecom equipment manufacturing hub. However, achieving this ambition will require a strategic shift from assembly-led manufacturing towards deep localisation, component ecosystem development, technology transfer, export orientation, and workforce strengthening. With focused implementation, the sector can significantly contribute to employment generation, export expansion, technological self-reliance, and India's broader objective of becoming a globally competitive manufacturing economy.

Introduction to telecom and network equipment

India is the second-largest telecommunications market globally with a subscriber base over 1,200 million. With approximately 85% of the population using telecom services regularly and approximately 75% leveraging internet services, digitalisation continues to permeate consumer-centric industries such as e-commerce, travel and tourism. India's relatively young population (median age of 28 years) and technology-driven governance, social change and service delivery, present an opportunity for the telecom and network equipment (TANE) manufacturing industry to benefit from favourable demand advantages and establish a domestic ecosystem for growth.

Figure 53: TANE contribution to Indian economy



Source: DPIIT

Currently, the telecom sector contributes around 6-6.5% to the nation's GDP and policies such as National Telecom Policy 2025 aim to leverage this potential to drive growth across investments, employment and export. The NTP-25 aims to accomplish the following strategic objectives in telecom sector by 2030:

1. Universal and Meaningful Connectivity for all.
2. Double the contribution of the sector to India's GDP.
3. Achieve an annual investment of Rs 1,00,000 crore
4. Double the export of telecom products and services.
5. Double the number of telecommunications startups.
6. Double the sectoral R&D spending on emerging telecom technologies.
7. Create 1 million new jobs
8. Upskill/reskill 1 million workers to meet the future demand.
9. Strengthen security by adopting quantum resistant cryptography.
10. Reduce carbon footprint by 30%.

As the industry providing underlying infrastructure for these objectives, ensuring growth of TANE becomes critical for the country.

Growth drivers

From 2018 to 2022, the Indian market was largely driven by the need to modernise legacy networks and deploy new hardware to support the rollout of 4G services. However, from 2023 to 2027, the scale and momentum of the 5G rollout, adoption of 5G-enabled enterprise services, including smart city initiatives, IoT applications, mission-critical communications and other emerging use cases are expected to drive the demand for telecom equipment. As 5G technology becomes more widespread, there is likely to be significant demand for telecom equipment that can support innovative applications such as smart city infrastructure, industrial automation, remote healthcare and immersive technologies such as augmented reality (AR) and virtual reality (VR), thereby driving growth in the Indian telecom equipment market. The Indian TANE market size is estimated at nearly $25 billion in fiscal 2025 and is expected to reach $50 billion by 2032, growing at a CAGR of 10%.

However, the equipment required to modernise existing telecom infrastructure as well as the equipment required for rollout of new services such as the 5G rollout in 2022 has been traditionally imported from countries such as China, Taiwan and other countries.

Table 16: India's trade position in telecom and network equipment manufacturing

all figures are in USD billion	2020	2021	2022	2023	2024
India total exports	275	395	453	431	442
India TANE exports	0.6	0.8	1.1	0.9	1.0
TANE share in exports	0.23%	0.20%	0.25%	0.22%	0.23%
India total imports	368	570	733	674	703
India NATE imports	4.0	4.4	5.1	4.6	3.6
TANE share in imports	1.1%	0.8%	0.7%	0.7%	0.5%

Note: All figures are in USD billion
Source: DGFT, Crisil Intelligence, E: Estimate

India's telecom and network equipment (TANE) sector stands at a pivotal juncture, poised to fuel the National Telecom Policy 2025 (NTP-25) ambitions of universal connectivity, doubled GDP contribution, and $1 trillion in exports by 2030. Yet stark trade imbalances underscore an urgent need for targeted intervention: domestic TANE exports languish at a mere 0.2-0.3% share of total exports ($0.6-1.0 billion annually from 2020-2024), while imports dominate at USD 4-5 billion yearly, constituting 0.7-1.1% of total imports, with over 80% sourced from China for critical components like 4G/5G antennas and signal processors. This heavy import reliance exposes the economy to supply chain vulnerabilities, geopolitical risks, and currency fluctuations, stifling self-reliance (Atmanirbhar Bharat).

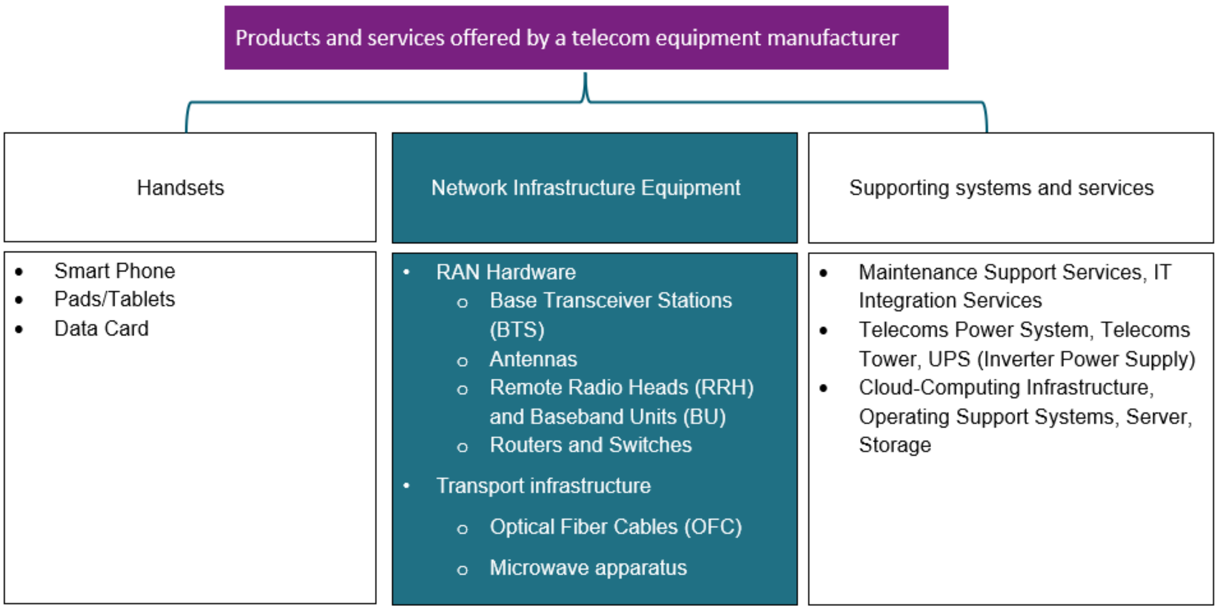
Robust government intervention will go a long way in catalysing domestic manufacturing, aligning with NTP-25's 150% output surge and 50% import substitution goals.

The sector has benefitted from interventions such as the Production Linked Incentive (PLI) scheme and similar supportive measures could double TANE's GDP share to 1-1.5%, generate 500,000 skilled jobs, and position India as a $50 billion export hub by 2035, transforming vulnerabilities into global leadership.

The Umbrella of TANE

The Telecom and Network Equipment (TANE) ecosystem forms the backbone of modern global connectivity, enabling voice, data, and video services across mobile, fixed-line, and enterprise networks. The following illustration categorizes the wide range of products and services offered by a telecom equipment manufacturer into three core pillars:

Figure 54: Products and services offered by telecom equipment manufacturer



Source: Crisil Intelligence

For the purposes of this study, we are focusing on the network infrastructure equipment, as handsets have been covered in a separate analysis. Additionally, services have been excluded from this study

1. Handsets: These are end-user devices that allow individuals to access telecom networks.

Key Products:
- Smartphones: Advanced mobile devices with internet, apps, multimedia, and cellular connectivity (e.g., 4G/5G).
- Pads/Tablets: Larger touchscreen devices used for productivity, entertainment, and mobile computing.
- Data Cards: USB or embedded modems that provide internet connectivity to laptops or IoT devices via cellular networks.

2. Network Infrastructure Equipment: This is the physical and functional foundation of telecom networks, responsible for signal transmission, routing, and connectivity.

Table 17: Network Infrastructure equipment and their functions

Type	Equipment	Function
Radio access network (RAN) hardware	Base Transceiver Stations (BTS)	Traditional macro cell towers housing radio transceivers.
	Antennas	Transmit and receive radio signals; include directional, omnidirectional, and MIMO types.

Type	Equipment	Function
	Remote Radio Heads (RRH) & Baseband Units (Bbaseband units (BU)	Modern split-architecture design: RRH near antenna handles RF; BBU processes baseband signals centrally (enables C-RAN). Routers and Switches Direct data traffic within and between networks; support IP/MPLS routing and Layer 2/3 switching. Transport Infrastructure High-capacity backbone linking RAN to core network.
Transport Infrastructure	Optical Fibre Cables (OFC)	High-speed, low-latency medium using light pulses; supports DWDM for massive bandwidth.
	Microwave Apparatus	Point-to-point wireless backhaul using microwave frequencies; ideal for remote or rapid deployment areas.

It is noteworthy that network infrastructure equipment accounts for ~50% of total TANE market value, with highest growth in 5G RAN and optical transport, making it a key enabler to profitability of manufacturing companies worldwide.

3. Supporting Systems and Services: These ensure reliability, scalability, and operational efficiency of the network.

Table 18: Key service offerings by TANE companies

Cloud Computing Infrastructure	Virtualized network functions (vRAN, SDN/NFV), servers, storage, and orchestration platforms.
Operating Support Systems (OSS)	Software for network monitoring, fault management, performance analytics, and automation.
Maintenance & IT Integration Services	On-site support, remote troubleshooting, system upgrades, and integration with enterprise IT.
Telecom Power Systems	Reliable power supply solutions including rectifiers, batteries, and UPS (Uninterruptible Power Supply).

Strategic focus of the study

For the purposes of this study, we are focusing on the network infrastructure equipment, as handsets have been covered in a separate analysis. Additionally, services have been excluded from this study to keep focus on equipment manufacturing.

Thus, the core analytical lens is on:

- Radio access network (RAN) hardware (BTS, RRH, BBU, antennas)
- Routers & Switches
- Transport Infrastructure (OFC, Microwave)

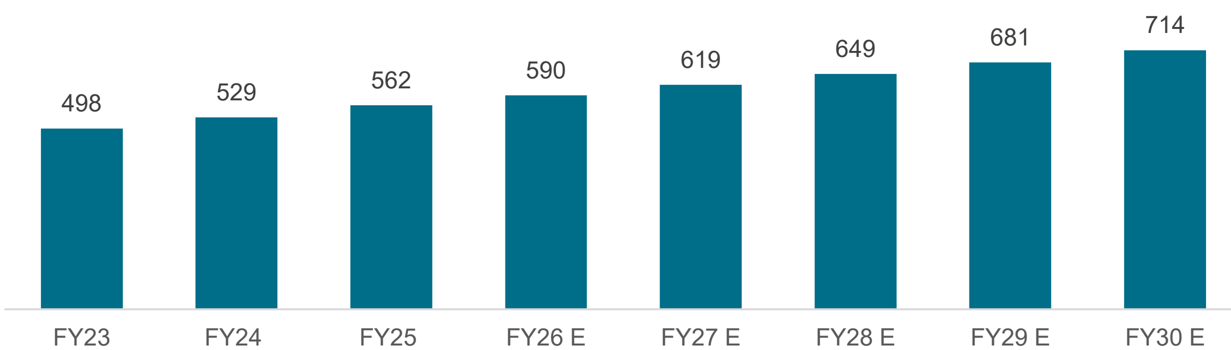
These segments are capital-intensive, technology-driven, and central to 5G rollout, edge computing, and fibreization trends. Domestic manufacturing of network infrastructure equipment is foundational to building a complete telecom equipment ecosystem in India. By producing core items like base stations, routers, and antennas locally, it creates steady demand for indigenous components such as RF modules, semiconductors, and PCBs, thereby nurturing ancillary industries and a robust supply chain. This localised production enables seamless design integration, customization, and rapid innovation in emerging 5G and 6G technologies. It also fosters skilled workforce development, R&D clusters, and attracts startups and global OEM partnerships, creating a self-sustaining cycle that transforms India from an import-reliant market into a fully integrated, competitive telecom manufacturing hub.

Global TANE industry – an overview

The global telecom equipment manufacturing landscape is characterized by a high degree of consolidation, with a small group of original equipment manufacturers (OEMs) holding a significant majority of the market share. Notably, industry leaders such as Huawei, Nokia, Ericsson, ZTE, Ciena, and Cisco collectively account for approximately 80% of the global market. The strong market presence and comprehensive product and service offerings of these established players create a substantial barrier to entry for Indian Telecom and Networking Equipment (TANE) manufacturers seeking to expand into international markets.

The global telecom equipment market is expected to increase from USD 498 billion in FY23 to USD 714 billion by FY30, at a compound annual growth rate (CAGR) of 5.28% over the period

Figure 55: Global TANE market size



Source: TRAI, Frost & Sullivan, TRAI, Crisil Intelligence, E: Estimate

The manufacturing of TANE products relies on a collaborative and interconnected global supply chain, where regions specialize in distinct high-value components, such as Taiwan's dominance in advanced semiconductors and South Korea's expertise in OLED displays and memory chips.

For instance, a 5G base station assembled in India integrates Taiwanese TSMC-fabricated chipsets, Japanese optical transceivers, and US-designed IP cores, enabling cost efficiency, rapid innovation, and resilience through diversified sourcing.

This interdependence means any disruption in one part can lead to supply chain interruptions in other locations. During the Covid-19 pandemic, widespread lockdowns, border closures, and social distancing measures disrupted the global supply chain of electronics components, including semiconductors, printed circuit boards, and other critical parts. Similarly, a severe drought in Taiwan in 2020, home to major semiconductor manufacturers such as TSMC affected the production of chips used in electronic products such as smartphones and laptops.

Indian TANE industry

India's Telecom and Networking Equipment (TANE) industry has evolved into a cornerstone of the nation's digital economy. This segment focuses on producing hardware like base stations, routers, optical fibre cables, antennas, and IoT devices that power mobile networks, broadband, and 5G ecosystems. Driven by government initiatives like "Make in India" and the Production Linked Incentive (PLI) scheme, the industry, coupled with the rapid rollout of 5G, now covering over 90% of districts and surging data consumption, the sector is poised to support India's ambition of becoming a global telecom export hub.

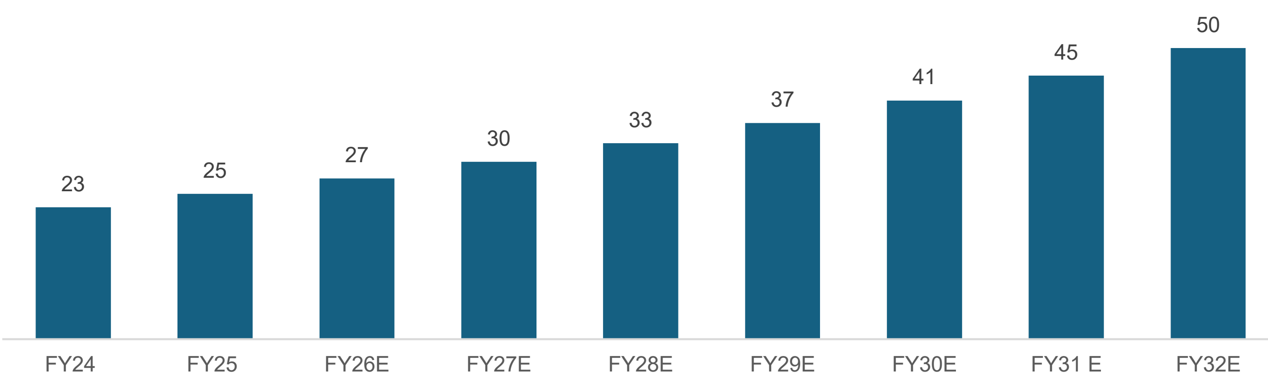
Table 19: Increasing uptake of digital services indicates a strong demand for TANE growth

S. No.	Key performance indicators	2024	2030F	CAGR
1	Smartphone (million)	7,160	8,330	3%
2	Mobile data traffic (EB/month)	124	303	16%
3	Fixed broadband connections (million)	1,590	1,890	3%
4	5G subscriptions (million)	2,270	6,350	19%
5	IoT connections (billion)	13.2	34.7	18%

Source: TRAI, Ericsson, Crisil Intelligence

The demand for TANE is expected to sustain in the Indian market

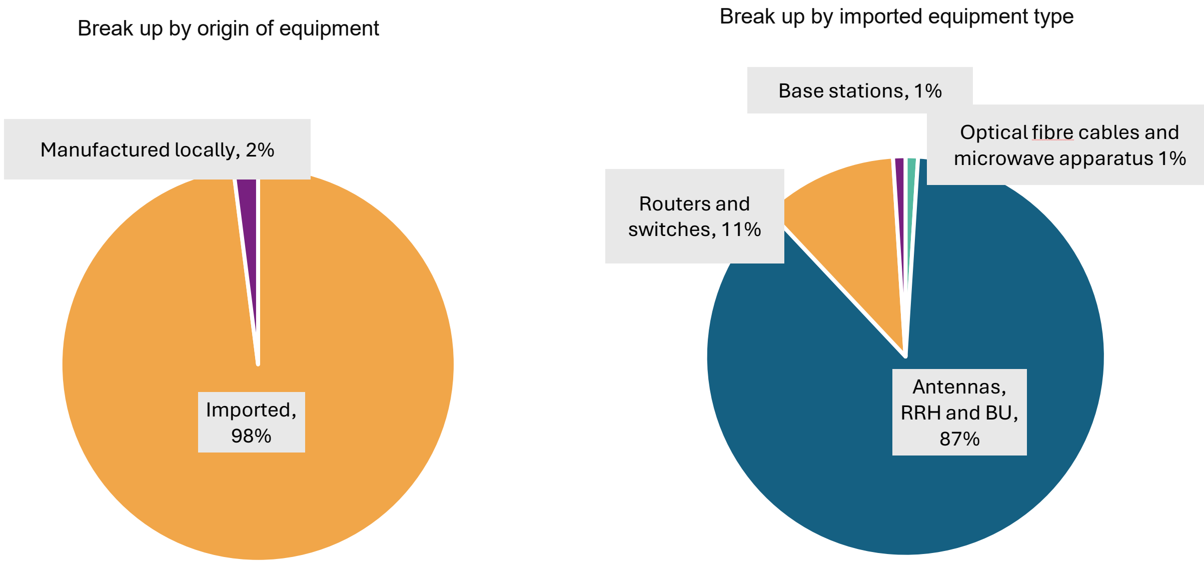
Figure 56: Indian TANE market size



Source: Ericsson, TRAI, Crisil Intelligence, E: Estimate

The three large Indian telecom service providers have historically met their network infrastructure equipment, including RAN hardware requirements through long-term deals with companies such as Huawei, Ericsson, and Nokia. This is in line with the trend around the globe as these companies are the market leaders, with sustained market dominance established by years of reliable service, product innovation, and quality standards. Innovation is at the core of the TANE industry, and to sustain this edge these original equipment manufacturers (OEMs) in regions such as South Korea, Europe, and the United States are collaborating with start-ups that specialise in cutting-edge technologies such as 5G, IoT, cybersecurity, cloud computing, AI, big data and analytics, and network functions virtualisation (NFV). Notably, companies like SK Telecom in South Korea, Deutsche Telekom and Nokia in Europe, and T-Mobile in the US have established their own accelerator programmes, which offer funding, product development support, and commercialisation guidance to start-ups, fostering innovation and driving growth in the telecom industry. Such initiatives enable start-ups to bring new ideas and solutions to market and let established players stay at the forefront of technological advancements.

Figure 57: Breakup of TANE equipment market in India



Source: DGFT, TRAI, Crisil Intelligence

Based on the nature of use, and to understand the import dependency along with the progress made by the domestic manufacturing across telecom and networking equipment product family, we can categorise the network infrastructure equipment (globally the most demanded as well as the key to successful 5G deployment and going forward, 6G introduction) in four subsets:

1. Antennas, remote radio heads (RRH), and baseband units (baseband units (BU)
2. Routers and switches
3. OFC and microwave apparatus
4. Base stations

Below is a detailed description of each category and how domestic manufacturing has evolved in recent years:

1. **Antennas, RRH, and BU** constitute a critical subset of network infrastructure equipment that facilitates radio frequency (RF) signal transmission and reception in wireless communication systems. These components collectively enable the conversion of digital signals to RF signals, amplification, and transmission over the air interface, using technologies such as beamforming and massive Multiple-Input Multiple-Output (MIMO).

   While exports of this subset have increased, the import dependency persists with a lack of substitutes made in India.

2. **Routers and switches** are fundamental components of network infrastructure, that enable efficient routing and switching of data packets across local area networks (LANs), wide area networks (WANs) and the Internet. They facilitate communication between devices, servers, and applications, ensuring reliable and high-speed data transfer.

   Since the inception of telecom Production Linked Incentive (PLI) scheme in 2021, imports have reduced to 50% from 2020 levels with Indian companies such as VVDN Technologies, Tejas Networks emerging as prominent manufacturers.

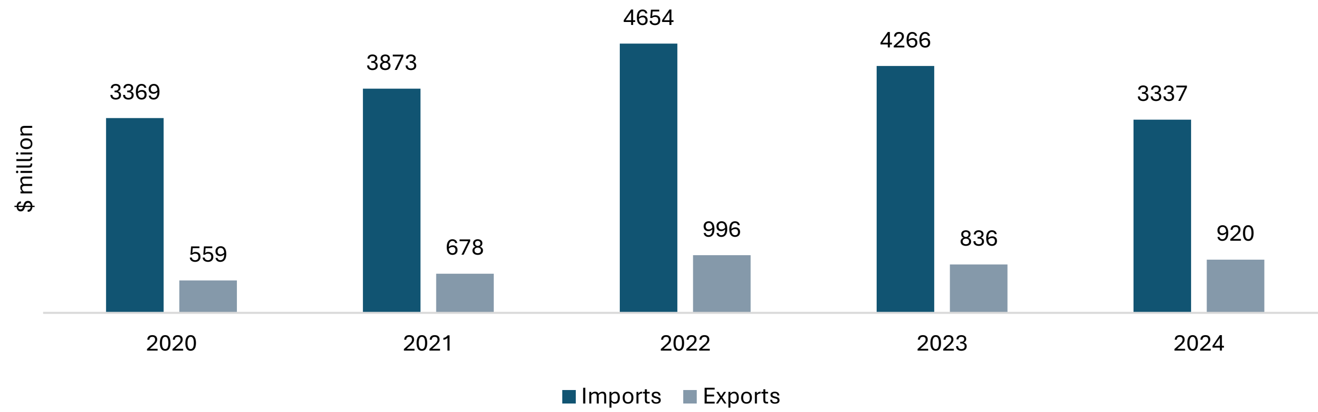
3. **OFC and microwave apparatus**: Companies such as Himachal Futuristic Communications Ltd (HFCL) have developed optical fibre cable and other related transport apparatus and indigenous capabilities. India

has achieved self-sufficiency in the production of common grades of optical fibre cables, particularly all-dielectric self-supporting (ADSS) and GYTC8S cables.

4. **Base stations** are the most commonly known among network infrastructure equipment. Base stations facilitate wireless communication between mobile devices and the core network. They transmit and receive radio signals, acting as a bridge between mobile devices and the larger network infrastructure. They are key to network deployment and were historically imported by India for all its requirements. A ban on Chinese gear in critical infrastructure saw the telecom companies procuring base stations manufactured in India by global OEMs such as Ericsson and Nokia. However, base stations manufactured by Indian OEMs still aren't competitive in terms of pricing, quality and technological capability. Companies such as Tejas Networks have made developments in domestic manufacturing, but a weak order book is a hurdle.

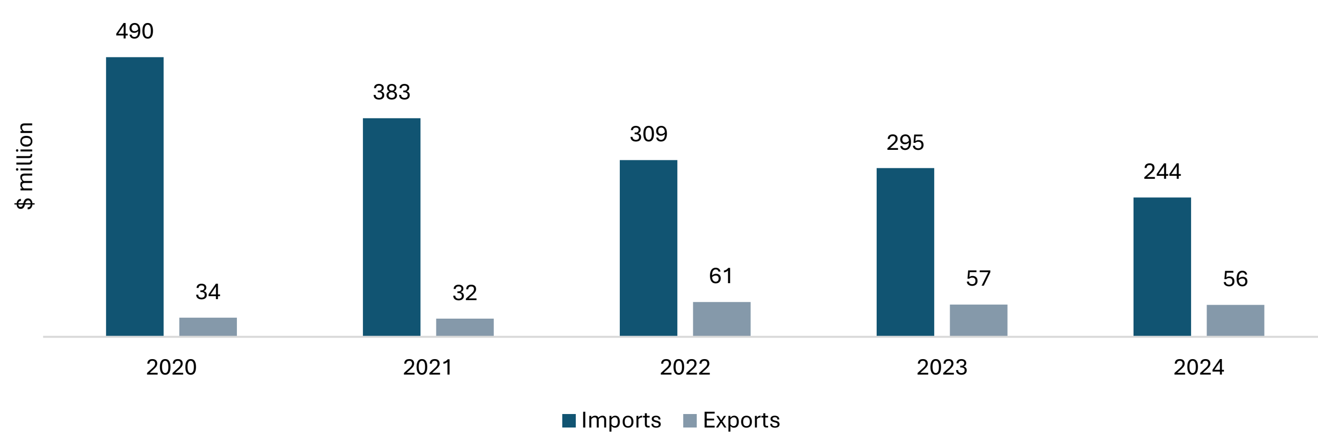
Following graphs show the import-export trend for each subcategory:

Figure 58: Antennas, RRH and BU



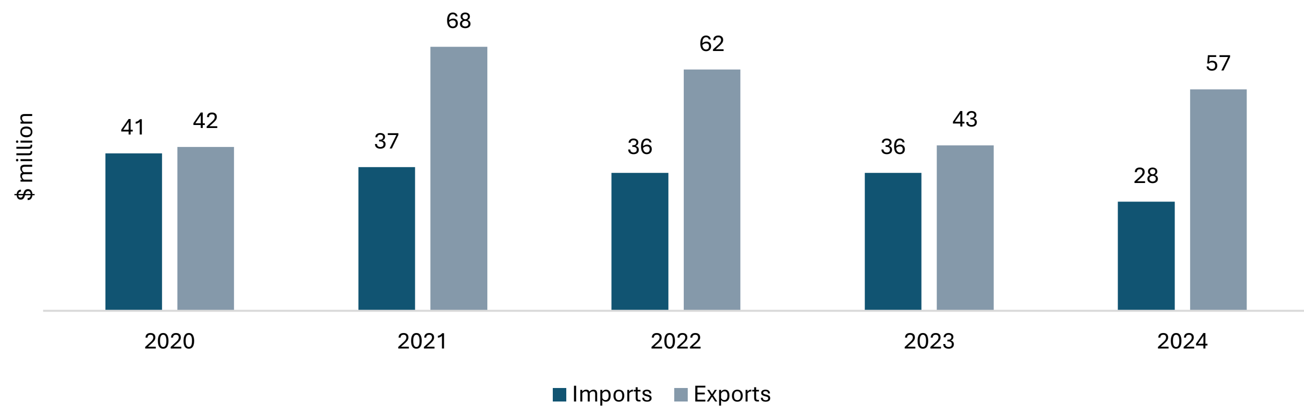
Source: DGFT, ITC Trade Vision

Figure 59: Routers and switches



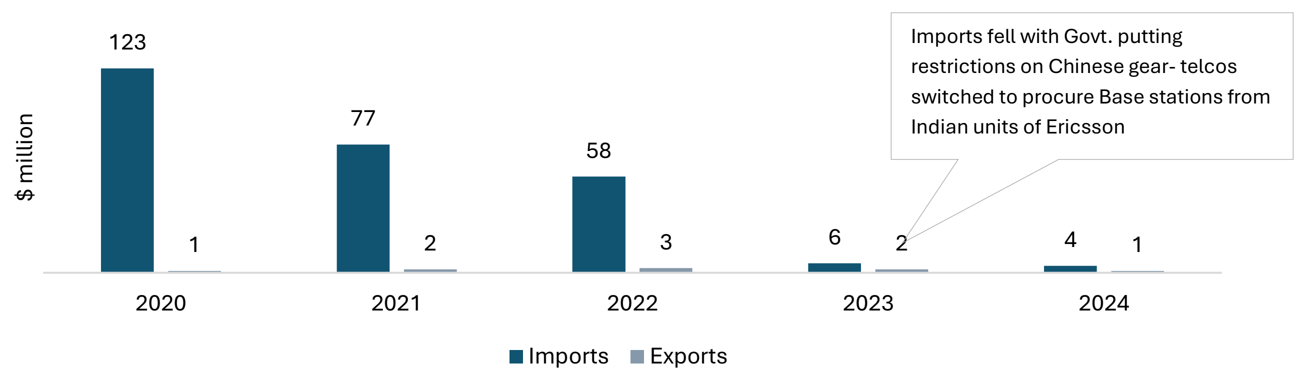
Source: DGFT, ITC Trade Vision

Figure 60: OFC and microwave apparatus



Source: DGFT, ITC Trade Vision

Figure 61: Base stations



Source: DGFT, ITC Trade Vision

Overall, the sector's trade dynamics reflect a gradually maturing ecosystem driven by the Production-Linked Incentive (PLI) scheme, yet persistent import dependence underscores the need for targeted assessments. In this context, it is imperative to evaluate India's import-export balance, its alignment with global trade frameworks, and opportunities to export products aligned with surging international demand, while building domestic manufacturing capabilities.

By focusing on globally demanded, domestically scaled products, India can achieve atmanirbharta with a dedicated telecom equipment export promotion policy. This assessment is vital for navigating geopolitical headwinds toward sustainable, geopolitically resilient growth.

Strategic alignment

With this context, India's ambition to emerge as a global hub for telecom equipment manufacturing, encompassing 5G/6G base stations, routers, antennas, handsets, and network infrastructure must be evaluated through the lens of strategic geopolitical alignment. This necessity arises from the industry's inherently fragmented and interdependent global value chain (GVC), where no single nation dominates all stages. Unlike commoditised sectors, telecom manufacturing involves high-value, technology-intensive processes distributed across geographies, creating vulnerabilities to supply disruptions, intellectual property (IP) risks, export controls, and geopolitical leverage. For India, a late entrant with a USD 20+ billion domestic market and "Make in India" incentives, misalignment with key GVC partners could derail self-reliance goals under the Production-Linked Incentive (PLI) scheme, while over-dependence on adversarial suppliers risks national security in critical information infrastructure (CII).

Availability of raw materials

The telecom and network equipment manufacturing industry relies heavily on a complex network of specialised suppliers for sub-assembled units and components. These components, such as printed circuit boards, antennas, and radio frequency (RF) modules, are crucial to make base stations, routers, and switches, among others. As the import dependency is high for these components, domestic manufacturers have to face 10-15% higher costs than global original equipment manufacturers (OEMs).

Indian companies making generic TANE equipment face up to 26% higher fiscal disability compared with their global peers in high-value-added telecom manufacturing. Further, the disability rises to 29% in product categories where buyer's credit is available against imports for an extended period.

Table 20: Raw material availability for TANE sector

Key components required	Amplifiers	Mixers	Oscillators	RF filters
Supplier country 1	China	Vietnam	China	China
Supplier country 2	Singapore	China	Singapore	USA
Supplier country 3	Japan	Thailand	Japan	Israel
Domestic availability	Yes	Yes	Yes	Yes
Import dependence	High	High	High	High
Reason for India's high import dependence	Indian components are expensive, and it is cheaper to import			

Table 21: Major suppliers of telecom equipment and degree of India's import dependence

Key component required	Processors	Integrated circuits	Static converters	Diodes	Transistors
Supplier country 1	China	China	China	China	China
Supplier country 2	Singapore	Singapore	Singapore	Singapore	Singapore
Supplier country 3	South Korea	South Korea	Germany	Japan	Germany
Domestic availability	No	No	Yes	Yes	Yes
Import dependence	High	High	High	High	High
Reason for India's high import dependence	Not manufactured in India		Indian components are expensive, and it is cheaper to import		

Geopolitical relationship	Positive	Neutral

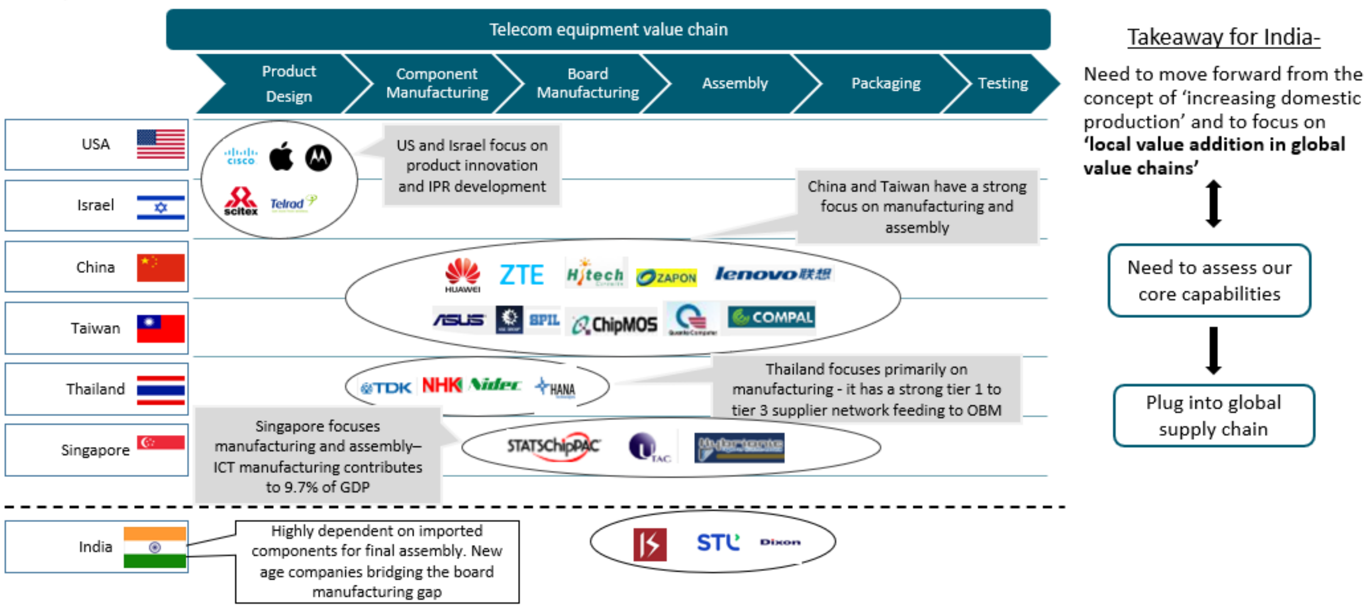
Source: Crisil Intelligence

Apart from taking up a substantial portion of the production cost, these sub-assembled units and components play a critical role in determining the performance and quality of the final product. Furthermore, the lead times for sourcing these components can be lengthy, and any disruptions to the supply chain can have a ripple effect on the manufacturing process. As a result, telecom equipment manufacturers must carefully manage their relationships with suppliers, monitor inventory levels and develop strategies to mitigate risks associated with component shortages or quality issues. This is necessary to ensure a stable and efficient production process. The Indian telecom equipment sector is dependent on imports for key components such as integrated circuits, diodes, transistors and amplifiers.

Value chain play

The telecom and networking equipment industry has a complex value chain with several stages, from conceptualisation to product delivery. The domestic industry has seen significant growth and localisation, and the country has emerged as a major hub for assembly of telecom and networking equipment.

Figure 62: Parts of the global collaborative chain



OBM: Original Brand Manufacturers
Source: Crisil Intelligence, COAI, Ministry of Trade and Industry, government of Singapore

Focus area: The value chain illustrates that no country is self-sufficient in isolation when it comes to end-to-end value chain. Countries have become successful by leveraging their domestic strengths for specific parts of the value chain, gained expertise in adjacent areas and later pivoted to build scale.

Product design: The stage involves the conceptualisation and development of telecom and networking equipment, focusing on functionality, performance and regulatory compliance. It demands expertise in radio frequency (RF) engineering, digital signal processing, and software development, among others. Historically, companies from the US and Israel have made significant breakthroughs in product design. That helped them design and develop many products for global markets.

The design stage involves creating detailed technical specifications, simulations, and prototypes to test and validate the product's performance. Companies such as Cisco of the US, Bell Telephone Manufacturing (BTM) of Belgium (now part of Alcatel), and Siemens of Germany were the pioneers in designing and developing new products and telecom equipment technologies. This trend continued until Chinese and Korean firms mastered reverse engineering, then invested heavily in R&D to develop proprietary technologies, for instance Huawei's breakthrough in 5G baseband chips and single RAN architecture, evolving from imitators into global innovators and market leaders.

Component manufacturing: This critical phase involves the production of key components such as radio frequency (RF) modules, amplifiers, filters and connectors. It demands high-precision engineering, cutting-edge manufacturing techniques, and stringent quality control processes to guarantee that components meet the exacting specifications required for reliable and efficient telecom systems.

Companies that specialise in telecom component manufacturing, such as Huawei, ZTE, Qorvo and Broadcom, possess the expertise and capabilities to design and produce these complex components. Other notable players in this field include Texas Instruments, STMicroelectronics and Analog Devices.

These companies offer a wide range of telecom components, including power amplifiers, low-noise amplifiers, and switches. For instance, Huawei is a leading provider of RF modules and amplifiers, while Qorvo is renowned for its expertise in filter and switch technology. Broadcom, on the other hand, offers a broad portfolio of telecom components, including optical and copper connectivity solutions. These companies, along with others, play a vital role in enabling the production of advanced telecom equipment, such as base stations, routers and switches, which are essential for modern communication networks. Notably, many companies that originated in China, Thailand and Taiwan hold expertise in component manufacturing.

Board manufacturing: The board manufacturing stage is where printed circuit boards (PCBs) are designed, fabricated, and assembled with precision. This stage demands expertise in PCB design, fabrication, and assembly, as well as the use of advanced manufacturing techniques such as surface mount technology (SMT) and through-hole technology (THT) to assemble components on a PCB.

Companies that specialise in telecom-related board manufacturing, such as Foxconn, Pegatron and Wistron (all Taiwan), possess the capabilities to design and manufacture complex PCBs for telecom and networking equipment. Foxconn has expertise in SMT and THT assembly. Pegatron specialises in designing and manufacturing complex PCBs for telecom and networking applications, including 5G and IoT devices. Wistron offers a range of board manufacturing services, including PCB design, fabrication and assembly, for telecom and networking equipment.

Other notable players in this field include Jabil, Flex and Sanmina (all USA). These companies offer a range of board manufacturing services, including PCB design, fabrication, and assembly, for telecom and networking applications. In Asia, Uniflex, BYD (China) and Tripod Technology (Taiwan) are among the prominent players in this space with expertise in producing high-quality PCBs. These companies leverage their advanced manufacturing facilities, cutting-edge technologies and rigorous quality control processes to meet the requirements of the telecom industry.

Assembly: The final stage of telecom equipment production involves the meticulous integration of components and boards into a cohesive unit. This intricate process requires a deep understanding of mechanical engineering, thermal management and electromagnetic compatibility (EMC), as well as the utilisation of cutting-edge manufacturing techniques such as robotic assembly and automated testing. By leveraging these advanced methods, manufacturers can ensure that the finished product meets the stringent specifications required by the telecom industry.

A number of companies have established themselves as experts in telecom-related assembly, including Foxconn, Pegatron (Taiwan), and Flex (USA). These industry leaders possess the requisite expertise and capabilities to assemble complex telecom equipment, such as base stations, routers and switches, with precision and accuracy. Other notable players in this field include Jabil, Sanmina and Kimball Electronics (USA).

In the Asian region, Wistron, Inventec and Quanta Computer (Taiwan) have developed a reputation for producing high-quality telecom equipment that meets the exacting standards of leading OEMs. By combining advanced manufacturing facilities, cutting-edge technologies, and rigorous quality control processes, they are able to deliver reliable and efficient telecom equipment that meets the evolving needs of the industry.

These large global OEMs have established units in India for two primary reasons: as a China+1 production site and to take benefit of the cheap labour in the country. Ericsson, Nokia, Sanmina, and Samsung are companies with notable Indian presence.

In the European region, Elmatica (Norway) and Note (Sweden) provide specialised assembly services for telecom equipment, including PCB assembly, cable assembly, and testing. These companies have shown they can meet the exacting standards of leading OEMs, and score high on reliability, quality, and timely delivery.

Packaging and testing: Here the product is packaged, software and firmware are installed, and rigorous testing is conducted to ensure that the product meets the required specifications. This stage demands expertise in software development, testing and validation, as well as the use of advanced testing equipment and methodologies such as automated testing and simulation.

Companies that specialise in telecom-related packaging and testing possess the expertise and capabilities to ensure that telecom equipment meets the required standards. The notable players are Keysight Technologies, Spirent Communications, Ixia (USA), Anritsu (Japan), Rohde & Schwarz (Germany) and EXFO (Canada). These players offer a range of testing and validation services, including automated testing, simulation and certification, for telecom equipment.

India's telecom and network equipment (TANE) manufacturing remains largely confined to low-value assembly operations, with firms importing high-cost sub-assemblies and components to meet PLI localisation thresholds through final integration and packaging. This model yields minimal domestic value addition which is often below 20%, leaving critical design, R&D, and core component fabrication abroad, as evidenced by persistent import reliance on RF modules, chipsets, and optical transceivers. Stakeholders, including industry bodies and global OEMs, have consistently emphasised the need for ecosystem-centric manufacturing—encompassing end-to-end capabilities from silicon design and PCB fabrication to software integration and certification testing, to shift India from a mere assembly hub to a strategic partner in global value chains. Only by building such integrated clusters can India ensure that multinational firms establish deep-rooted operations driven by competitive advantage, not transient policy incentives, thereby securing sustained investment, technology transfer, and resilience against incentive withdrawal.

Benchmarking against competing countries

Selection of champion countries

China and Hungary are strategically chosen as champion countries for studying the global telecom equipment manufacturing industry due to their distinct yet complementary strengths. China, a powerhouse, commands over 40% of the market through giants like Huawei and ZTE, leveraging unmatched scale, state-backed R&D, and extensive supply chains exporting to 170+ countries. Its cost efficiencies and 5G dominance offer critical lessons for India's self-reliance goals. Conversely, Hungary, Europe's telecom manufacturing hub, hosts Nokia's largest 5G factory in Komárom, producing 2.5 million units annually, and Huawei's key R&D center. Its skilled workforce, EU market proximity, and focus on high-tech precision manufacturing highlight diversified, quality-driven models. Together, they provide a comprehensive blueprint comprising China's volume-driven approach and Hungary's innovation-centric ecosystem for India to enhance its ESDM sector, reduce import dependency, and boost export competitiveness under Atmanirbhar Bharat.

Table 22: Champion countries and their share in global exports

Telecom equipment	Country	Export value ($ billion, FY25)	% share in global exports
Base stations	China	1.9	53%
	Hungary	0.28	8%

Source: UN World Trade Statistics

China

China is the world's largest manufacturer of base transceiver stations (BTS), an essential component in cellular networks to facilitate wireless communication. This dominance is driven by a combination of advanced manufacturing capabilities, significant investment in research and development and supportive government policies. Huawei and ZTE lead the global market, contributing to China's manufacturing prowess in the sector. Chinese OEMs have over 42% share of the global BTS market. These OEMs include Huawei, ZTE Corp, Datang Telecom and FibreHome Networks.

Research and development (R&D): In 2018, R&D spending by multinational corporations in this industry was $15 billion-$20 billion. It supported innovation and technological advancements. The R&D focus helped Chinese firms develop proprietary technologies.

Skilling initiatives: Technology experts and foreign scientists have helped to enhance human resource development and competitiveness. Educational programmes, training workshops and collaborations with foreign experts have developed the skills and knowledge of domestic employees

Tax incentives: The Chinese government provides tax incentives and subsidies to domestic industries and researchers to increase production and innovation.

Infrastructure incentives: Telecommunication Regulation of PRC-The Decree of the State Council No. 291 of 2000 states that telecom equipment connected to public networks must meet licensing system set by the state. The licensing system, known as Network Access License (NAL), is a network access licence agreement that applies to telecom equipment connected to the public telecom network using wired or wireless technology. After obtaining the NAL, some devices also need to get the China Compulsory Certification (CCC), a national security and quality mark.

Regulatory environment

The regulatory environment in China for telecom equipment manufacturing is shaped by various government bodies and policies. These aim at technological advancement and maintaining security standards.

- **Ministry of Industry and Information Technology (MIIT):** The MIIT oversees the allocation and management of radio frequencies used by BTS. This ensures efficient use of the spectrum and minimises interference. The ministry sets the guidelines and enforces the requirements for network security, including the implementation of security protocols in BTS equipment to protect against cyber threats. These standards cover aspects such as signal strength, data transmission rates and energy efficiency.
- **China Communications Standards Association (CCSA):** CCSA is responsible for creating detailed technical standards for telecommunications equipment. These standards ensure that BTS manufactured in China meet international quality and performance benchmarks. CCSA works with global standardisation organisations to harmonise Chinese standards with international practices, facilitating global interoperability of Chinese-made BTS equipment.

Government policies

The Chinese government has implemented several policies to support the growth and global competitiveness of its BTS manufacturing sector. These include:

- Made in China 2025: This strategic policy aims to upgrade manufacturing capabilities, with a focus on high-tech industries, including telecommunications. It promotes innovation, quality improvements and the development of advanced manufacturing technologies.
- **5G development plan:** China launched its 5G technology in October 2019, significantly ahead of India, establishing a robust digital infrastructure that fuelled domestic demand. The Chinese government prioritised the deployment of 5G networks, which boosted demand for advanced BTSs substantially. Significant investments have been made in infrastructure development, research and international cooperation to establish the country as a leader in 5G technology.

Investment

The government's commitment to promoting the construction of the new infrastructure as a national strategy of China is highly valued.

The Ministry of Industry and Information Technology (MIIT) of China officially issued commercial 5G licences in 2019, initiating a nationwide 5G rollout. Approximately a year later, the ministry unveiled measures to accelerate the pace of construction of 5G infrastructure and to improve the capabilities to support innovation in 5G technologies.

This approach not only created a strong domestic market for 5G services but also set the stage for China to lead the global 5G landscape.

Infrastructure

In 2022, Chinese telcos and China tower built approximately 887,000 5G base stations, with an investment exceeding RMB 180 billion ($26 billion).

As of March 2026, China had achieved a remarkable feat in 5G infrastructure by establishing a total of 4.958 million 5G base stations, forming 65% of the world's total. As a result, over 70% of mobile users in the country are now utilising 5G services, positioning the country as a global leader in this technology, according to MIIT.

- **Special Economic Zones**
  China started setting up special economic zones (SEZs) with the government establishing the first four SEZs in Shenzhen, Xiamen, Zhuhai and Shantou between 1979 and 1980. Shenzhen is a world leader in shipping and supply chain. Shenzhen was selected to set up the first SEZ in the country primarily to facilitate international trade and investment.

  Some of the policies under Shenzhen SEZ:

  i. **Corporate income tax rate**
  Corporate income tax (CIT) rate for telecom equipment manufacturers located in China's SEZs is significantly lower than those outside. The tax rate for telecom equipment manufacturers in these zones is 15% while that for players outside is 25%.

  ii. **Tax reductions**
  - **Export enterprises*:*** If export value is more than 70% of their total annual production, they are offered a reduced 10% enterprise income tax rate
  - **Manufacturing enterprises:** If established for more than 10 years, they could get two years of income tax exemption
  - **High-tech enterprises:** Income tax rate of 10% for an additional three years if established for more than 10 years
  - **High-tech industries** - integrated circuits (IC) manufacturing enterprises:
    - A refund will be applied to value-added tax (VAT) exceeding 6% for sales of self-produced IC products.
    - General taxpayers will pay VAT at 17%

    Refunded tax shall be used for R&D related to IC products and expanded production. It shall not be subject to the levy of corporate income tax.

Free trade agreements – China-ASEAN Free Trade Area (CAFTA)

CAFTA is a trade agreement between China and the 10 members of the Association of Southeast Asian Nations (Asean).

The agreement eliminated tariffs on 90% of goods traded between China and Asean countries. By eliminating tariff on telecom equipment, CAFTA reduced cost for manufacturers, encouraging production.

The FTA has significantly boosted the supply chain for telecom equipment, with many components and raw materials sourced from Asean countries.

Training, learning and development – Huawei ICT Academy:

The Huawei Information and Communications Technology (ICT) Academy was established in 2013 as part of Huawei's commitment to developing ICT talent globally. The academy has trained over 150,000 students, of which a significant portion is Chinese. The academy collaborates with more than 900 universities and colleges in China and abroad to integrate the company’s courses into their curriculums. This academy includes a wide range of specific technologies, of which 5G technology is one. There are courses on development, architecture and applications of 5G networks.

Land policies

Export-oriented and high-tech enterprises need to pay only half the industrial land-use fees for the first five years.

Newly purchased properties for establishing production facilities and operations for high-tech enterprises and projects are exempt from property tax for five years starting from the date of completion of the purchase.

Hungary

In 2024, the country's telecommunication equipment export increased 31.4% to $5.5 billion making it one of the most important exporters after China.

Regulatory developments

- **Spectrum auctions:**
  In May 2023, the Hungarian telecom regulator, National Media & Infocommunications Authority (NMHH) auctioned the 32 GHz spectrum for HUF 970 million for 15-year entitlements until May 23, 2038, to facilitate 5G mobile broadband services and promote competition and technological advancement in the sector.

- **Support for mobile device upgrades:**
  As of end-2021, 95% of mobile internet traffic and 62% of voice traffic in Hungary was 4G. NMHH decided against phasing out 2G due to its importance for some users and critical services. To ensure a smooth 3G phase-out, NMHH launched the "NetreFel" programme, including a subsidy for upgrading to 4G/5G phones. By March 2023, 120,000 phones were replaced with a HUF 4.2 billion budget, leading to a complaint-free 3G switch-off by December 2023.

Government policies

Infrastructure development

- *5G network expansion*: Major telecom operators, particularly Magyar Telekom, are investing heavily in upgrading mobile networks to 5G, including by expanding fibre-optic connections to enhance service delivery.
- *Fixed broadband growth:* In 2021, the number of fixed broadband subscribers in the country increased 2.8%, supported by the wider availability of fibre network. By the end of 2022, Magyar Telekom provided 1Gb/s service to over 3.4 million premises.
- *Consolidation of services:* The acquisition of Vodafone Hungary by 4iG has led to a more unified service offering, combining mobile and fixed broadband services to enhance customer experience.

Tax measures

Introduction of an additional tax on telecom revenue is aimed at bolstering state finances. It, however, impacted operators' profitability but also ensured continued investment in infrastructure. These reflect Hungary's commitment to modernising its telecom infrastructure.

- **Utility tax abolition**
  The Hungarian government abolished the utility tax payment obligation for electronic telecommunications providers starting January 2024. Additionally, the supplementary telecommunications tax was eliminated from January 2025. This move was aimed at boosting the financials of telecom operators and encouraging investment in infrastructure

- **Corporate income tax**
  Hungary has one of the lowest CIT rates in Europe at 9%. This applies to telecom companies, making it an attractive location for investment.

- **Local business tax (LBT)**
  Telecom companies are subject to an LBT imposed by municipalities. However, the rate has a ceiling of 2% of the calculated LBT base.

- **Other corporate tax**
  Telecommunications service providers in Hungary are subject to another specific tax — for private individuals, HUF 2 per minute for calls and also per message; for other entities, HUF 3 per minute for calls and also per message.

Policy framework and industry support mechanism

Production linked incentive scheme for promoting telecom and networking products manufacturing in India

The Government of India had introduced the Production Linked Incentive (PLI) Scheme to promote the manufacturing of telecom and networking products in India, with the objective of boosting domestic production, attracting investments, and increasing exports of "Made in India" products. The scheme aims to incentivize companies to set up or expand their manufacturing facilities in India, creating a robust ecosystem for the production of telecom and networking products.

The scheme, with an overall financial outlay of 12,195 Crore came into effect from 1st April 2021 for a period of five years. Support under the Scheme is provided to companies who manufacture specified telecom and networking products in following 4 product categories in India:

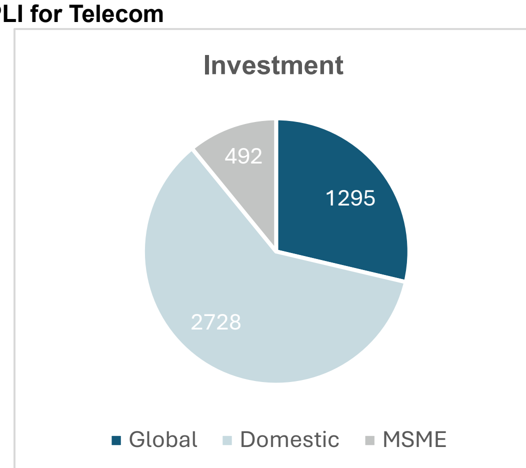
1. Core transmission Equipment
2. 4G/5G, Next Generation RAN and Wireless Equipment
3. Access & CPE, IoT Access Devices and Other Wireless Equipment
4. Enterprise Equipment: Switch and Router

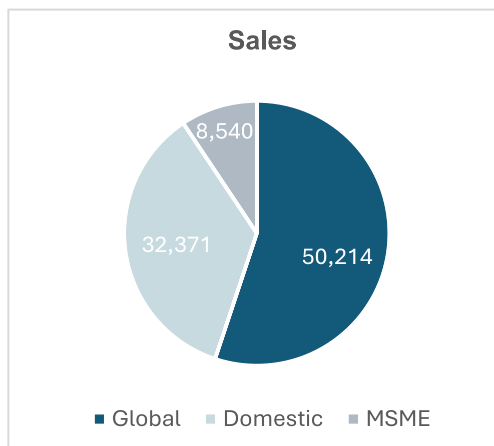
Incentive structure: The incentive is provided as a percentage of the incremental sales of manufactured goods, net of taxes, over the base year (FY 2019-20).

The scheme has helped achieve landmark progress towards the overall "Make in India" objective across investment, sales and employment statistics:

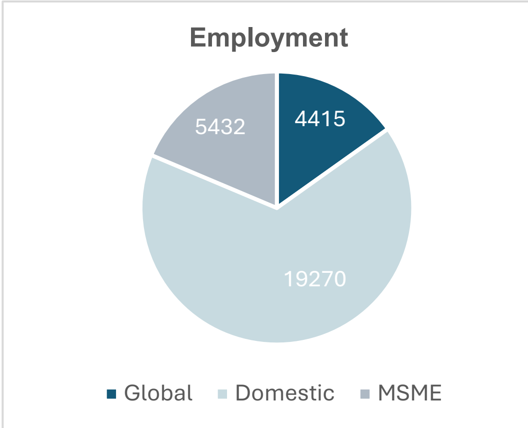
Figure 63: PLI for Telecom

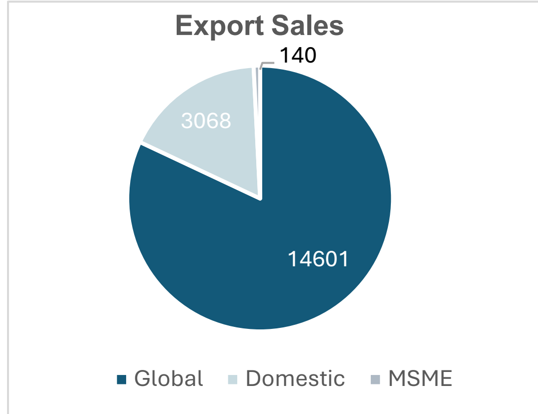
(INR Crore)





(Number of jobs)





Note: Scheme performance as on July 2025
Source: PLI Dashboard

However, the domestic manufacturers face three major challenges with the current PLI scheme design-

1. A challenge for local manufacturers, particularly component manufacturers, is that they typically operate at smaller scales compared to finished goods manufacturers, with many small and medium-sized players in the component manufacturing ecosystem. As a result, they struggle to meet the eligibility criteria for the Production-Linked Incentive (PLI) scheme, which requires a certain level of Global Manufacturing Revenue during the base year and minimum new domestic investment. To support these local manufacturers, it is essential to have more lenient eligibility criteria, tailored to their specific needs and scale of operations.
2. Domestic manufacturers are of the opinion that the scheme lacks requirements for domestic value addition or the development of downstream industries, allowing beneficiaries to import up to 100% of the components, simply assemble them, and still qualify for the Production-Linked Incentive (PLI) benefits, without contributing to the growth of the local ecosystem.
3. At present, the minimum investment threshold for all categories remains uniform. However, the investment requirements vary significantly across categories, with core transmission equipment, 4G/5G radio access network, and wireless equipment likely requiring substantial investments, whereas the production of customer premises equipment (CPEs) and Internet of Things (IoT) devices may necessitate relatively lower investments.

Other notable schemes include:

- **Scheme for financial assistance to select states for skill development in ESDM sector**
  Overview and Impact: Approved in November 2013 with Rs 113.77 crore (Rs 100 crore grant-in-aid), this scheme targets 90,000 candidates in 9–10th standard frameworks across states like Odisha and Uttar Pradesh. It provides 100% funding for SC/ST/EWS and 75% for general categories via NIELIT, ESIC, and state agencies, focusing on IoT, 5G, and robotics. By 2025, it certified 263,624 individuals, boosting employability in manufacturing/services through industry-linked curricula in 10 key states/UTs, per NIELIT's ESDM-Skill portal.

  Limitations and Gaps: MeitY's HRD Division evaluations indicate uneven state implementation due to limited private-sector tie-ups, resulting in placement rates below 60% in non-metro areas. The scheme's focus on entry-level skilling overlooks advanced R&D needs, with gaps in monitoring long-term job retention. Resource constraints in select UTs have capped outreach to only 70% of targeted 90,000, per 2024 NIELIT reports, underscoring the need for broader geographic expansion and digital tracking tools.

- **Chips to startup scheme**
  Overview and Impact: Initiated in 2021 as an umbrella under National Policy on Electronics (NPE) 2019, C2S allocates Rs 250 crore to train 85,000 professionals in VLSI/embedded design over five

years. It fosters academia-industry collaborations via C-DAC, funding IP cores, SoCs, and startups. By July 2025, MeitY committed Rs 2.34 billion to 22 projects (total cost Rs 6.9 billion), supporting hackathons and RFPs.

This has accelerated chip design startups, aligning with India's semiconductor ambitions.

Limitations and Gaps: MeitY's Detailed Project Report (2023) identifies system-level challenges like inadequate fab access and high prototyping costs, limiting output to prototypes rather than commercial chips. With only 22 funded projects against 100+ applications, selection biases toward established entities exclude nascent MSMEs. Gaps in post-training incubation (e.g., funding beyond Rs 1–2 crore per project) have slowed commercialisation, with official data showing under 30% of trainees entering ESDM jobs, per 2025 MeitY evaluations.

- **Special Manpower Development Programme (SMDP)**

Overview and Impact: Building on SMDP phases (9th–10th Plans targeting 5-15% global VLSI share), this MeitY initiative (launched ~2014) equips thousands via 60 institutions like IITs and NITs with hands-on labs, courses, and prototypes in VLSI/embedded systems. It has broadened R&D through networked PhDs and IP protection, fostering innovation in full-spectrum chip-to-system development, as detailed on SMDPC2SD.gov.in and IIT implementation reports.

Limitations and Gaps: MeitY's capacity-building reviews (2024) highlight dependency on imported tools (e.g., Synopsys/Mentor suites), inflating costs and restricting access for non-elite institutions. Skill gaps persist in full-spectrum deployment, with only ~70% utilization of sanctioned labs due to maintenance funding shortfalls (Rs 1.69 crore per site often insufficient). The program's phased structure limits scalability, achieving under 50% of 15% market share goals by 2020, per historical MeitY assessments, due to weak industry-academia linkages.

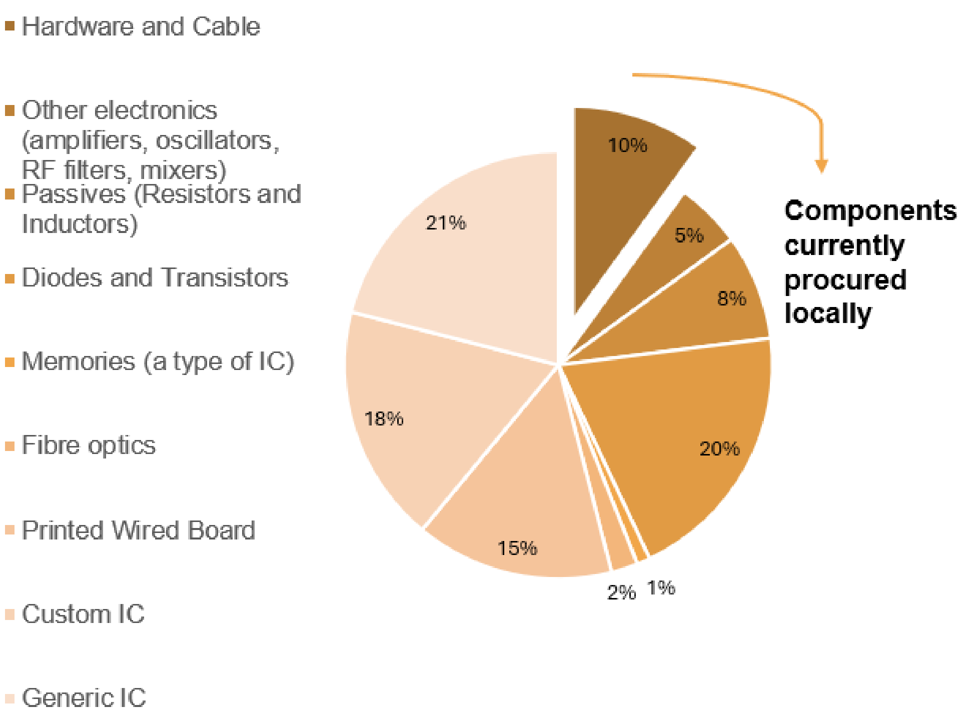
Overall Gaps Across Schemes

While these initiatives have certified over 300,000 professionals and spurred Rs 80,000 crore in PLI-linked sales, MeitY's 2025 HRD synthesis reveals systemic shortcomings: over-reliance on grants without sustained funding for scaling (e.g., no dedicated venture capital for ESDM startups), fragmented monitoring across states, and insufficient focus on women/non-engineering inclusion (under 20% participation).

Challenges hindering India's global competitiveness

1. High import dependence faced by TANE manufacturers for components

Figure 64: Bill of materials – BTS/Access components manufacturing



Source: TRAI, Crisil Intelligence

India's telecom equipment manufacturing sector grapples with vulnerabilities stemming from an underdeveloped domestic ecosystem for critical components like semiconductors, PCBs, and specialty chemicals.

A deep dive into specific telecom products and components helps us understand the status of localisation across different products:

Table 23: Underdeveloped ecosystem limiting localization across TANE products

S. No.	Specified Telecom & Networking Products	Total electronic BOM as % of sales	Total Other BOM as % of sales	Localization excluding electronics	Localization overall
1	4G/LTE RAN Base Station	55%	13%	15%	4%
2	5G RAN Base Station	64%	9%	19%	5%
3	Switches	51%	21%	9%	3%
4	GPON ONT	61%	30%	34%	12%

S. No.	Specified Telecom & Networking Products	Total electronic BOM as % of sales	Total Other BOM as % of sales	Localization excluding electronics	Localization overall
5	Wi-Fi Access Point and Controller	48%	29%	15%	5%
6	Internet Set Top Box	57%	25%	15%	5%

Source: Department of Telecommunication

Initiatives like the Production Linked Incentive (PLI) scheme, have boosted production, reduced overall import dependency by 60% as of 2024 in imports of antennas, GPON (Gigabit Passive Optical Network) & CPE (Customer Premises Equipment), and base stations. However, the import dependency for components persists with import of Baseband unit and Remote Radio Units (key components required to manufacture Base Stations) increasing by 24% and 36% respectively in 2024 as majority of the PLI goods are manufactured by importing components and assembling them in India. The absence of localised sourcing forces manufacturers into heavy reliance on component imports, predominantly from China. This gap arises from historical neglect of indigenous R&D, insufficient infrastructure for high-precision fabrication, and skill shortages, leaving domestic firms unable to scale component production economically.

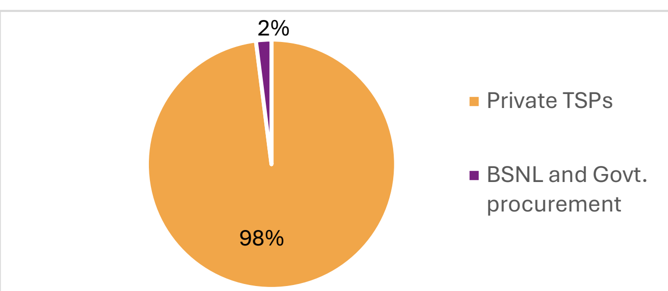
In the current form of PLI, as on July 31, 2025, 42 beneficiary companies had invested INR 4,518 crore, generating INR 91,125 crore in sales, including INR 17,809 crore in exports, and creating 29,117 jobs. Even with these commendable outcomes, the scheme's impact remains concentrated in assembly-led manufacturing, with comparatively limited progress on deeper localisation across the component value chain.

Localization is pivotal for three primary reasons:

1. It facilitates the progressive deepening and diversification of the domestic value chain.
2. It strengthens the global competitiveness of Indian manufacturers by enabling them to capture a larger share of value within the supply ecosystem.
3. It serves as a strategic safeguard, mitigating risks associated with global supply chain disruptions and geopolitical uncertainties. Nonetheless, realizing meaningful localisation necessitates the realignment of global supply chains and the creation of targeted incentives to attract component and sub-component manufacturing to India.

2. Limited market access for domestic TANE manufacturers

Figure 65: Telecom equipment demand is dominated by private telecom service providers

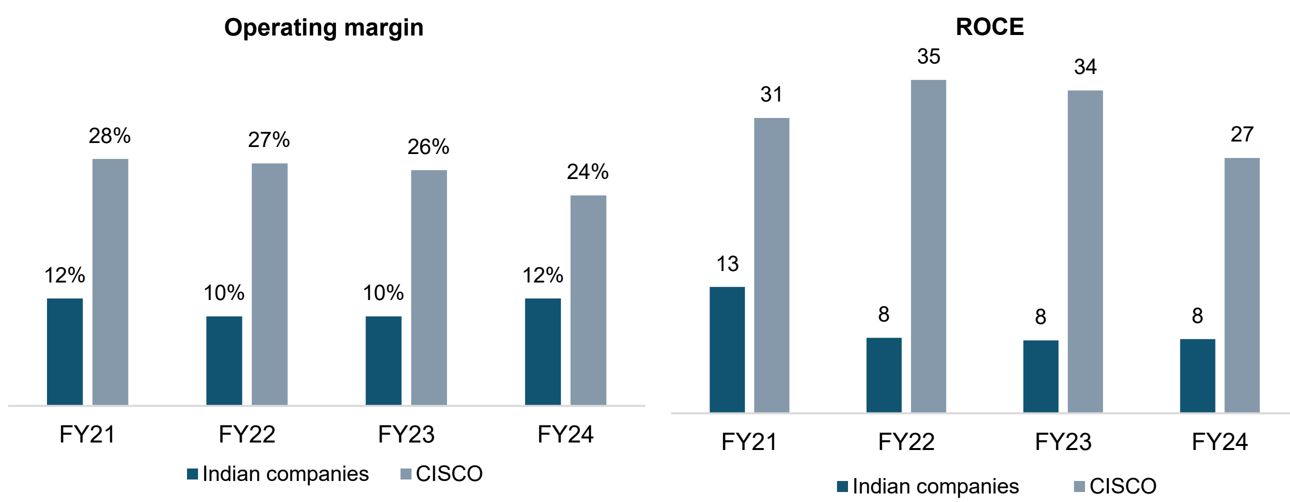


- The majority (98%) of domestic TANE demand is from private telecom service providers
- These players prefer buying from large global OEMs as their products are certified, globally tested and economical unlike domestic manufacturers

There exist numerous examples of private telecom service providers (TSPs) in India favoring global OEMs over domestic TANE manufacturers. In 2022 during the initial 5G rollout phase, a major private TSP signed multi-year supply agreements worth approximately $2.5 billion (over Rs 19,750 crore) with Ericsson (Sweden), Nokia (Finland), and Samsung (South Korea) for radio access network (RAN) equipment, including base stations and core infrastructure, to deploy 5G services starting in key cities like Delhi and Mumbai. These contracts explicitly excluded domestic players like Tejas Networks or HFCL, despite their PLI-eligible 5G offerings, due to TSPs' emphasis on globally certified, interoperable gear with proven scalability, leaving local firms sidelined to minor or future-proofing roles. Similarly, another TSP awarded major RAN deals to Nokia and Ericsson for its nationwide 5G expansion, further illustrating how TSPs prioritize reliability and vendor ecosystems from established global players, perpetuating the 98% market lockout for unproven domestic alternatives.

3. Financial viability

Figure 66: Indian companies operating at lower profitability margins



Note: Indian companies considered are HFCL and Tejas Networks

Source: Company reports, Crisil Intelligence

Operating margin and return on capital employed (ROCE) of international players are consistently higher than Indian players, indicating higher input costs and intense competition in India. The extensive distribution network and strong brand recognition of international players enable them to command premium pricing. Additionally, international firms benefit from cost efficiencies through global sourcing, optimised supply chain, and advanced manufacturing technologies.

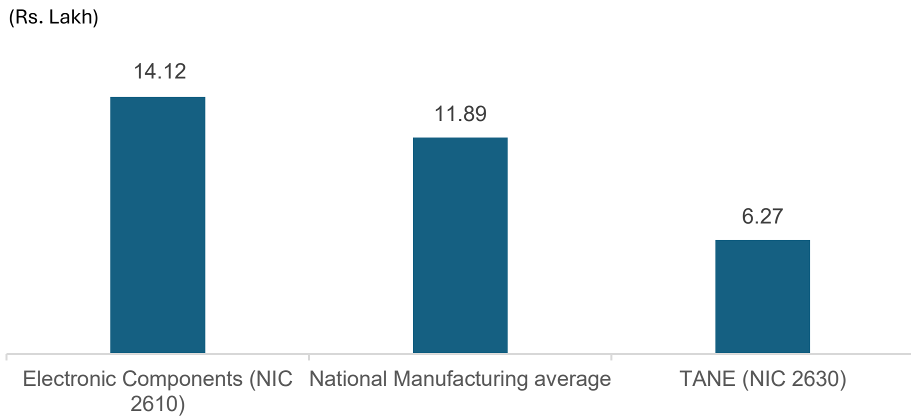
4. Lack of skilled workforce

Employee productivity

Employee productivity in India's telecom and network equipment (TANE) manufacturing sector, as measured by Gross Value Added (GVA) per person engaged, lags significantly behind comparable segments, according to the Annual Survey of Industries 2022. At Rs 6.27 lakh per person for TANE (NIC 2630, encompassing IT hardware, computers, electronics, and optical products), productivity is about 53%

of the national manufacturing average (Rs 11.89 lakh) and 44% of the electronic components sub-sector (NIC 2610, at Rs 14.12 lakh). This underperformance highlights structural inefficiencies, including skill gaps favoring semi-skilled labor, limited automation, and heavy import reliance for high-value inputs, which dilute value capture domestically. In contrast, electronic components, earlier in the value chain benefit from higher specialization and scale, underscoring the need for targeted upskilling and ecosystem investments in TANE to bridge this gap and align with Atmanirbhar Bharat objectives.

Figure 67: GVA per person engaged



Notes: For telecom equipment National Industrial Classification (NIC2630) has been referred to

Telecom equipment includes IT hardware, computer, electronic and optical products

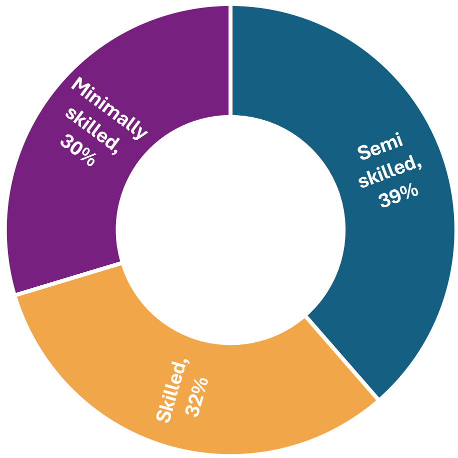
Source: Crisil Intelligence, Annual Survey of Industries 2022

Skill requirement

The telecom sector Skill Council (TSSC), jointly set up by The Cellular Operators Association of India (COAI), Indian Cellular Association (ICA) & Telecom Centres of Excellence (TCOE) to ensure adequate availability of skilled manpower to boost growth and productivity in the telecom sector. The ‘Telecom Talent in 5G Era’ report highlights the following challenges-

The chart below shows the skill level required in the telecom equipment sector. Semi-skilled workers are those with some specialised training but not with extensive expertise. They can perform tasks such as operating machinery, perform basic equipment maintenance or work with standard telecom systems. Skilled workers possess a higher level of technical expertise and are capable of handling tasks such as installing advanced telecom equipment, troubleshooting or managing systems. Minimally skilled workers handle tasks like general labour, simple assembly work or play supporting roles in production and maintenance of telecom equipment.

Figure 68: Skill-level distribution



Source: Crisil Intelligence, National Skill Development Corporation

Their talent requirement can be segregated according to the NSQF (National Skills Qualification Framework) into levels of ranking based on knowledge, skills, and aptitude. The overall Telecom talent has been bifurcated into Blue-Collar, and corporate talent, where the corporate talent represents the executive/leadership workforce and Blue Collar represents support-related functions.

The growth of the sector is dependent on the way telecom talent is utilised as well as the availability across different roles is triggered and undertaken by employers and agencies alike.

Only 40% of India's graduates in computer science, IT and telecommunication are employable in the technology sector owing to the mismatch between academics and industry demands, as per the telecom sector Skill Council's 2023-24 report, Telecom Talent in 5G era.

The table below details the primary factors contributing to China's effective cost advantage in telecom equipment manufacturing:

Table 24: Factors that lead to cost reduction in Telecom and Network Equipment manufacturing

S. No.	Factors resulting in cost reduction	India	China
1	Fiscal incentives based on incremental production (PLI)	4% -7%	1%-2%
2	Corporate income tax exemption/reductions	0.73% - 0.95%	2%
3	State subsidies in India for capital investments	0.6%-1.2%	NA
4	R&D subsidy	0.15%	2%
5	Industrial land development support	0.40%	0.60%
6	Infrastructure development cost (Building etc.)	Negligible	1%
7	Labour subsidy	Negligible	2%
8	Cost of power	Negligible	1%
9	Subsidy for machinery and equipment	0%	3%
10	Exemption/reduction of the land rental costs	0%	0.60%

11	Interest subvention on working capital	0%	3%-3.5%
12	Logistics	0%	1%
13	Other factors improving the "Ease of doing Business"	-	2%-3%
14	Duty-free imports for creating fixed assets and inputs not available domestically	0%	-
Total		5.88% -9.7%	19.2%-21.7%
Cost disability differential for India vs China		-	12%-13.32%

Source: TRAI, Crisil Intelligence, US-India Strategic Partnership Forum (USISPF)

Note: Percentages represent each government incentive or subsidy as a share of total manufacturer revenue, based on ICEA estimates (2018). Each figure is calculated by applying the applicable policy benefit rate, such as a tax exemption, interest subsidy, or direct grant to the assumed share of that cost item in a manufacturer's total revenue. For instance, India's R&D subsidy of 0.15% reflects the weighted tax deduction under Section 35(2AB) of the Income Tax Act applied to an estimated R&D spend of ~1% of revenue at prevailing corporate tax rates.

As observable from the table, TRAI assessments and industry analyses, India's overall production costs remain 12–13% higher than China's even after PLI adjustments-due to persistent gaps in scale, infrastructure reliability, and supply chain depth, though India's labour edge and policy reforms are narrowing the divide to potentially under 10% in targeted segments like 5G components.

Despite the numerous challenges that have hindered the growth of India's telecom equipment manufacturing industry, a few pioneering companies have managed to navigate these obstacles and achieve success, demonstrating that domestic manufacturing is not only possible but also profitable. By examining these examples, we can gain valuable insights into the strategies and innovations that have enabled these companies to thrive and explore how they can be replicated and scaled up to drive industry-wide growth.

Success story: Reliance Jio's partnership with Sanmina

Reliance Jio, one of the leading players in the Indian telecom services space, has been at the forefront of 4G deployment as well as 5G rollout across the country. The telecom hardware requirements for its network services, including MIMO antennas and RRH, were historically fulfilled by awarding multi-billion-dollar contracts to large global OEMs such as Ericsson and Nokia.

This comprised one of the largest components of the company's network capex spend, with overall network capex spend estimated at nearly $3.15 billion in fiscal 2023.

In a bid to develop an in-house solution for its 5G equipment requirements as well as to lower dependence on global vendors such as Ericsson and Nokia, Jio developed plans to deploy its own network products.

In 2022, Reliance Industries' subsidiary, Reliance Strategic Business Ventures, entered into a joint venture with Sanmina Corporation, a US-based integrated manufacturing solutions provider.

The joint venture aims to build a world-class electronic manufacturing hub in India, in line with the Hon'ble Prime Minister's "Make in India" vision. The joint venture will prioritise high technology infrastructure hardware for growth markets and across industries such as communications networking (5G, cloud infrastructure, hyperscale datacentres), medical and healthcare systems, industrial and cleantech, and defence and aerospace. In addition to supporting Sanmina's current customer base, the joint venture will create a state-of-the-art 'manufacturing technology centre of excellence' that will serve as an incubation centre to support the product development and hardware startup ecosystem in India, as well as promote research and innovation of leading-edge technologies.

This partnership, which aims to leverage Sanmina's advanced manufacturing experience and Reliance Industries' expertise and leadership in the Indian business ecosystem, has been paying off:

- **In-house shift:** Reliance Jio has started deploying its own 5G small cells and radio units, moving away from foreign suppliers to reduce costs and increase control over its network infrastructure
- **Local production:** The new equipment is manufactured near Chennai through a joint venture between Reliance Industries and Sanmina Corp
- **Cost advantages:** By using domestically produced components, Jio aims to cut 5G deployment costs by up to 60%, driven by lower import duties, fewer licensing fees and reduced reliance on global manufacturing

An imported small cell (a type of radio access telecom equipment) typically costs ~$4,000. By using its own small cells, Jio could cut costs by 50-60%.

How can more such partnerships be encouraged?

The growth of TANE manufacturing on cluster model in Madhya Pradesh

- Madhya Pradesh is actively developing its telecom sector, with a focus on attracting investment and fostering innovation. A Telecom Manufacturing Zone (TMZ) is being established in Gwalior, and Indore is emerging as a hub for IT and telecom-related activities.
- The TMZ in Gwalior is designed to attract investments of Rs 12,000 crore and create 5,000 jobs. It will focus on manufacturing telecom equipment, including SIM cards, chips, and antennas, as well as research and development in 6G technologies.
- Tech Growth Conclave 2025 in Indore: This event, organized by the Department of Science and Technology, will focus on translating investment commitments from the Global Investors Summit into tangible projects. It will include the unveiling of new policy guidelines, and the launch of an AI-based Centre of Excellence.

Success story: Nokia's India story: leveraging local strengths for global success

Figure 69: Telecom equipment visual

2007-08

- Nokia invests ₹2,500 crores in Sriperumbudur to develop one of the most advanced mobile device manufacturing plants in the world.

2008

- Micromax, originally a specialized hardware manufacturer for Nokia, benefits from the partnership and evolves into an Indian handset manufacturer

2012

- Started producing components and sub-assemblies, including PCBs, RF components, base stations, and mechanical components

2017

- Expanded to include telecom equipment manufacturing, 2G, 3G, and 4G (LTE) base stations, as well as optical network equipment and IP routing equipment.

2018

- Increases its local procurement in India, with a target of sourcing 50% of its components and materials from local suppliers.

2019-20

- Partnership with Bharat Electronics Limited (BEL) to develop and manufacture 5G equipment.

2022

- Over 70% of its production being exported to countries outside of India.
- Announces plans to increase its local R&D investment in India, with a focus on developing 6G and quantum computing-related technologies.

Recommendations: Policy initiatives and reforms

Recommendation I - Scheme for localisation of Telecom & Networking Products and Ecosystem Development

India may adopt a phased approach to promote domestic manufacturing of components essential for telecom equipment production. Given the current lack of robust local suppliers for semiconductors and certain electro-mechanical components, the government can introduce localisation incentives for the procurement of plastic, mechanical, and select electro-mechanical components that are already produced within the country

To identify scope for localisation, the Department of Telecommunications (DoT) had held stakeholder discussions with manufacturers operating on a diverse scale- domestic and foreign OEMs (original equipment manufacturers) and EMS (Electronics Manufacturing Service). Stakeholders expressed concerns that a localisation requirement based on a list of specific components to be sourced from Indian suppliers may be challenging to implement, as many of these components are not available in the local market

The optimum way forward would be evaluating manufacturers on a Bill of materials-based criteria, where companies get certified from designated auditor/certification bodies that attest to the percentage of BoM that has been procured locally by manufacturers of telecom equipment (final products). The manufacturers can procure non-semiconductor components to begin with (such as plastics and insulation components), and in a phased manner, when electro-mechanical and semiconductor component manufacturing picks up in India, the localisation qualification for availing scheme benefits can be increased to higher localisation percentages. This will help the current plastics and insulation component manufacturers to gain scale and attract other key component manufacturers to set up shop as well.

Ministry of Electronics and Information Technology’s Electronic Component Manufacturing Scheme (ECMS) already provides incentives for several components including electro-mechanicals such as connectors, switches, heat sinks, antennas and filters, multi-layer Printed Circuit Boards, enclosures, passive components, and supply-chain inputs used in electronics manufacturing. It also provides turnover-linked, capex and hybrid incentives across these eligible segments, with a telecom-specific sub-assembly category currently covering Optical Transceiver - SFP. Accordingly, the proposed localization scheme is intended to complement ECMS by covering the remaining telecom equipment Bill of Materials from the demand side, particularly components and materials used in final telecom/networking products such as 4G/5G RAN, switches, GPON ONT, CPE/STB equipment, RF cables, insulation materials, plastics, mechanical parts and other non-semiconductor inputs that may not be fully addressed through ECMS as final-equipment-level procurement support. The proposed mechanism would therefore incentivise telecom OEMs/EMS players to source a certified share of their BoM domestically and provide price-gap support for eligible components that are costlier to procure locally, thereby creating assured demand for domestic component manufacturers while avoiding duplication with ECMS.

Scheme features:

- Phased Increase in Localization: Achieving higher localisation will require companies to make substantial investments and/or promote domestic component manufacturing. This approach demands greater and more immediate investments towards developing component ecosystems compared to current PLI schemes that do not mandate localisation.

- Targeted support to produce essential telecom equipment: Financial incentives should be strategically directed toward procurement for manufacturing of high-demand products such as 4G/5G RAN, switches, GPON ONT, and CPE/STB equipment. Gradually localizing components for these products will boost local value addition, strengthen global competitiveness, and foster the development of a robust domestic manufacturing ecosystem.

Let's take an example of providing benefits for Polytetrafluoroethylene (PTFE)

Polytetrafluoroethylene (PTFE) is a special type of plastic used in telecom equipment. In telecom networks, PTFE is mainly used in RF cables, Connectors, and High frequency circuit boards to help signal travel smoothly without interference

In terms of pricing, PTFE is cheaper in China and other Northeast Asian countries compared to India. The price difference is approximately 30-35% lower in China than in India, making it more economical for telecom components manufacturers in India to import PTFE from China rather than procure it locally.

However, if Indian equipment manufacturers are provided support of the price difference as incentive, they will be encouraged to procure locally. After compensating the price gap, the effective price becomes comparable to that of China's.

Table 25: Effective PTFE pricing after price-gap support

Category	Imported PTFE (China)	Domestic PTFE (India)	Domestic PTFE with Support
Base price ($/kg)	7.3	11	11
Price Difference Support	-	-	3.7
Final effective price ($/kg)	7.3	11	7.3

The benefit may be extended to companies that source at least 20% of their Bill of materials (BOM) components from domestic suppliers. Price gap funding may be provided exclusively for those components that are more expensive to procure locally yet have been sourced domestically by the company.

This benefit should be aimed at being phased out in a period of five years as the domestic component manufacturers achieve scale

Recommendation II - Promoting joint ventures with established players to build domestic capability

Rationale: Case study of China:

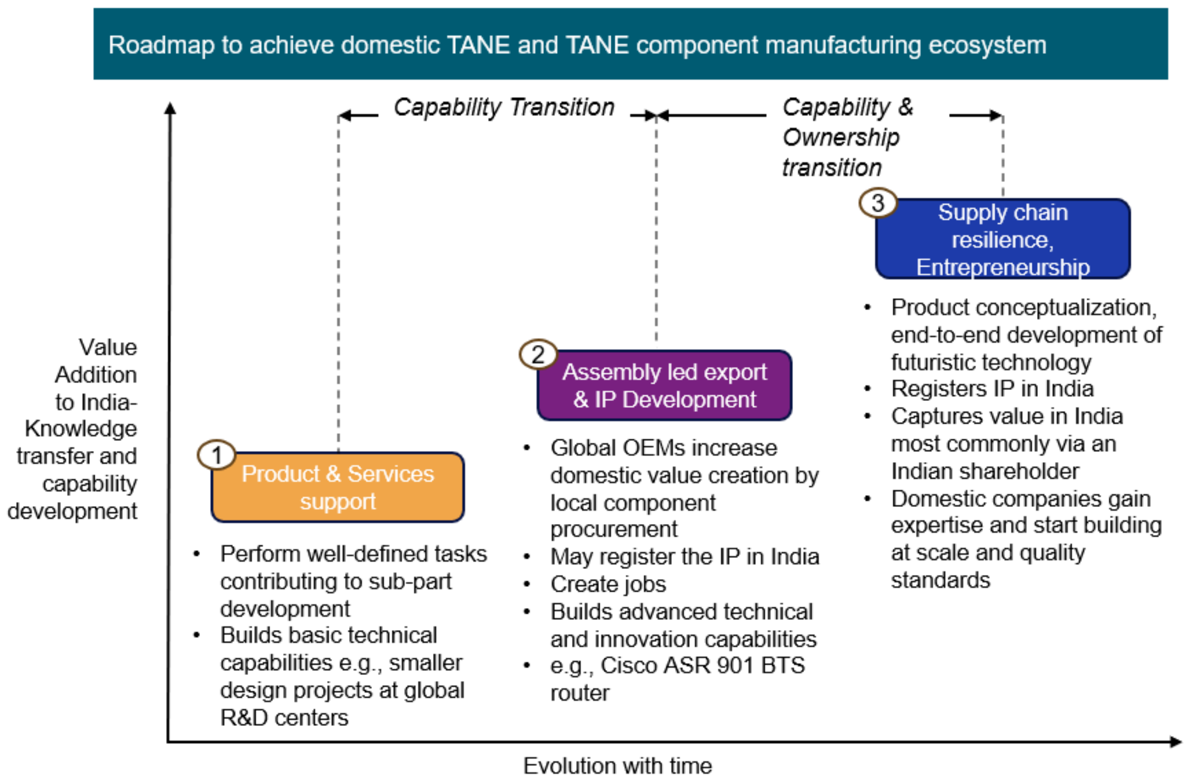
In the early 1980s, China's communication infrastructure was weak. Furthermore, the industry was not geared to design or manufacture digital communication products, such as stored program controlled (SPC) switches, which were at that time considered to be relatively advanced equipment. The government realised that the only way forward was to import foreign technologies and to adapt, innovate and develop Chinese products on the basis of these technologies. In order to achieve this, the former Ministry of Posts & Telecommunications drew up a three-pronged strategy: to import, to establish joint ventures with foreign counterparts and, in parallel, to conduct independent research and development (Peng 1999).

In the early stages of China's opening up to the West, the government encouraged foreign companies to establish joint ventures in China. Shanghai Bell Co, Ltd, which was the result of a partnership between China Posts and Telecommunications Industry Corporation and BTM of Belgium (now part of Alcatel), became the first telecom equipment joint venture, manufacturing SPC switches. Production at Shanghai Bell started in 1985 and, by 1998, it had produced a total of 33 million lines of its System-12 SPC switch – about a quarter of all switches sold in China. By then, its component localisation rate had reached 74% and software development, 90%. Total sales revenue over 1985-1998 reached $28.2 billion.

Opportunity for India:

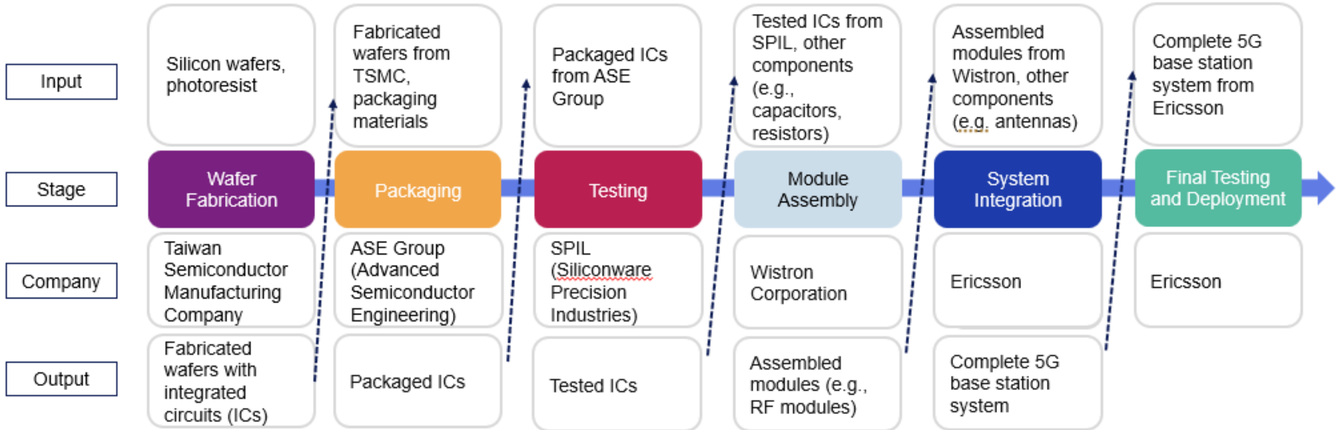
India is currently positioned in a comparable situation. With a supportive government vision of 'Atmanirbhar Bharat' and favourable demographics, there is an opportunity to develop domestic capability. Over time, as India's component ecosystem deepens, domestic firms can increasingly capitalise on anchor investments by global OEMs, driving technology and know-how transfer, productivity spillovers, and a broader base of local manufacturing across product categories. This evolution broadly reflects the path seen in China and several Southeast Asian economies, where foreign OEMs first accelerated localisation, and domestic players subsequently moved up the value chain from low-value assembly toward higher-value design, engineering, and ultimately branding.

Figure 70: Roadmap to developing domestic capability via tech transfer and partnerships with global players



Takeaway for India

Figure 71: The cluster model followed by China and Taiwan can be replicated in India



This cluster in Tainan city, Taiwan, brings together companies involved in various aspects of telecom equipment manufacturing, from design and development to packaging and testing. The presence in the same city of multiple suppliers and buyers, who share knowledge, facilities and infrastructure, reduces cost and provides linkage benefits.

Recommendation III - Focus on Radio infrastructure equipment to unlock the export potential

Market Overview

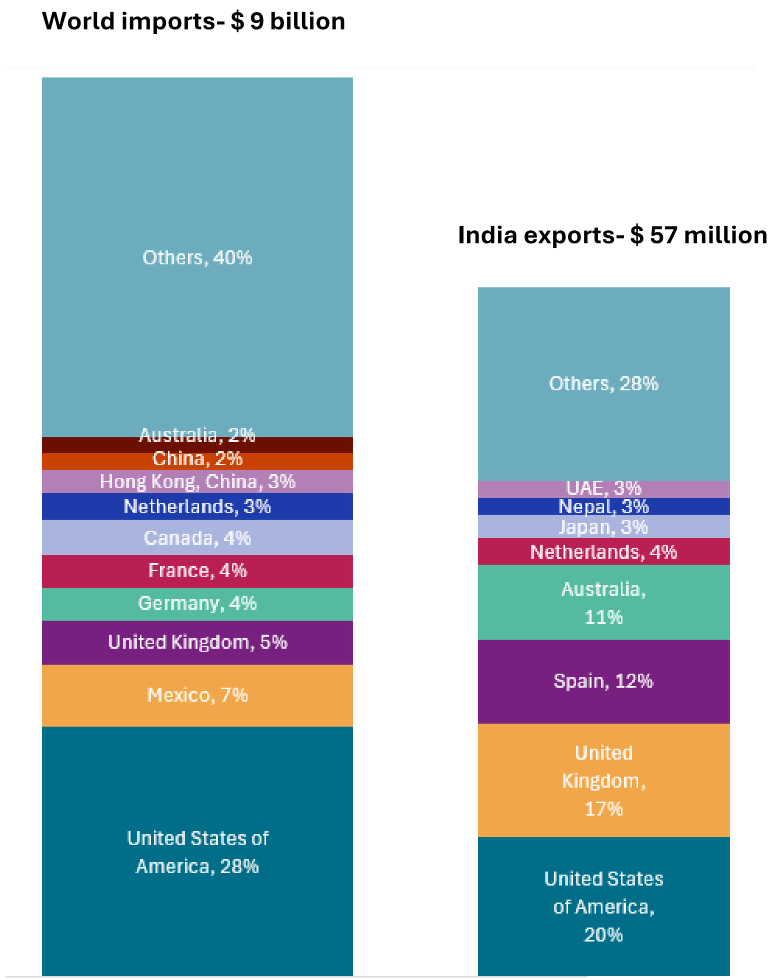
Global trade in telecom infrastructure components presents a lucrative opportunity for India, with world imports totaling USD 219 billion in 2024 (antennas, Remote Radio Heads (RRH), and Base Units (baseband units (BU)) and USD 9 billion (Optical Fibre Cables (OFCs) and microwave apparatus). India's current exports stand at $0.9 billion for the former and $0.5 billion for the latter, capturing less than 1% of the market.

Figure 72: Trade of Antennas, RRH, and BU as of calendar year 2024

Source: ITC Trade Map

Top importers like the US, China, and EU nations dominate the global demand driven by 5G rollout, data center expansion, and digital infrastructure investments. By targeting these high-volume markets, India can scale exports to $5-10 billion annually within 3-five years, leveraging its manufacturing ecosystem under the Production Linked Incentive (PLI) scheme.

Figure 73: Trade of OFCs and microwave apparatus



Note: Charts not to scale

Source: ITC Trade Map

Current key target markets

Table 26: Current key target markets

Category	Top Importers (Share %)	Import Value (USD billion)	Opportunity for India
Antennas, RRH & BU ($219B)	US (20%), China (18%), Hong Kong (8%), Netherlands (7%), Germany (5%)	US:43.8, China: 39.4	High-volume 5G base stations; align with US Federal Communications Commission (FCC) specifications for duty-free access via Generalized System of Preferences (GSP) restoration
	UK (3%), Japan (5%), Singapore (3%), Mexico (3%)	UK: 6.6, Japan: 11	Post-Brexit UK FTA; Japan's semiconductor ties for joint ventures.

Category	Top Importers (Share %)	Import Value (USD billion)	Opportunity for India
OFCs & Microwave ($9B)	China (28%), US (25%), Hong Kong (26%)	China: 2.5, US: 2.3	Fibre-optic backbone for data centers; US CHIPS Act subsidies for suppliers.
	Netherlands (10%), UAE (5%), Mexico (5%)	Netherlands: 0.9, UAE: 0.5	EU Green Deal for sustainable cabling; UAE's smart city projects.

Note: CHIPS: Creating Helpful Incentives to Produce Semiconductors

The roadmap below outlines phased strategies to target $10–15 billion combined exports by 2030 (5-year) and $40–50 billion by 2035 (10-year), capturing 5–7% global share in these categories. It focuses on policy leverage, capacity building, innovation, and market access, assuming sustained government support (e.g., PLI extension) and private investments.

Figure 74: Telecom and network equipment export promotion roadmap

10-Year Roadmap (2031–2035) Innovation Leadership and Global Dominance

Shift to high-value, IP-driven exports for 6G ecosystems, targeting developed markets (US, EU) and supply chain diversification from China. Build on 5-year gains for $8–10 billion annual exports by 2035, with 50% from advanced RAN (6G-compatible) and 50% from next-gen OFC (e.g., hollow-core fibers)

Phase	Key Actions	Milestones/Targets	Enablers
Year 6–7 (2031–2032): Tech Leapfrogging	- Roll out Bharat 6G standards; allocate $3B for 6G testbeds and AI-integrated RRH/BU R&D - Vertical integration: MSMEs supply 50% components; export green telecom gear (low-power antennas) to meet EU sustainability norms - Double down on microwave for rural FWA; partner with startups for quantum-secure OFC	- Antenna/RRH/BU exports: $4-5B (10% global RAN share) - OFC/microwave exports: $7-8B (20% share, led by $1B+ annual orders) - 100,000 high-skill jobs; $50B FDI attracted	- 6G Vision rollout; PLI 2.0 with 25% incentives for IP creation - Global FWA/AI boom
Year 8–10 (2033–2035): Market Mastery	- Lead global standards bodies (3GPP/ITU) with Indian IP; establish overseas assembly in 5 countries - Diversify to satellite-microwave hybrids for defense exports; aim for $10B in value-added services (design/export consulting) - Sustainability focus: 100% recyclable materials; carbon-neutral factories	- Combined exports: $40–50B/year (7% global share) - Top-3 exporter in telecom gear; $200B cumulative production - Telecom contributes 2% to India's GDP (doubled from 2025)	- Advanced manufacturing roadmap to 2035 - Market growth to $697B globally

Manufacturing sectors like telecom equipment have significant spillover effects, including jobs in supply chains (e.g., components, logistics, R&D), services, and ancillary industries. Based on broader electronics manufacturing data in India, indirect job multipliers range from three to five times direct jobs. With focused execution, India can triple exports to USD 3 billion by 2028, creating 200,000 jobs and boosting forex reserves by $2.5 billion. This estimate assumes continued PLI incentives, supply chain localisation (increasing value addition from ~30-40% to 50%), and ecosystem growth.

Recommendation IV - Establishing a centralised testing agency for all companies / access to trial / testing beds:

Access to telecom networks for field-level test / trial of products under development remains a challenge for Indian companies, making it difficult to get quality certifications. Accordingly, to enhance the credibility and global acceptance of domestically manufactured TANE, the centralised testing agency should establish partnerships with renowned international certification bodies to align domestic standards with global testing benchmarks.

Recommendation V - Offer financial support to prestigious institute-manufacturer partnerships to incentivise skill development of the workforce and promote practical product development experience

- Incentivise AICTE-affiliated advanced technical institutions that are offering advanced courses in electronics design, fabless products design and VLSI engineering

- The topic for research can be selected in consultation with industry stakeholders (TANE manufacturers and component manufacturers). A programme for scaling research into practical products can be facilitated via institute-industry collaboration

- Financial incentives can be given by the government as well as TANE companies; the products developed as part of the research can be commercialised by TANE manufacturers

Appendix

Table 27: Tariffs relevant to Telecom and Network Equipment Manufacturing

S. No.	Tariff item	Description of goods	Rate of duty	Import policy
1	8517	Telephone sets, including telephones for cellular networks or for other wireless networks; other apparatuses for the transmission or reception of voice, images or other data, including apparatus for communication in a wired or wireless network (such as a local or wide area network), other than transmission or reception apparatus of heading 8443, 8525, 8527 or 8528	0%	Free
2	85176	Other apparatus for transmission or reception of voice, images or other data, including apparatus for communication in a wired or wireless network (such as a local or wide area network)	0%	Free
3	851770	Other apparatus for transmission or reception of voice, images or other data, including apparatus for communication in a wired or wireless network (such as a local or wide area network)		
4	8518	Microphones and stands; therefore, loudspeakers, whether or not mounted in their enclosures; headphones and earphones, whether or not combined with a microphone, and sets consisting of a microphone and one or more loudspeakers; audio-frequency electric amplifiers; electric sound amplifier sets	0%	Free
5	8525	Transmission apparatus for radio broadcasting or television, whether or not incorporating reception apparatus or sound recording or reproducing apparatus; television cameras, digital cameras and video camera recorders		Free
	85255030	Transmission apparatus for radio broadcasting or television, whether or not incorporating reception apparatus or sound recording or reproducing apparatus; television cameras, digital cameras and video camera recorders; Transmission apparatus; Broadcast equipment sub-system;	7.5%	
6	8535	Electrical apparatus for switching or protecting electrical circuits, or for making connections to or in electrical circuits (for example, switches, fuses, lightning arresters, voltage limiters, surge suppressors, plugs and other connectors, junction boxes), for a voltage exceeding 1,000 volts	10%	Free

SOLAR PHOTOVOLTAIC MANUFACTURING

PV value chain

Polysilicon to module

India scale-up

Manufacturing competitiveness

Policy roadmap

PLI, ALMM, BCD, R&D

Table of contents

Executive summary

Solar PV manufacturing at a glance

100 GW
India module capacity

25 GW
India cell capacity

>85%
China global capacity share

48 GW
PLI capacity awarded

17-20%
India market CAGR

500 GW
Non-fossil target by 2030

Upstream integration | Capital goods access | R&D intensity | Skilled workforce | Export diversification

Sector overview

The solar photovoltaic (PV) manufacturing sector is becoming strategically important as global renewable-electricity demand rises and solar remains one of the key technologies supporting decarbonisation. The report notes that the share of renewable energy in electricity is expected to increase from 30% in 2023 to 46% by 2030, largely driven by solar and wind power.

China continues to dominate global PV manufacturing, with over 85% of global supply capacity and a highly integrated presence across polysilicon, wafers, cells and modules. Its scale advantage, early policy push, low-cost finance, tax incentives, R&D support, skilling programmes and 23 free trade agreements have allowed Chinese manufacturers to build cost leadership and strong export competitiveness.

India's PV manufacturing sector has grown rapidly, especially in downstream modules and cells. Solar module manufacturing capacity enlisted in ALMM rose to 100 GW by August 2025, from nearly 2.3 GW in 2014, while solar cell capacity increased to 25 GW by March 2025, from less than 1.2 GW in 2014. However, the sector remains dependent on imports for upstream inputs such as polysilicon and wafers, with only limited domestic wafer capacity.

Domestic demand is structurally strong. India had installed 106 GW of solar capacity by March 2025 and needs to add about 174 GW to meet the 2030 target of 280 GW solar capacity. The domestic PV market, estimated at Rs 32,400 crore / $3.7 billion, is expected to grow at a 17-20% CAGR between fiscal 2023 and fiscal 2030, supported by utility-scale solar, rooftop solar, open-access projects and green hydrogen-linked demand.

Industry structure

The PV value chain comprises four broad stages: polysilicon production, ingot and wafer production, cell fabrication, and module assembly. The report highlights that value-chain integration is critical because players operating from polysilicon to module are less exposed to supply disruptions and raw-material price volatility.

India's manufacturing base is currently concentrated in cells and modules, while the upstream ecosystem remains underdeveloped. India has domestic availability in modules, cells and limited wafers, but polysilicon import dependence remains close to 100%, wafer import dependence is above 90%, cell import dependence is above 60%, and module import dependence is above 40% of available supply after exports.

China's dominance is visible across the global supply chain. In 2024, China accounted for 93-98% of installed and new polysilicon production, 95% of wafer capacity, 91% of cell capacity and 82% of module capacity, while India's share was comparatively stronger only at the module stage.

India's export profile has improved but remains concentrated. PV exports in fiscal 2025 were eight times those in fiscal 2018, driven by higher cell-to-module capacity under the PLI scheme. However, the US accounted for 97% of India's PV exports in fiscal 2025, exposing Indian manufacturers to geographic concentration risk.

Financially, domestic manufacturers have benefited from policy-driven support such as ALMM and BCD, alongside record solar additions in India. Domestic players showed stronger resilience in fiscal 2025, while international players faced pressure from global oversupply, lower prices and margin compression.

Global case studies and best practices

Case study	Key policy / strategy levers	Outcomes / evidence	Implication for India
China: Long-term industrial strategy	Identified solar PV manufacturing as a strategic industry in 2009; supported the sector through low-cost debt, subsidies, tax incentives, R&D programmes, industrial incentives and skilling support.	China scaled PV manufacturing by over **18,000x between 2004 and 2024** and continues to dominate the global PV value chain.	India should treat PV manufacturing as a long-term industrial policy priority, not only as a renewable-energy deployment objective.
China: Trade-led export competitiveness	Used **23 FTAs with 30 countries / regional blocs**, including FTAs with Iceland, Switzerland, RCEP members and Serbia, to improve market access and reduce trade barriers.	China led the global PV export basket with about **57% share in 2024**, supported by large-scale production and preferential market access.	India should align manufacturing policy with trade-market access, especially for major importing regions.
Jinko Solar: Tax and R&D incentives	Benefited from preferential corporate income-tax rates, including "High and New Technology Enterprise" incentives and other encouraged-industry tax benefits.	Jinko Solar's R&D allocation rose from **RMB 461.6 million in 2021** to **RMB 911.9 million in 2023**; it achieved **11% global market share in 2024**, with large module, cell and wafer capacities.	India can link tax and fiscal incentives more directly to technology upgrading, R&D intensity and domestic IP creation.
Vietnam: Emerging-market manufacturing hub	Leveraged FTAs, tax incentives, import-duty exemptions, streamlined approval processes, PPA incentives and skilling programmes; proximity to China reduced input-material delivery timelines from weeks to days.	Vietnam accounted for **10% of global PV exports in 2024** and became a key manufacturing base for global and Chinese PV players.	India can draw lessons on combining policy certainty, trade access, skilling and logistics efficiency to build export competitiveness.
India: Policy foundation for scale-up	Implemented PLI, ALMM, BCD, domestic content requirements, safeguard duties and international cooperation platforms such as the ISA.	PLI has a total outlay of **Rs 24,000 crore / $2.7 billion** and awarded around **48 GW / 48.3 GW** of integrated PV	India has created a strong downstream manufacturing base; the next phase must deepen upstream integration,

Case study	Key policy / strategy levers	Outcomes / evidence	Implication for India
		manufacturing capacity across two tranches.	R&D, skills and export-market access.

Key challenges and recommendations

Challenge	Why it matters	Recommended actions	Expected strategic outcome
Upstream import dependence	India has expanded module and cell capacity, but upstream segments remain underdeveloped. Polysilicon import dependence is close to 100%, wafer import dependence is above 90%, cell import dependence is above 60%, and module import dependence is above 40% of available supply after exports.	Provide long-term policy clarity; consider future BCD on polysilicon and wafers; extend ALMM to wafers; incentivise polysilicon-to-module integrated manufacturing; encourage alternative sourcing and strategic partnerships.	Reduces supply-chain vulnerability, captures more domestic value and improves resilience against raw-material price volatility.
Limited access to machinery and capital goods	Capital goods for polysilicon, wafer and cell manufacturing are concentrated largely in China, creating access constraints for Indian manufacturers and risking delays in PLI commissioning timelines.	Encourage JVs, acquisitions and global partnerships; diversify capital-goods sourcing beyond China; support bilateral technology engagement; develop manufacturing clusters with shared infrastructure.	Improves access to critical production technology and accelerates upstream capacity creation.
Low R&D intensity	Indian players' R&D spend is negligible compared with Chinese peers, where average R&D spend is around 3% of revenue and can reach 6% for some players. MNRE R&D disbursement till December 2024 was only about $19 million, compared with $1.4 billion in grants received by Chinese players.	Create a dedicated solar R&D fund; increase MNRE's R&D allocation; introduce performance-linked R&D incentives; strengthen academia-industry partnerships; fast-track IP protection; encourage firms to raise R&D spend towards global benchmarks.	Supports technology upgrading, domestic IP creation and competitiveness in TOPCon, HJT, perovskite and tandem technologies.
Skilled-labour availability	India's employee productivity per MW is about one-third of global peers, partly due to lower scale and limited process integration. The shift from Mono PERC to TOPCon, HJT and tandem cells will increase manufacturing complexity.	Establish an industry-led solar skills development council; expand grants beyond two institutes per year; create curricula for polysilicon, wafer, cell and module manufacturing; mandate apprenticeships; partner with global solar leaders for advanced training.	Builds a skilled workforce capable of supporting advanced, integrated PV manufacturing.
Export concentration	India's PV exports have grown sharply but remain highly concentrated in the US. The US accounted for 97% of India's PV exports in fiscal	Negotiate trade agreements and MoUs with key importers; provide market-development support; extend export credit lines; organise trade missions; support overseas	Diversifies export markets, reduces single-market risk and positions India as

	2025, while India has limited exposure to major importers such as Brazil, the Netherlands, Germany and Spain.	assembly/manufacturing bases in target markets.	a larger global PV manufacturing hub.
6. Ease of doing business and manufacturing clusters	Scaling PV manufacturing requires access to land, utilities, clean power, testing facilities, logistics and faster approvals. India's upstream expansion will be capital-intensive and needs supportive state-level ecosystems.	Develop solar manufacturing hubs; provide single-window clearance; identify suitably sized land parcels; enable affordable open-access renewable energy; co-locate R&D and testing facilities; classify solar manufacturing as a priority sector.	Lowers entry barriers, improves manufacturing economics and supports multi-GW scale hub development.

Photovoltaic manufacturing

Introduction

The global shift towards sustainable and renewable energy is anticipated to drive a substantial increase in solar energy demand, presenting a significant opportunity for nations to emerge as leading manufacturers of photovoltaic (PV) systems. India is poised to leverage this trend, given its aggressive renewable energy goals and expanding manufacturing capabilities.

The global PV industry is dominated by China, which accounts for over 80% of the global supply capacity. China's success in expanding its PV manufacturing base can be attributed to its early push in the industry, strategic trade agreements, and government policies that have enabled economies of scale and cost reduction. The country's tax incentives, research and development (R&D) initiatives, and skilling programs have also played a crucial role in driving growth. China's dominance in the global PV industry is evident from its large-scale manufacturing presence, and its ability to conclude 23 free trade agreements (FTAs) which involve 30 countries (including regional blocs), which has helped the country to tap export potential.

The global PV market is expected to experience significant growth, driven by increasing demand for renewable energy and decreasing costs. The industry is experiencing a shift towards technological advancements, with the adoption of high-efficiency solar cells and modules. The use of TOPCon (Tunnel Oxide Passivated Contact) cells and HJT (Heterojunction) cells are becoming increasingly popular, and the industry is also seeing a trend towards larger wafer sizes and new geometries. Other countries such as the United States, India, and Southeast Asian nations are emerging in the global PV market. The United States is seeing significant growth in domestic module production, while India is emerging as a potential export hub for PV modules. The International Solar Alliance is playing a key role in promoting solar energy solutions and reducing global carbon emissions. The alliance has set a goal of mobilizing $1 trillion in solar investments by 2030 and promoting low-carbon growth trajectories, particularly in underserved segments and geographies across Africa.

Other countries such as Vietnam, Thailand, and Malaysia are also emerging as significant suppliers, driven by the diversification of the supply chain and the imposition of anti-dumping duties on Chinese products. These countries have increased their production capacity in recent years, with Vietnam, Thailand, and Malaysia accounting for over 10% of global production of solar cells and modules in 2022. India has made significant progress in advancing solar cell materials, solar inverters, and PV deployment and reliability through research and development initiatives. The National Centre for Photovoltaic Research and Education (NCPRE) has implemented several projects, including the development of perovskite-silicon tandem solar cells, medium voltage direct grid connect inverters, and the study of degradation of solar panels in hot and humid climates.

China has invested heavily in research and development, with a focus on improving the efficiency and quality of solar photovoltaic products. The country has collaborated with renowned institutes and agencies to improve its research and development capabilities.

Vietnam has become a hub for solar photovoltaic manufacturing, driven by its business environment, including skilling programs, free trade agreements, tax incentives, and end-user drivers. The country has signed several free trade agreements, such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and the European Union-Vietnam Free Trade Agreement (EVFTA), which have reduced tariffs and simplified trade procedures, making it an attractive destination for solar photovoltaic manufacturers. Additionally, Vietnam offers tax incentives, such as corporate income tax exemptions and import duty exemptions, to encourage investment in the solar photovoltaic sector. The country has also implemented skilling programs, including government-funded training centers and subsidized courses, to develop a skilled workforce for the industry.

The global PV industry is characterised by a significant trade imbalance, with China, Vietnam, Thailand, and Malaysia dominating the export market due to their large manufacturing bases. The USA, India, and Germany are among the major importers of PV products, driven by their renewable energy targets and policies. The country has implemented various policies, such as trade agreements, tax exemptions, and reductions, to support the growth of industry. China has provided various incentives to the solar photovoltaic manufacturing industry, including tax exemptions and reduced rates, to encourage investment and innovation. These incentives have enabled companies, such as Jinko Solar, to invest in research and development and gain a competitive edge in the market.

India has introduced several research and development (R&D) incentives, including collaborations with international partners, such as the United States of America (US) and Germany, to develop advanced solar photovoltaic technologies. These initiatives aim to improve the efficiency and competitiveness of domestic manufacturers. India has introduced several industrial incentives, including the PLI scheme, to promote the growth of its solar photovoltaic manufacturing industry.

The Indian PV manufacturing industry has witnessed significant growth in recent years, driven by comprehensive government initiatives and policies. The solar manufacturing capacity has increased to 100 GW by August 2025, up from less than 3 GW in 2014. However, much of this growth has occurred over the past four fiscal years, following the introduction of Approved List of Models and Manufacturers (ALMM) and Production Linked Incentive (PLI) scheme. Furthermore, capacity expansion has been largely concentrated on the downstream value chain, with the upstream chain still heavily reliant on imports.

The industry is a crucial component of India's renewable energy landscape, driven by increasing demand for clean energy, decreasing technology costs, and supportive government policies. The industry is heavily dependent on imports for upstream components such as polysilicon and wafers due to a lack of domestic manufacturing capacity. China is the largest supplier of these components, accounting for over 59% of India's cell and module imports in 2024. The industry is expected to play a crucial role in achieving India's target of 500 GW of non-fossil fuel energy capacity by 2030. However, the industry will need to address its dependence on imports and develop domestic manufacturing capacity for upstream components to achieve sustainable growth.

The Indian government has implemented various measures to protect the domestic solar photovoltaic manufacturing industry, including safeguard duties and basic custom duty (BCD). Safeguard duties were imposed in 2018 to protect the domestic industry from influx of imports, and the BCD was introduced in 2022 to bring parity between domestic and international prices. Safeguard duties were imposed in 2018 to protect the domestic industry from cheap imports. The duties were applicable for two years, with a rate of 25% from 30th July 2018 – 29th July 2019 in the first year, 20% from 30th July 2019 – 29th January 2020 and 15% From 30th January 2020 – 29th July 2020 in the second year. SGD was further extended wherein its rate was 14.9% from 30 July 2020 to 29 January 2021 and 14.5 from 30 January 2021 to 29 July 2021. The purpose behind the same was to protect the domestic solar manufacturing industries.

The BCD was introduced on April 1, 2022, to bring parity between domestic and international prices. The duty is applicable on imported solar cells and modules, with a rate of 25% for cells and 40% for modules. Furthermore, from 2nd February 2025 the tariff rate for solar cells decreased from 25% to 20%, while the tariff rate for solar modules decreased from 40% to 20%. The Agriculture Infrastructure and Development Cess replaced the Social Welfare Surcharge from 2.5% to 7.5% for solar cells and from 10% to 20% for solar modules.

The government introduced a PLI Scheme initiative to promote the domestic manufacturing of high-efficiency solar PV modules in India. The scheme has two tranches, with the first tranche having an outlay of Rs. 4,500 crore ($510 million) and the second tranche having an outlay of Rs. 19,500 crores ($2.2 billion). In all the scheme awarded 48 GW of integrated PV capacity.

The ALMM is a comprehensive list of approved models and manufacturers of solar PV modules, cells, and wafers. The list is maintained by the MNRE and is updated regularly. The government has introduced guidelines for open access projects and net-metering, which require the use of modules, cells, and wafers from the ALMM list. The guidelines promote the use of domestically manufactured components and reduce reliance on imported components for renewable energy projects. The government has accelerated its push for creating domestic manufacturing capacities across the solar value chain by proposing to mandate the use of India-made wafers under the ALMM starting June 1, 2028. The MNRE has issued a draft amendment to the ALMM order, which proposes creating an ALMM List-III for wafers.

The International Solar Alliance (ISA), initiated by India, had a well-defined governance structure, with the ISA Assembly serving as the supreme decision-making body. The Assembly was responsible for making key decisions, such as selecting the Director General, overseeing the functioning of the ISA, and approving the operating budget. The ISA launched several initiatives, including the Solar Technology Application Resource Centre (STAR C) program, the Indian Technical and Economic Cooperation (ITEC) Scheme, and the One Sun, One World, One Grid (OSOWOG) initiative. These initiatives aimed to promote solar energy deployment, enhance energy access, and reduce carbon emissions. The ISA launched a fellowship program for mid-career professionals, aiming to enhance the long-term development capabilities of its member countries by creating a pool of skilled and qualified professionals who could effectively manage solar energy projects, programs, and policies. The ISA worked to increase access to affordable and sustainable energy solutions through various projects, including mini-grids, solar-powered agriculture pumps, solar rooftop installations, and solar water heaters, among others. The ISA played a vital role in promoting clean energy globally, with a primary objective of advancing the use of solar energy as a clean, renewable, and sustainable source of energy. The ISA's efforts helped reduce carbon emissions, promote energy access, and contribute to a more sustainable and equitable future for all.

India's solar manufacturing sector faces challenges due to limited access to capital goods, primarily controlled by Chinese companies, which may delay expansion plans and hinder growth. The PLI scheme's timelines are at risk due to slow progress in commissioning polysilicon, wafer, and cell manufacturing facilities, with high import dependence and capital expenditure requirements. This may result in missing renewable energy targets and perpetuating dependence on imports, ultimately impacting the nation's self-reliance and economic growth.

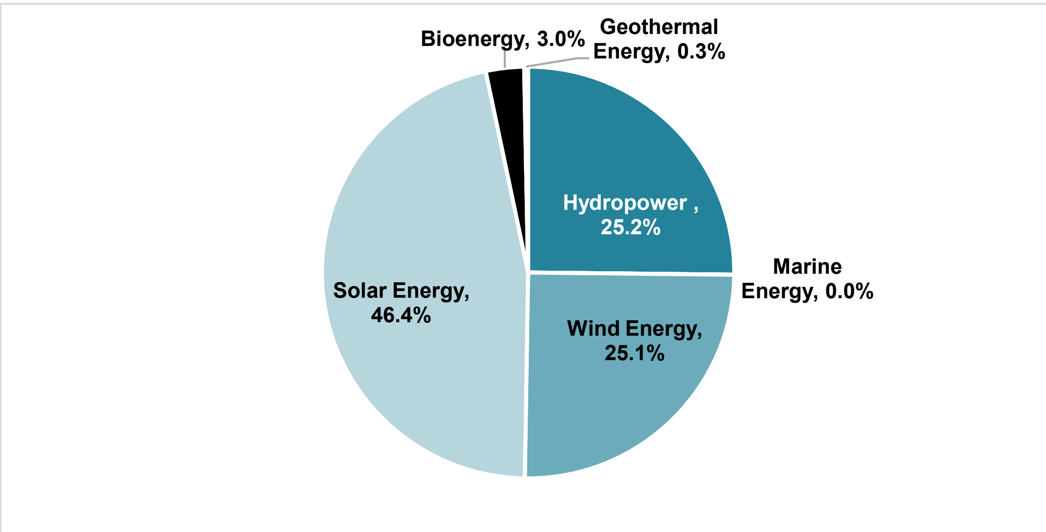
India's solar industry faces challenges due to low employee productivity, with average productivity per MW being lower than global players, mainly due to scale and integrated processes. The industry's rapid technological evolution and need for skilled labor to drive innovation in R&D exacerbate the issue, making labor availability crucial for scaling manufacturing technologies. Limited government support for human resource development and training, as well as increased training hours, can raise costs and delay projects for solar module and cell manufacturers.

Global PV industry – An overview

The share of renewable energy in the electricity sector is expected to expand significantly, from 30% in 2023 to 46% in 2030. This growth will be largely driven by solar and wind energy. As a result, the increased use of renewable electricity will have a positive impact on other sectors, such as industry, building heating, and transportation, by reducing their carbon footprint. Additionally, renewable electricity will be used to produce renewable hydrogen, which will be used in various applications, including materials, chemicals, and power generation, accounting for nearly three-quarters of the demand for renewable hydrogen by 2030.

Solar has already emerged as the largest component of the global renewable power-capacity basket. At the end of 2025, solar accounted for approximately 46% of installed renewable power capacity globally, compared with around 25% each for hydropower and wind.

Figure 75: Global installed renewable power capacity by technology, 2025 (%)



Source: IRENA

Solar's leading share of renewable capacity, together with expectations of continued capacity additions through 2030, is likely to support sustained demand across the PV manufacturing value chain. China leads the PV manufacturing capacity with over 85% share in the global base. However, manufacturing remains highly geographically concentrated. China accounts for more than 85% of global PV manufacturing capacity and has maintained a dominant position across key stages of the value chain owing to early policy support. Infact, China has dominated the PV manufacturing market from early 2010s. The government of China identified PV manufacturing as a strategic industry in 2009 and attempted to accelerate its growth principally through a combination of low-cost debt and subsidy. By 2010, China accounted for nearly half of global production of PV[61].

China's success in expanding PV manufacturing base also enabled it to become leading exporter. Its share in global PV exports (cell and module) in CY2024 and H1 2025 was 59% and 64%[62] respectively.

Other Asian countries such as Vietnam, Malaysia, Thailand, Cambodia, Indonesia, Laos and India collectively contributed 28% of exports.

[61] C-STEP

[62] ITC Trademaps

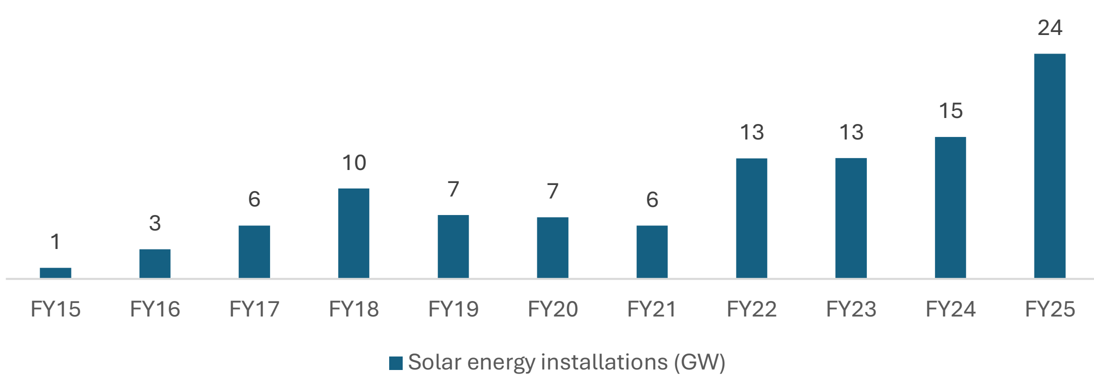
Indian PV manufacturing industry – A detailed profile

ALMM List-I drove module manufacturing capacity additions; solar cell capacity is following suit

The Indian PV manufacturing industry is largely concentrated in the solar cell and module stage of the value chain. The total solar module manufacturing capacity enlisted in ALMM increased to 100 GW in August 2025 from nearly 2.3 GW[63] seen in 2014. India's solar cell manufacturing capacity increased to 25 GW in March 2025[64] from less than 1.2 GW in 2014. Consequently, India's share in exports of solar cells and module was 3% and 4% in 2024 and H12025 respectively from less than 1% in 2014. The PV manufacturing industry is crucial component of the India's renewable energy landscape, driven by the increasing demand for clean energy, decreasing technology costs, and supportive government policies.

Between FY2015 and FY2025, India added 103 GW of solar capacity, implying a conservative minimum solar-module demand of 103 GW(factoring 1.1 times[65] DC overloading in solar rooftop and 1.4-1.5[66] times DC overloading in groundmounted solar projects).

Figure 76: Fiscal 2025 sees recording breaking 24 GW of solar additions



Source: MNRE

These installations have helped the solar energy base to reach 106 GW[67] in March 2025. India is expected to add 174 GW to achieve the target of 280 GW in 2030[68]. This is expected to generate significant demand (after factoring DC overloading).

While India's PV module and cell capacity has grown significantly in between 2014-2025, the industry is import dependent for upstream components such as polysilicon and wafer (2 GW) owing to lack of manufacturing capacity.

The below section highlights major producers of the value chain and India's dependence on nations.

---

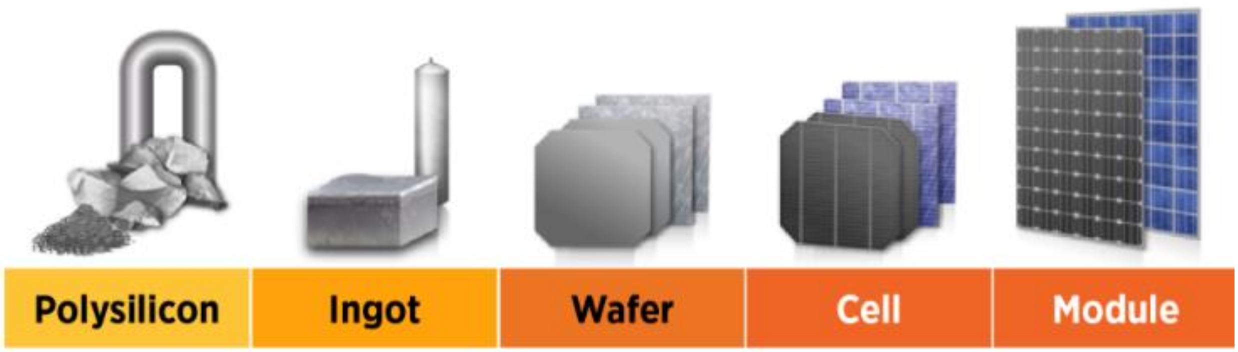
[63] PIB MNRE (Aug 2025)
[64] PIB Energy & Environment (Aug 2025)
[65] Technical specification
[66] Based on player benchmarks
[67] Installed capacity MNRE (Mar 23)
[68] MNRE

Value chain[69]

Solar PV module

The PV module can be manufactured using multiple process – multi-crystalline, polycrystalline and thin-film. The most commercially available PV module relies on crystalline silicon as the absorber material. These modules have several manufacturing steps that typically occur separately from each other.

Figure 77: Crystalline PV module manufacturing value chain



Source: Industry

Polysilicon Production

Polysilicon, a highly pure and fine-grained form of silicon, is produced in various shapes, including rods and beads, depending on the manufacturing method. The production process typically involves the use of highly reactive gases, which are synthesized from metallurgical-grade silicon, hydrogen, and chlorine. One such method, known as the Siemens process, involves the decomposition of a silicon-hydrogen-chlorine gas mixture on a heated silicon filament, resulting in the formation of a large, U-shaped polysilicon rod. This process features a closed-loop system, where the hydrogen and chlorine atoms are recycled and reused. To prevent contamination, the filament is made of pure silicon. An alternative method involves the use of small silicon beads in a cone-shaped vessel, where a silicon-hydrogen gas mixture is introduced, causing the beads to float near the surface. As the vessel is heated, the silicon atoms deposit onto the beads, increasing their weight until they sink to the bottom, where they can be collected and used.

Ingot and Wafer Production

To transform polysilicon into wafers, it is melted in a container to form a liquid mass. The Czochralski process is one method used to create a large, cylindrical ingot of single-crystal silicon, where a small seed crystal is introduced to the liquid surface and slowly lifted upwards, allowing the crystal to grow. Alternatively, the directional solidification process involves gradually cooling the liquid mass from the bottom up, resulting in a large-grained, multi-crystal silicon ingot. The ingots are then cut into extremely thin wafers using diamond-edged saws, producing silicon dust known as kerf in the process. However, kerfless production methods also exist, such as removing cooled silicon layers from a molten bath or depositing silicon atoms onto a crystalline template using gaseous silicon compounds, allowing for the creation of thin wafers without generating waste.

---

[69] US department of energy (Solar Photovoltaic Manufacturing Basics)

Cell Fabrication

The silicon wafers are then transformed into photovoltaic cells through a series of fabrication steps. The initial step involves chemically texturing the surface of the wafer to remove any damage caused by the sawing process and to enhance its ability to absorb sunlight. The subsequent steps vary depending on the specific design of the device. Typically, the wafer is exposed to a gas that contains an electrically active dopant, and layers are deposited on the surface to improve the cell's performance. Additionally, many cell types require the application of silver metallization through screen printing to create electrical contacts.

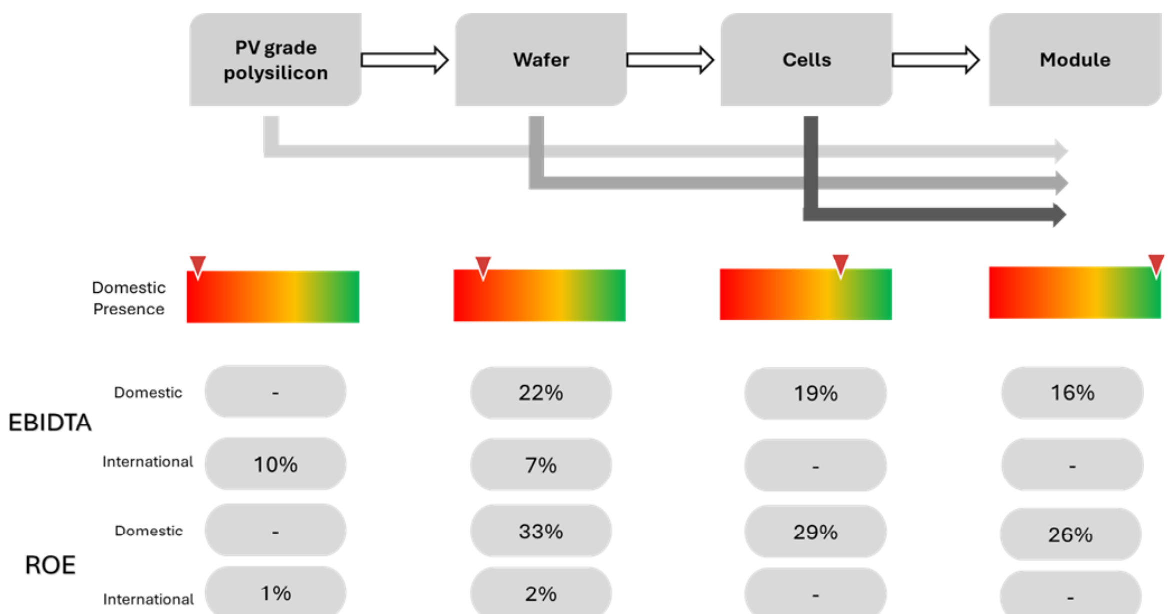
Solar Module Assembly

At a module assembly facility, cells are connected together using copper ribbons with solder to link the silver busbars on the front of one cell to the back of another, a process called tabbing and stringing. The connected cells are then arranged face-down on a glass sheet coated with a polymer encapsulant, and another layer of encapsulant is added on top. A durable backsheet or additional glass is placed on top, and the entire stack is sealed in an oven to make the module waterproof. The module is then framed with aluminum, sealed with edge sealant, and equipped with a junction box that houses diodes to prevent reverse electricity flow. Finally, electrical cables from the junction box transmit the modules' generated current to adjacent modules or the system's power electronics.

Value chain play

The financials of the players are closely influenced by the presence in the value chain. It is observed that players active across all four stages of the value chain have registered better financials.

Figure 78: Importance of value chain presence in player's financials



Note: EBITDA and ROE are averages of FY24 and FY25 owing to full year of large-scale cell to module operations for Indian players. Financials of international players are considered on Calendar Year. CY2024 is compared with FY25.

Formula used for above ratios are below

1. *EBITDA = Total income – (Total expenses – interest and finance cost - depreciation and amortization)*

2. *EBITDA Margin = EBITDA / total income*
3. *ROE = Profit after tax / total equity*

Players considered for financials are below

1. *India = Waaree Energies, Vikram Solar, Premier Energies, TP Solar, Emmvee Power Photovoltaic, Rayzon Solar, Adani Mundra PV and Solex*
2. *International = Longi Green, Canadian Solar, Jinko Solar, Trina Solar, JA Solar and GCL Poly*

Source: Crisil Intelligence, Company Reports

The above figure indicates EBITDA and ROE for integration of value chains for Indian and international players. It is observed that the returns increase as the level of integration increases. Players operating in all the stages of the value chain (polysilicon to module) gain cost competitiveness over those operating in cell to module and only module segment as they are less exposed to supply chain disruptions and volatility in the raw material prices.

While globally, a few players operate in polysilicon to module stages of the value chain, India has limited presence in ingot-wafer to module stage.

Over CY2023 and CY2024, the returns of the international players have been impacted owing to oversupply in the PV component market resulting in pricing pressures. The fall in prices resulted in a fall in revenue of 29% on year in CY2024 for the sample of international players considered. Consequently, absolute EBITDA shrunk by 85% on year for the same period. The reduction in EBITDA further impacted the profit after tax, ultimately impacting the ROE of the international players in CY2024.

On the other hand, the returns of the Indian manufacturers improved owing to implementation of domestic tariff and non-tariff barriers in form of BCD and ALMM I. This, coupled with increasing solar additions in the country, boosted sales. Revenue from operations for the sample set considered increased nearly 1.8 times in fiscal 2025 as India witnessed a record breaking 24 GW of solar additions. A few players also gained benefits with exposure to the export market as pricing of Indian make remained favourable compared to the US make. This further amplified the returns for the Indian players.

The globally low raw material prices (solar cells for standalone module manufacturers and wafers for solar cell manufacturers) also enabled improvement in returns. However, as Indian manufacturers' presence remained limited largely to cell to module stage, they are also exposed to volatility in prices.

In fiscal 2026/CY2025, the Chinese government has driven intervention to consolidate the outdated and low competitive capacity. The result of this initiative may drive consolidation of capacity to 2 million tons from 3.25[70] million tons resulting in upward movement in prices. Additionally, the US investigation of Foreign Entities of Concern (FEOC) may also increase demand for non-China, Russia, North Korea and Iran polysilicon resulting in upward movement in the prices. Therefore, any increase in raw material prices will impact the prices of Indian made modules until backward integration is achieved.

Thus, while the current oversupply dynamics coupled with timely policy intervention by the government of India have favoured the Indian manufacturers, the returns in the stable scenario favour integrated value chain players that the global players exhibited. Therefore, it will be critical to expand in the polysilicon to cell manufacturing stage in the future.

[70] Reuters

Manufacturing Process (TOPCon Solar Cell)[71]

The TOPCon solar cell manufacturing process revolves around creating an advanced cell structure that boasts higher efficiency and reduced degradation compared to traditional solar cells. This innovative technology features both front and back electrical contacts, which minimizes resistance losses and enhances current collection. As a result, TOPCon cells offer superior performance and reliability, making them a preferred choice among photovoltaic (PV) manufacturers seeking to optimize energy output.

The key aspect of TOPCon technology lies in its unique contact configuration, which distinguishes it from conventional cells with rear contacts only. By incorporating both front and back contacts, TOPCon cells achieve lower resistance and increased current collection, ultimately leading to higher efficiency and reliability. This design advancement has contributed to the growing adoption of TOPCon technology in the solar industry, as manufacturers strive to produce high-performance solar cells that can maximize energy generation.

Silicon Wafer Preparation

The initial stage of TOPCon solar cell production involves preparing silicon wafers, which commences with slicing silicon ingots into thin discs using a wire saw. The resulting wafers, typically 180-200 microns thick, then undergo a series of treatments to refine their surfaces. Chemical etching, employing solutions such as sodium hydroxide or potassium hydroxide, is used to remove sawing damage and smooth the wafer surfaces. An alternative acidic etching solution may also be utilized for this purpose.

Following etching, the wafers are subjected to a rigorous cleaning process to eliminate any residual contaminants. This involves a combination of cleaning methods, including SC1 cleaning with ammonium hydroxide, hydrogen peroxide, and water, as well as RCA cleaning using hydrochloric acid, hydrogen peroxide, and water to remove organic impurities. The final step in wafer preparation entails surface planarization, which can be achieved through either polishing with polyurethane pads and slurry or chemical mechanical planarization (CMP). Upon completion of these steps, the silicon wafers are rendered extremely flat and level, making them suitable for the subsequent stages of solar cell fabrication.

Surface Texturing

Surface texturing is a vital step in the TOPCon solar cell manufacturing process, aimed at enhancing cell efficiency by reducing reflectivity and increasing light trapping. This is achieved by creating micrometer-scale pyramids on the silicon wafer surface, which helps to minimize the amount of light that reflects off the surface and instead allows it to enter the cell. The pyramid structures accomplish this through two primary mechanisms: increasing the likelihood of light entering the wafer at an angle, rather than reflecting off, and expanding the surface area to provide more opportunities for light absorption.

The texturing process involves anisotropic etching of the silicon wafer surface using solutions such as potassium hydroxide (KOH) or sodium hydroxide (NaOH). By carefully controlling factors like solution temperature, concentration, and etching time, the optimal surface structure can be achieved. The resulting pyramids, typically 5-10 μm in height and 10 μm in base width, strike a balance between effective antireflective properties and minimizing recombination of electron-hole pairs within the cell. Ultimately, surface texturing plays a crucial role in boosting solar conversion efficiencies by enabling more light to enter the cell.

The anisotropic etching process selectively etches the silicon wafer, creating pyramids with precise dimensions. This controlled etching process is critical in achieving the desired surface texture, which is essential for maximizing light absorption and minimizing reflectivity. By optimizing the texturing process,

[71] SOLARNPLUS

manufacturers can significantly improve the efficiency of TOPCon solar cells, making them more effective at converting sunlight into electrical energy.

Doping

Doping is a crucial step in the manufacture of TOPCon solar cells, involving the intentional introduction of impurities into the silicon wafer to create regions with different electrical properties. This process utilizes dopants such as phosphorus and boron to create n-type and p-type semiconductor regions, respectively. Phosphorus introduces excess electrons, resulting in a negatively charged n-type region, while boron introduces electron holes, creating a positively charged p-type region.

The intersection of these n-type and p-type regions forms a p-n junction, which is essential for separating photogenerated electrons and holes, thereby enabling the flow of current when the cell is exposed to light. The precise control of the doping process allows manufacturers to optimize the electrical properties of the cell, including open-circuit voltage and short-circuit current, which are directly influenced by doping profiles and concentrations.

Advanced doping techniques, such as selective emitter doping, further enhance efficiency by heavily doping the front emitter region while lightly doping the rear emitter. This selective approach minimizes recombination losses, particularly near the front contacts, leading to improved overall performance. The doping process is fundamental to creating an efficient solar cell capable of reliably converting sunlight into electricity, and careful optimization of doping parameters is essential for maximizing the performance of TOPCon cells.

By carefully controlling the doping process, manufacturers can create a highly efficient p-n junction that effectively separates charge carriers and enables the generation of electrical current. This, in turn, allows to produce high-performance TOPCon solar cells with optimized electrical properties, ultimately leading to increased energy conversion efficiency and reliability.

While the doping step is described here prior to tunnel oxide formation, the precise sequence may vary across TOPCon manufacturing routes. Some manufacturers may perform certain doping or dopant activation processes after the formation of the tunnel oxide and/or polycrystalline silicon layers, depending on the specific cell architecture and production technology employed.

Edge Isolation

Edge isolation is a crucial step in the manufacturing of TOPCon solar cells, aimed at preventing electrical shunting between the front and back surfaces at the cell's edges. This shunting can significantly reduce the overall efficiency of the solar cell, making edge isolation essential to minimize electrical losses and ensure optimal performance.

The primary objective of edge isolation is to eliminate any conductive paths around the cell's perimeter, which is achieved by creating narrow trenches that disconnect unwanted lateral conduction paths. Several techniques are employed for edge isolation in TOPCon cells, including laser isolation, plasma etching, and mechanical scribing.

Laser isolation involves using a laser to ablate narrow trenches around the cell edges, effectively cutting through conductive layers to isolate the front and back surfaces. This method is fast and precise, making it a popular choice. Plasma etching, on the other hand, utilizes an etching plasma to selectively remove material along the cell edges, creating isolation trenches without causing collateral damage. Mechanical scribing involves using a diamond or carbide tip to mechanically scribe isolation lines along the edges, cutting through the layers to isolate the surfaces.

The dimensions of the isolation trenches, including width and depth, are carefully optimized to balance processing time and ensure the complete removal of shunting paths. Following the creation of the trenches, a dielectric material is typically applied to fill the trenches and guarantee robust long-term isolation. Proper edge isolation is vital for TOPCon cells to operate at maximum efficiency, and this step is usually performed after metallization to electrically isolate the entire cell.

By implementing effective edge isolation, manufacturers can significantly reduce electrical losses and improve the overall performance of TOPCon solar cells. The choice of edge isolation technique depends on various factors, including the specific cell design, materials, and manufacturing requirements. Regardless of the method used, the goal of edge isolation remains the same: to prevent electrical shunting and ensure that the solar cell operates at its maximum potential.

Tunnel Oxide Layer Formation

The tunnel oxide layer is a vital component in the production of TOPCon solar cells, and its formation is a critical step in the manufacturing process. This extremely thin layer of silicon dioxide (SiO_2) is grown on the surface of the silicon wafer, and its quality has a significant impact on the overall efficiency of the solar cell. The most common method for growing the tunnel oxide layer is thermal oxidation, which involves exposing the silicon wafers to oxygen at high temperatures, typically between 800-1200°C, to produce a uniform and defect-free layer of SiO_2.

To ensure the formation of a high-quality tunnel oxide layer, it is essential to carefully control the oxidation conditions, including temperature, pressure, flow rates, and time. Any impurities or defects in the layer can negatively impact the tunneling of charge carriers and ultimately affect the performance of the solar cell. The thickness of the tunnel oxide layer is also critical, typically ranging from 10-30 nm, as it determines the electrical properties of the interface between the silicon and the oxide layer.

The growth of the tunnel oxide layer requires meticulous attention to detail, as any imperfections or defects can compromise the quality of the layer. Advanced analytical techniques are employed to characterize the chemical composition and structural quality of the tunnel oxide, ensuring that it meets the required standards. The formation of a high-quality tunnel oxide layer is essential for manufacturing highly efficient TOPCon solar cells, and its quality has a direct impact on the overall performance and efficiency of the cell.

By carefully controlling the oxidation process and ensuring the formation of a defect-free tunnel oxide layer, manufacturers can produce TOPCon solar cells with optimized electrical properties and improved efficiency. The tunnel oxide layer plays a critical role in enabling the efficient tunneling of charge carriers, and its quality is a key factor in determining the overall performance of the solar cell.

Deposition of Polycrystalline Silicon Layer

The deposition of the polycrystalline silicon layer is a crucial step in the TOPCon solar cell manufacturing process, as it serves as the emitter layer responsible for collecting electrons generated by light absorption in the cell. This layer is deposited using a chemical vapor deposition (CVD) process, where silane gas (SiH_4) is used as the silicon source and is mixed with hydrogen and nitrogen. The silane gas mixture is then introduced into a CVD chamber, along with a dopant gas such as phosphine (PH_3) or diborane (B_2H_6), which provides the necessary phosphorus or boron atoms to create a highly doped polycrystalline silicon layer.

The CVD chamber is equipped with heating coils that provide the energy required for the silane gas to decompose into silicon atoms, which then deposit onto the silicon wafer surface. The dopant gas ensures that the deposited polycrystalline silicon layer is highly doped, either n-type or p-type, depending on the specific requirements of the solar cell. To achieve a uniform and highly doped polycrystalline silicon layer of the desired thickness, precise control over the silane gas flow, dopant gas flow, chamber pressure, and temperature is essential.

The deposited polycrystalline silicon layer acts as the emitter in the finished solar cell device, playing a critical role in extracting charge carriers efficiently. The quality and properties of this layer have a significant impact on the overall performance and efficiency of the solar cell. By carefully controlling the CVD process and depositing a high-quality polycrystalline silicon layer, manufacturers can produce TOPCon solar cells with optimized electrical properties and improved efficiency.

The polycrystalline silicon layer is a critical component of the TOPCon solar cell, and its deposition requires careful attention to detail to ensure that it meets the required standards. The use of advanced CVD techniques and precise control over the deposition process enables the production of high-quality polycrystalline silicon layers, which are essential for manufacturing efficient and reliable TOPCon solar cells.

Passivation and Anti-Reflective Coating

The passivation and anti-reflective coating step are a crucial stage in the TOPCon solar cell manufacturing process, aimed at enhancing cell efficiency. Following the deposition of the polycrystalline silicon layer, the cell surface undergoes passivation to minimize recombination of electron-hole pairs. This is achieved by depositing a thin layer of silicon nitride using plasma-enhanced chemical vapor deposition (PECVD).

The silicon nitride layer serves a dual purpose: passivation and anti-reflection. As a passivating layer, it reduces surface recombination velocity, resulting in higher carrier lifetimes, and provides chemical passivation by shielding the silicon surface from impurities. Additionally, the silicon nitride layer acts as an effective anti-reflective coating due to its lower refractive index compared to silicon, increasing the amount of light absorbed in the cell and further boosting efficiency.

The thickness of the silicon nitride layer is carefully optimized to provide minimal reflectivity across a broad range of wavelengths. This step is essential for reducing recombination losses and improving light trapping in TOPCon solar cells. By incorporating a high-quality silicon nitride layer, manufacturers can significantly enhance the performance and efficiency of their solar cells.

The passivation and anti-reflective coating process is critical for achieving high-efficiency TOPCon solar cells. The silicon nitride layer plays a vital role in minimizing energy losses and maximizing energy conversion. By carefully controlling the deposition process and optimizing the layer thickness, manufacturers can produce solar cells with improved efficiency, reliability, and overall performance. The use of silicon nitride as a passivating and anti-reflective layer has become a standard practice in the industry, enabling the production of high-quality TOPCon solar cells that meet the demands of modern renewable energy applications.

Metallization

Metallization is a crucial step in the TOPCon solar cell manufacturing process, involving the addition of metal contacts to the front and back of the silicon solar cell to facilitate current collection. The metallization process typically employs screen printing to apply a metallic paste in a grid pattern to the front of the cell and a full-area metal contact to the back. This technique offers precise control over gridline width and thickness, and is fast, scalable, and cost-effective.

The front contact gridlines are printed using a silver-based metallic paste, while the back contact utilizes aluminum or silver paste. The pastes contain metal particles, glass frit, and organic binders, which are carefully formulated to optimize the electrical and mechanical properties of the contacts. The gridlines on the front of the cell are designed to balance current collection and minimize shading, while the back contact ensures uniform current collection.

Following the printing of the contacts, the cells undergo a high-temperature firing step, which serves to fuse the contacts into the silicon wafer and remove the organic binders in the paste. This firing process forms a strong electrical and mechanical bond between the silicon and metal contacts, with the glass frit etching the silicon and facilitating metal diffusion into the wafer. The resulting metallic contacts exhibit excellent current collection and low resistance losses, making them ideal for high-efficiency TOPCon solar cells.

The screen-printing metallization process is a reliable, simple, and efficient method for mass-producing solar cells with consistent quality. The front gridlines and back contact play a critical role in extracting current and maximizing the efficiency of the TOPCon cell, and the metallization process is carefully optimized to ensure that these contacts meet the required standards. By using advanced screen-printing techniques and carefully controlling the metallization process, manufacturers can produce high-quality TOPCon solar cells with optimized electrical properties and improved efficiency.

Testing and Sorting

The final stage of the TOPCon solar cell manufacturing process involves testing and sorting the completed cells to ensure that only the highest efficiency cells are shipped to customers. This critical quality control step assesses several key parameters, including efficiency, open-circuit voltage (Voc), short-circuit current (Isc), fill factor, series resistance, and shunt resistance. These tests determine the overall performance and quality of each cell, allowing manufacturers to sort and classify them into different bins based on their efficiency and characteristics.

The testing process involves measuring the conversion efficiency of each cell under standard test conditions, which reveals the percentage of sunlight energy that is converted into usable electrical energy. Cells with higher efficiency are typically sold at a premium price, while lower-grade cells are sold at reduced prices to budget-conscious buyers. The open-circuit voltage (Voc) and short-circuit current (Isc) are also measured, as these parameters depend on the quality of materials and interfaces used in the cell. A higher Voc indicates that the cell can produce more power, while a higher Isc suggests that the cell can produce more current.

The fill factor, which is a measure of cell quality, is also evaluated, as it depends on both Voc and Isc. A higher fill factor value indicates higher cell efficiency. Additionally, the series resistance and shunt resistance are measured, as these parameters can impact the cell's overall performance. Lower series resistance and higher shunt resistance are generally desirable, as they can improve the cell's efficiency and reduce energy losses.

After testing, the solar cells are sorted and classified into different bins based on their performance. The highest-grade cells, which exhibit the highest efficiency and best characteristics, are packaged and sold at a premium to customers who prioritize maximum efficiency. Lower-grade cells, which may have slightly lower efficiency or other limitations, are sold at reduced prices to customers who are more budget-conscious. By properly testing and sorting the solar cells, manufacturers can ensure that each customer receives cells that meet their specific needs and priorities, whether it be maximum efficiency, cost-effectiveness, or a balance between the two.

Strategic Alignment

Raw Material Availability

Table 28: Malaysia and Vietnam emerging countries in PV value chain

Raw Materials	PV grade polysilicon	Wafer	Solar cells	Module	Solar glass
Raw material intensity	High	High	High	High	Medium
Producer 1	China	China	China	China	China
Producer 2	Malaysia	Vietnam	Vietnam	Vietnam	India
Producer 3	Germany	Malaysia	Malaysia	Malaysia	-

Source: Crisil Intelligence

PV grade polysilicon, wafer, solar cell and glass are the key raw materials for the solar photovoltaic manufacturing industry. The table above shows the top 3 source countries for each of the raw materials for the global solar photovoltaic manufacturing industry.

The Indian solar photovoltaic manufacturing sector relies on imports for key raw materials such as solar wafers, cells and modules. Imports of polysilicon are limited owing to lack of operational wafer manufacturing capacity (2 GW as of March 2025) in the country. Furthermore, India had sufficient production capacity of solar glass (~15 GW[72] in June 2025) resulting in limited imports.

Table 29: India's presence in upstream value chain limited

Raw Materials	PV grade polysilicon	Wafer^	Solar cell	Module
Supplier Country 1	China	China	China	China
Supplier Country 2	Taiwan	Vietnam	Malaysia	Vietnam
Supplier Country 3	US	Other APAC nations	Thailand	Malaysia
Domestic availability	No	Yes	Yes	Yes
Import share	~100%	>90%	>60%	>40%*

Geopolitical relationship	Positive	Neutral

*Note: The above data is for fiscal 2025. * Share of imports in total available supply post exports. ^ Wafer's Exim is excluded due to lack of data in the public domain.*

Source: Crisil Intelligence

India relies on import on solar cells and modules in the value chain while imports of wafer and polysilicon remain limited over to lack of wafer and low capacity for cell manufacturing capacity respectively. Nearly 59% of the photovoltaic (cell and module) exports in 2024[73] was attributed to China alone. This is owed to the large-scale manufacturing presence of China with over 80% share in global supply capacity by December 2024 set up in China. Early decadal push to the industry in form of tax and power charge exemptions, R&D and skilling incentives and free trade (refer to section on China) agreements has enabled economies of scale resulting in high-quality-low-priced offerings.

[72] Borosil Renewables
[73] ITC Trademap

However, India has also imported from Vietnam, Thailand and Malaysia owing to diversification of supply chain which together account for 14%[74] of the photovoltaic imports in fiscal 2025. The production in Vietnam and Thailand has increased in recent years as major Chinese solar cell manufacturers have built production bases in these countries to circumvent the USA antidumping duties (AD) and countervailing duties (CVD) imposed on Chinese products. Further, increase in the domestic demand for solar installation to attain renewable energy goals in electricity has also created demand for Chinese photovoltaic manufacturers in these economies. Thus, the share of Vietnam, Thailand and Malaysia in global production of solar cells and modules was over 10% in 2022 post imposition of duties on China in 2022. The production capacity in 2024 stood over 40 GW[75] for Vietnam, Thailand and Malaysia.

For eg1: Trina Solar[76], a Chinese photovoltaic manufacturer's unit with an investment of $203 million became operational in August 2023 in the northern city of Thai Nguyen, Vietnam. This unit produces industry leading 210 m-m monocrystalline silicon wafers. The factory, with 700 workers, has seen its workforce more than double to 1,500 workers by August 2024 and commenced production of solar cells and modules. It is steadily ramping up to its maximum annual production capacity of 6.5 GW of wafers, 4 GW of solar cells and 5 GW of modules.

Consequently, these economies also play a crucial role in global exports.

SOLAR R&D

Solar Photovoltaics[77]

The Ministry of New and Renewable Energy (MNRE) has funded several Solar Photovoltaic (SPV) R&D projects, and the highlights of the progress achieved under these projects are listed below. The National Centre for Photovoltaic Research and Education (NCPRE) implemented Phase III of the Ministry's flagship project in solar photovoltaics. This flagship project had several workstreams, and the main highlights of the progress made are briefly described below.

Advancements in Solar Cell Materials: The National Centre for Photovoltaic Research and Education (NCPRE) had been working on addressing the challenges associated with scaling up perovskite-silicon tandem solar cells. The team had investigated new laser-cutting processes to prevent the loss of cell efficiency and stability due to edge shunting. They demonstrated a 4T-tandem solar cell with an efficiency of 29.2% at 17.5 mm^2 and 26.9% at 108 mm^2, with a bottom silicon solar cell efficiency of 25%. Furthermore, third-party laboratory testing had shown that the perovskite absorber had remained unaffected for up to 750 hours under damp-heat testing conditions. The team had also developed near-infrared (NIR) transparent solar cells with a power conversion efficiency of approximately 18.8%.

Advancements in Solar Inverters for Grid Integration: The grid integration group at NCPRE had focused on developing a medium voltage (MV) direct grid connect inverter using high voltage Silicon Carbide (SiC) MOSFETS. The team had worked on developing the entire inverter indigenously at the lab, with a focus on improving efficiency, power density, and reliability.

PV Deployment and Reliability: The National Centre for Photovoltaic Research and Education (NCPRE) conducted field surveys to study the degradation of solar panels in hot and humid climates. The surveys had identified the root cause of degradation as inner layer cracks in the backsheet, which led to accelerated potential-induced degradation (PID) and corrosion. The team had designed a weather station to collect data on the performance of solar panels and had discovered a vulnerability in commercial PV modules under

[74] Ministry of Commerce
[75] Taiyangnews
[76] TrinaSolar
[77] Annual Report MNRE 2025

high temperature reverse bias operation of bypass diodes. They had also developed a setup to assess this vulnerability and had studied the effect of load applied during cleaning on the durability of anti-soiling coatings.

Overall, the NCPRE has made significant progress in advancing solar cell materials, solar inverters, and PV deployment and reliability, which will contribute to the growth of the solar energy sector in India.

World Trade

Figure 79: Major PV exporting nations

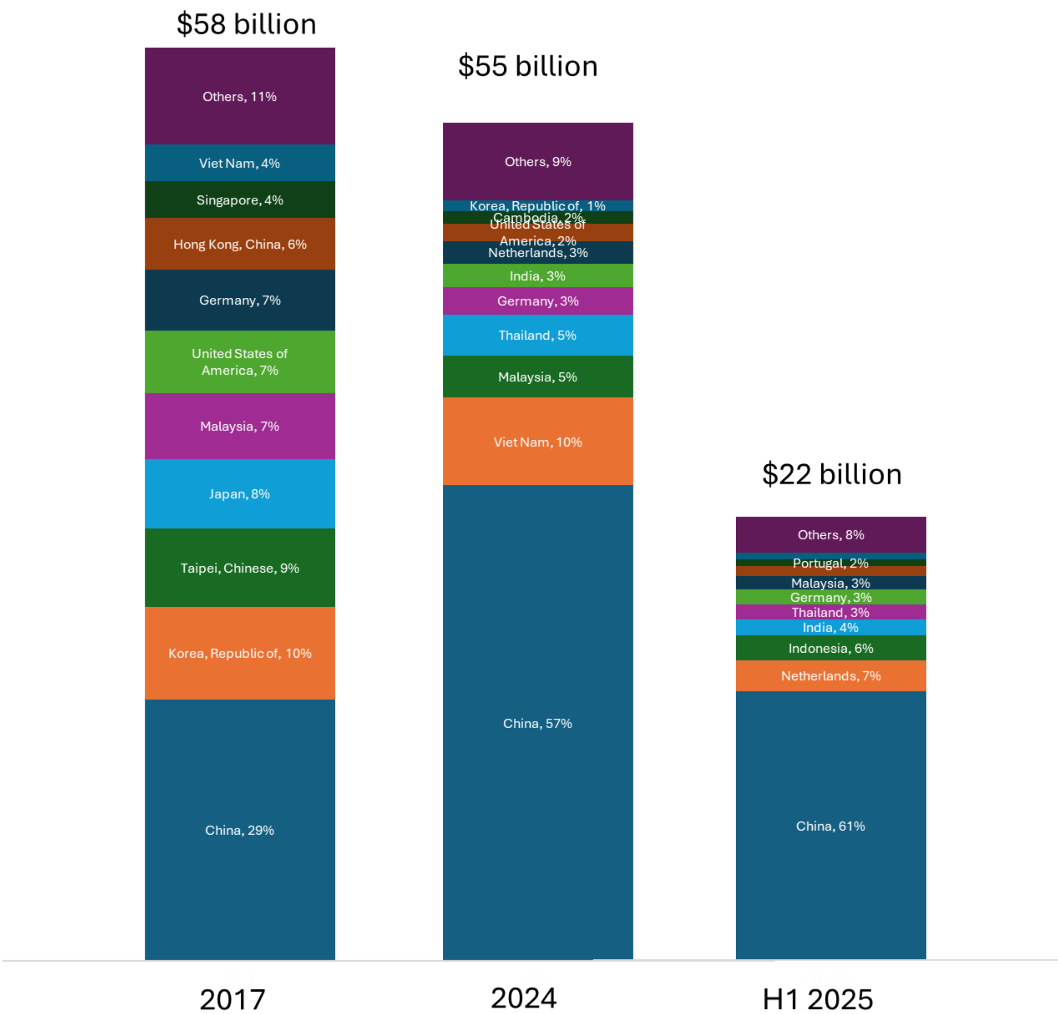
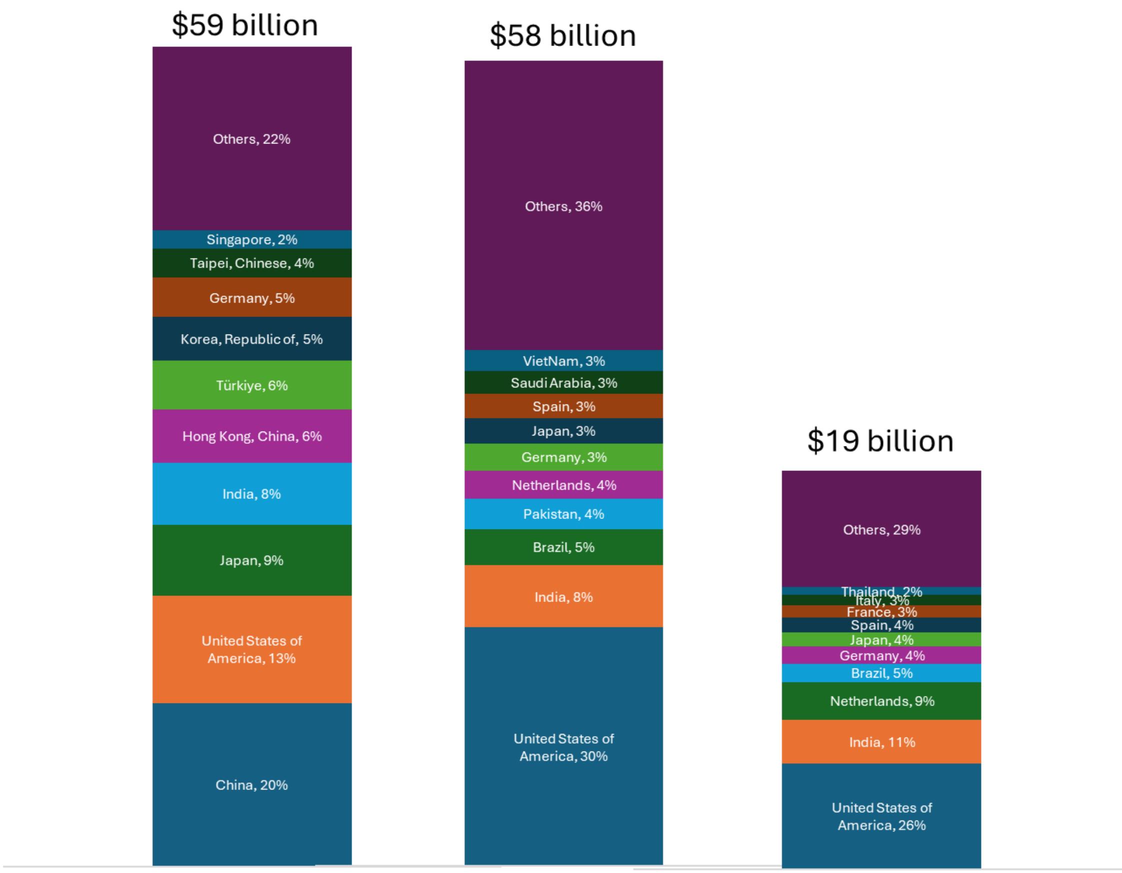


Figure 80: Major PV importing nations



Note: The above data includes Exim for Polysilicon – 280461, Solar cells and modules (2017) – 854140, Solar cells (2024 and H1 2025) – 854142 and solar modules (2024 and H1 2025) – 854143. Wafer's Exim is excluded due to lack of data in the public domain.

Source: Trade Map

China, Vietnam, Thailand and Malaysia dominate the PV export market due to their large manufacturing base. China led the global export basket with a 57%[78] share in 2024 driven by players GCL Polytech, TrinaSolar, Jinko Solar, JA solar and Longi Solar. These players cumulatively had a module and wafer manufacturing capacity of over 300 GW[79] and over 150 GW of cell manufacturing capacity as of December 2024. The country's tax and skilling incentives enabled savings for the players, which were then invested in R&D over the last three decades leading to cost reduction and increased efficiency of technology. Furthermore, the ability to conclude 23 FTAs[80] with 30 countries has also helped the country to tap export potential. Vietnam accounted for 10%[81] of the exports in 2024. Apart from the presence of local players such as SolarBK, Vsun, VinaSolar, the Vietnamese photovoltaic manufacturing is largely being driven by entry of the Chinese photovoltaic manufacturers resulting in Vietnam gaining 6% share in last 7 years. Players such as TrinaSolar, JA solar and Jinko Solar have increased their presence over the years. Lately, TrinaSolar was awarded an investment certification for a project in the northern province of Thai Nguyen

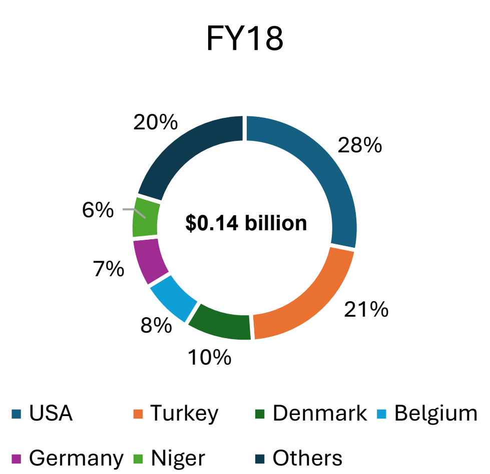
---

[78] ITC Trademap
[79] Company filings
[80] [China Briefing]
[81] ITC Trademap

worth $454 million[82] to produce solar modules and batteries. This has raised the total amounted invested in Vietnam by Chinese firms to $932 million. Similarly, Thailand and Malaysia have seen a surge in their installed base driven by domestic and international players such as Solartron, Risen Energy, Yingli Green, TS Solartech, JA solar, JinkoSolar and First Solar.

On the import side, the USA led with 30%, driven by Energy efficiency and Renewable Energy (EERE) mission. The country aims to install an average 30 GW[83] of solar capacity each year till 2025 and 60 GW per year from 2025-2030 to generate 80% energy through renewable sources by 2030. The country imported 48.5 GW[84] of modules in 9 months 2024 with over 75%[85] coming from Vietnam, Malaysia and Thailand. Similarly, India's import share of 8% in global imports is driven by Panchamrit goals of 50%[86] energy requirement from renewable fuels by 2030. India's import in 11 months of fiscal 2025 were driven by modules and cell to the extent of Rs 322 billion/$ 3.8 billion[87], from Rs 515 billion / $6.2 billion in fiscal 2024. Imports fell in fiscal 2025 owing to the reimposition of ALMM. On the other hand, Germany's import share accounted for 3% in 2024 driven a 215 GW[88] of solar energy target by 2030. The country needs to add 22 GW of solar per annum by 2030. Annual production capacity of 3.5 GW[89] coupled with a sharp fall in prices of PV led to imports in 2024.

Figure 81: Major Indian PV export nations



Note: The above data includes ExIm for Polysilicon – 28046100, Solar cells and modules (FY18) – 85414011, Solar cells (FY24) – 85414200 and solar modules (FY24) – 85414300. Wafer's ExIm is excluded due to lack of data in the public domain.

Source: DGFT, Crisil Intelligence

India's PV exports in fiscal 2025 were 8 times of those in fiscal 2018. The increase was driven by increased capacity in the cell to module part of the value chain under the production linked incentive scheme. The geographic concentration over the years has changed with the US accounting for 97% of exports in fiscal

[82] VCCI
[83] NREL
[84] NREL
[85] US office of energy efficiency and renewable energy
[86] Ministry of Environment, Forest, and Climate Change
[87] Ministry of Commerce and Industry
[88] Bundeswirtschaftministerium
[89] Fraunhofer

2025. The high concentration was driven by the USA's ban on import of production from China's Xinjiang province owing to inhumane treatment of the province's Uyghurs and other Muslim majority communities. The ban enforced in June 2022, restricted entry of all goods and services that used materials or workers from the Xinjiang Uyghur Autonomous Region. With over 39% of the global polysilicon manufacturing base installed in Xinjiang province by 2022, the Chinese module supply to the USA hit a roadblock resulting in an increased demand for modules from countries other than China, especially India. The premium offered by the US market drove Indian manufacturers to focus on exports to the country resulting in geographic concentration.

As of fiscal 2025, India had limited exposure to other top importing countries such as Germany, Brazil, Netherlands owing to high traded price difference of $0.1-0.12/watt between Indian modules vis a vis Chinese module. Further, the lack of a free trade agreement has also been a challenge to increase exports. Increasing PV manufacturing capacity, free trade agreements and exploring new export markets will be key to harnessing India's export potential.

Technology Readiness

India's readiness in the PV manufacturing value chain differs in downstream and upstream components. While module and cell ecosystems have seen development, the polysilicon and wafer ecosystems have been slow to pick up.

Figure 82: Technology readiness

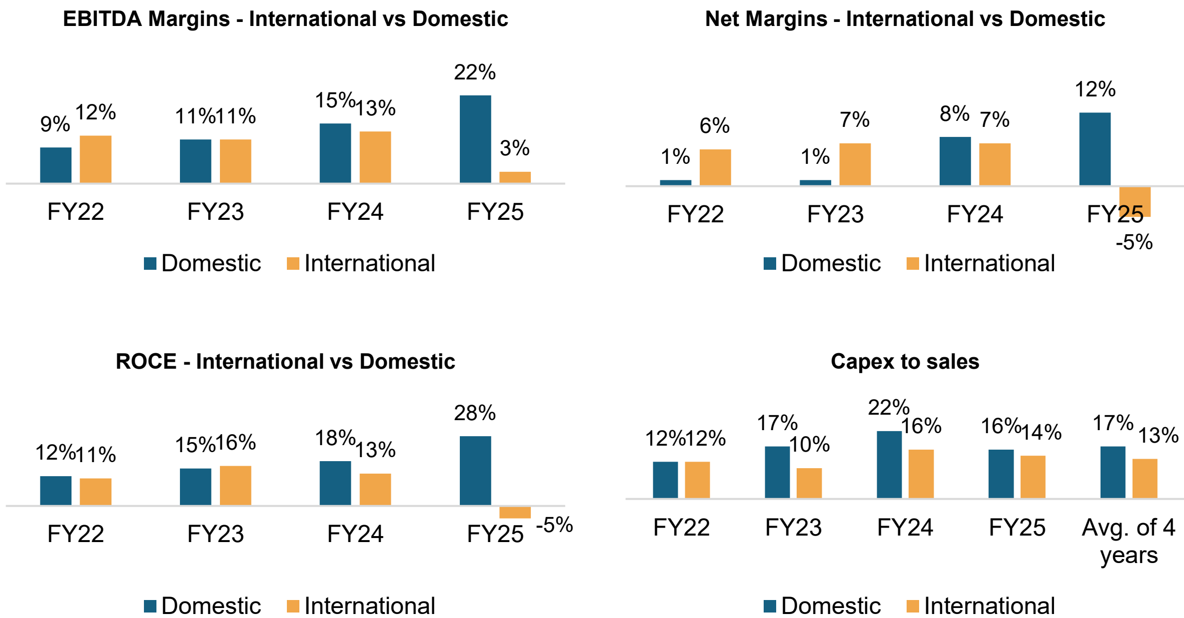
Module and cell - Technology Readiness		
Local Availability of Tech	**Foreign partnerships**	**Tech Know-How**
With 30 manufacturers operating over the last decade, Indian players have developed technology prowess in solar module assembling, while cell have picked up as well over the same period	Indian players have tied up/acquired R&D wing of global entities to enhance their offerings	India possesses the know how to assemble and manufacture module and cell respectively

Polysilicon and wafers - Technology Readiness		
Local Availability of Tech	**Foreign partnerships**	**Tech Know-How**
Lacks the local availability of tech in polysilicon while capacity of wafer was limited to 2 GW by March 2024	Lacks foreign partnership for polysilicon and wafers	Limited to the extent of R&D incentives provided under the SERIIUS and Indo-German partnerships for research on next gen photovoltaic manufacturing

Source: Crisil Intelligence

Financial Viability

Figure 83:Financial viability of domestic and international players



Note: Financials of international players FY25 denotes CY2024. Companies considered for domestic sample are Adani Solar Mundra, Waaree Energies, Tata Power Solar Systems, Vikram solar, Renewsys and Premier Energies. They accounted for over 28% and 59% of the module and cell installed base respectively as of September 2025. International players considered include GCL Polytech, Jinko Solar, Canadian Solar and Longi Solar that account for over 23% of the global capacity as of December 2023)

The above ratios are calculated as follows:

1. *EBITDA = Total income – (Total expenses – interest and finance cost – depreciation and amortization)*
2. *EBITDA margin = EBITDA / Total income*
3. *PAT margin = Profit after tax as reported by the companies / Total income*
4. *ROCE = (EBITDA – depreciation and amortization) / (Total assets – total current liabilities)*
5. *Capex to sales = Investment in fixed assets and/or capital expenditure / total income*

Source: Crisil Intelligence, Company Reports

The financial comparison between domestic and international players highlights a clear divergence in performance over FY22–FY25. International players have experienced a material decline in profitability, as reflected in sharply falling EBITDA and net margins in FY25. This downturn is largely attributable to oversupply in global solar markets, which triggered intense pricing pressure, eroded realisations, and compressed operating spreads. The impact of this margin contraction is further evident in the significant drop in Return on Capital Employed.

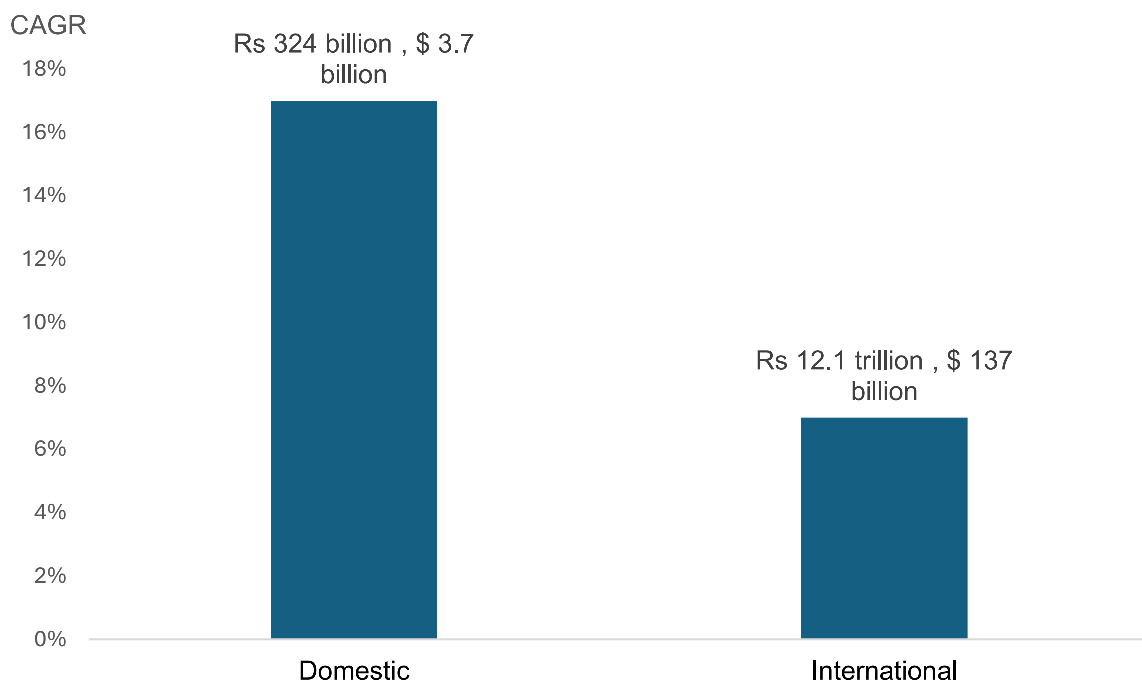
In contrast, domestic players demonstrated relatively steady and resilient financial performance across all profitability metrics. Policy-driven non-tariff measures particularly India's Approved List of Module Manufacturers (ALMM) created a protective market environment that limited foreign competition and prevented aggressive price competition. Additionally, rising solar additions boost the revenue. As a result, domestic firms were able to garner improved earnings, and returns on capital.

The CAPEX-to-sales ratio further reinforces this structural difference. Domestic manufacturers show consistently higher capital expenditure intensity, reflecting expansion-led investments to cater to a rapidly growing Indian solar market. Meanwhile, international players operating in more mature global markets allocated relatively lower incremental capital, signaling slower industry growth and reduced expansion appetite.

Sector Outlook

The domestic PV market size (Rs 324 bn / $3.7 billion[90]) is estimated to grow at a CAGR of 17-20% between FY23 and FY30, supported by government policies to achieve the Panchamrit goal. Along with the utility scale ground mounted additions, the government interventions to further other solar segments such as rooftop solar under PM SuryaGhar Yojana scheme is also expected to boost demand. Additionally, positive intervention by states on adoption of Green Energy Open Access rules 2022 will also drive demand for solar photovoltaic manufacturing. Lastly, expansion of green hydrogen will also result in demand for solar modules over 2030. In contrast the international market (Rs 12.1 tn / $137 billion) is expected to grow at a moderate 6-8% CAGR driven by China's domestic demand and decarbonization targets of the US, EU and Asia pacific by 2030.

Figure 84: Photovoltaic industry growth (CY23-CY30 CAGR)



Note: Market size in USD has been arrived using an exchange of 88.3 (average of fiscal 2026).

Source: Crisil Intelligence, Company Reports Note: The number represents the market size as of CY2023. Solar module prices considered are as of CY2023.

[90] Market size in USD arrived using average exchange rate of 88.3 INR to USD in fiscal 2026.

Case Studies and Global best practices

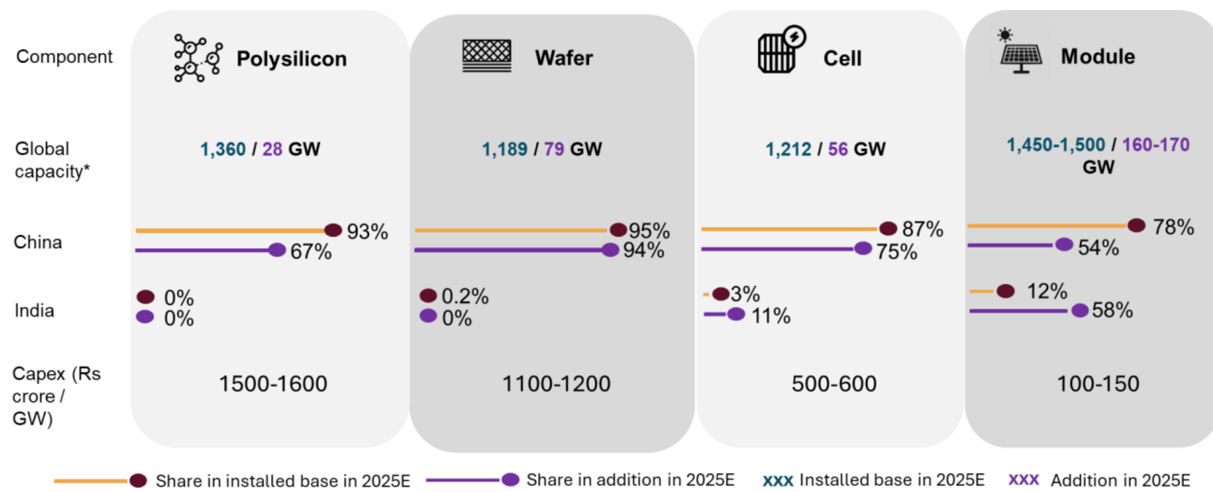
The global solar PV manufacturing landscape is highly concentrated, with China retaining the majority share across all upstream segments of the value chain. By the end of 2025E, global polysilicon manufacturing capacity expanded to 1,360 GW, adding 28 GW year over year. The chart also shows that China controlled 67–93% of both installed and new polysilicon production, underscoring a highly skewed production geography.

A similar pattern emerged in wafer production. Global manufacturing capacity increased to 1,189 GW in 2025E, up 79 GW from 2023. China accounted for 95% of the installed base and 94% of new additions. This scale advantage has enabled China to maintain cost leadership, technological integration, and uninterrupted supply-chain control. Meanwhile, India held less than 1% of wafer capacity, highlighting the early stage of its ecosystem development.

Global solar cell capacity reached 1,212 GW, with China accounting for 87% of the global total. However, unlike polysilicon and wafers, the cell segment shows early signs of geographic diversification, particularly in India. This is driven by industrial policy support, import substitution, and rising domestic solar deployment.

In the module segment, global capacity reached 1,450–1,500 GW. China continued to lead with 78% of global share, while India accounted for 12%, making it comparatively stronger at the end of the supply chain.

Figure 85:PV manufacturing concentration across countries



*Note: *Global capacity is of CY 2025, India capacity is of March 2026.*

Source: IEA renewable energy outlook, Crisil Intelligence

China

The decades of Chinese march

The rising global demand for solar energy, coupled with the domestic push for solar manufacturing, has elevated China to a leading position. Since 2004, China's production march on all fronts of the solar ecosystem began – polysilicon, wafers, cells and modules. By 2008, the growth of solar industry became formidable as the Chinese firms started reaping economies of scale in production of purified silicon. By then, China had become the largest PV manufacturer in the world, with 98%[91] of its product shipped overseas. In 2009, the government identified solar manufacturing as a strategic industry and attempted to accelerate its growth principally through combination of low-cost debt and subsidies. While this was the beginning, over the years the government policy support has enabled a meteoric growth of over 18,000x between 2004 to 2025E.

Years of free trade agreements with European and Asian blocs has helped the country to develop strategic ties for exports. This couple with tax incentives enabled the players to invest in research and development, increasing the efficiency of the existing module technologies and mass development of new technologies. The below are measures driven the solar photovoltaic market in China.

Regulatory environment and government policies in China

Trade agreements – China currently has 23[14] FTAs with 30[14] countries and regional blocks (including ASEAN), which include provisions for various sectors, including solar products. Notable agreements that explicitly cover solar modules are

Table 30: China's push to PV manufacturing industry

China-Iceland 201392 & China-Switzerland 2014	Signed amid escalating tensions over EU's investigation into dumping of Chinese solar panels proved crucial to improve economic diplomacy with European countries over the years. The FTAs enabled tariff reduction on 99.7%25 of the Chinese exports. While the share of Switzerland and Iceland was low in China's photovoltaic export basket, the partnership of these two European nations in EFTA agreement, opened doors for China. The share of China in Europe's PV imports photovoltaic was 37%93 in 2024.
Regional comprehensive economic partnership (RCEP) 202094	Includes 14 other Asia Pacific nations other than China. While tariff cuts varied among countries, the FTA meant that 85% of Chinese products, including solar products, becoming eligible for zero tariffs. Furthermore, a substantial 98.3% of these products would be exempt from Australian tariffs over time, effectively eliminating trade barrier. China accounted for 80%26 of the solar cells and module imports for RCEP members in 2024.

[91] CSTEP
[92] Aqsiq
[93] ITC Trademap
[94] RCEP

China-Serbia 2023[95]	Albeit a small market, Serbia exempts tariffs on approximately 90% of the products traded between the nations, while over 60% of them enjoy zero tariffs. Inclusion of PV modules in the zero-tariff category opened China's door to first central and eastern European country.

Tax Exemptions and Reductions:

2003[96]	A tax rebate system introduced in 1985 which refunds some of its indirect taxes paid by the local manufacturers on production and distribution of exports. PV products were included in list from 2003. However, lately in 2024, the export rebate was reduced from 13% to 9%.
2011[97]	Full exemption of corporate income tax (CIT) for first two years, profitable years and a 50% reduction for the subsequent three years for qualified solar enterprises to encourage investment and innovation
2013[98]	Offered tax rebates to solar manufacturers, aiming to enhance competitiveness and reduce production costs
2013[99]	Continued support through VAT refunds and preferential CIT policies for advanced technology enterprises in the solar sector

R&D incentives:

2008[100]	Establishment of National High-Tech R&D Program (863 Program), which provided significant funding for R&D projects in high-tech sectors, including solar
2023[101]	Super deduction, which allows companies to deduct up to 100 percent of their R&D costs.

Industrial incentives:

2011-20	Objectives 1. Expand and modernize PV industry with large scale production capacity 2. Strengthen domestic production and supply chain of components 3. Promote technical innovations to improve conversion efficiency and product quality

[95] The State Council - The People's Republic of China
[96] Taiyangnews
[97] China Briefing
[98] BBC
[99] AECEA
[100] China Briefing
[101] China Briefing

	4. Increase share of non-fossil energy in total energy consumption to 25% Outcomes 1. China on track to achieve its target of non-fossil. It has increased its target to 30% in 2025[102]
2014[103]	Launched Solar Energy for Poverty Alleviation Program to systematically deploy 10 GW solar photovoltaic projects to benefit more than 2 million citizens. This helped improve demand for manufacturers
2015[104]	Preferential policy under “Made in China 2025” initiative, focusing on technological upgrading and quality improvement of solar manufacturing

Skilling incentives:

Vocational training programs	Specifically tailored to the need of the solar PV industry, aimed at providing technical skills and required manufacturing, installation, and maintenance of solar PV systems. China National Solar Energy vocational education alliance (CNSVEA)[105] partnered collaborates with industry partners and vocational schools to develop curriculum and training program specifically for solar PV.
University and research collaboration	Collaboration between universities, research institutions and industry players to develop specialized courses, research projects and academic programs focusing on solar PV technology and applications. The Tsinghua university and the Chinese academy of sciences[106] have established research centres dedicated to Solar PV. They collaborate closely with industry leaders and government to conduct research on advanced PV materials, efficiency enhancement techniques and integration of solar PV systems with grid infrastructure.
Government sponsored training programs	These include initiatives aimed at enhancing the skills of workers and technicians involved in various aspects of solar photovoltaic technology. The China National Solar Energy Training and Education Center[107], established by the chinese renewable energy industries association and supported by government agencies conducts training sessions and workshops across various provinces, focusing on equipping participants with the latest knowledge and skills required for working in the solar PV industry

[102] Down to earth
[103] Institute of Development studies
[104] European Chamber
[105] China Briefing
[106] CSTA
[107] Ministry of Science and Technology – The People’s Republic of China

The above incentives have enabled growth stories in PV industry. One of which is highlighted in the form of a case study below:

Case Study on incentives provided to Jinko solar by the Chinese Government

Jinko Solar Holding Co, Ltd, a Chinese PV manufacturer, has benefited from various tax incentives provided by the Chinese government over the years. The company has received tax exemptions and reduced rates, including a two-year exemption from corporate income tax (CIT) and a reduced CIT rate of 12.5% for the subsequent three years, starting from 2009.

Several of Jinko Solar's subsidiaries benefit from the preferential tax rate of 15% across years under the “High and New Technology Enterprises” incentive. Subsidiaries including Jiangxi Jinko, Zhejiang Jinko, Haining Jinko, Yiwu Jinko, Shangrao Jinko, Zhejiang New Materials, and Anhui Jinko, were designated as "High and New Technology Enterprises" by local authorities, making them eligible to a preferential tax rate of 15% from 2021 to 2023. Additionally, subsidiaries such as Jiangxi Jinko, Haining Jinko, Shangrao Jinko, and Zhejiang New Materials were designated as "High and New Technology Enterprises" in November and December 2022 and benefited from the preferential tax rate of 15% from 2022 to 2024. Anhui Jinko was also designated as a "High and New Technology Enterprise" in November 2023 and will benefit from the preferential tax rate of 15% from 2023 to 2025.

Other subsidiaries, including Jinko Jinchang, Sichuan Jinko, Leshan Jinko, Qinghai Jinko, and Chuxiong Jinko, were designated as "Enterprises in the Encouraged Industry" and are eligible for a preferential tax rate of 15% until December 31, 2030, as per the "Announcement on Continuation of CIT Policies for Large-scale Development in the Western Region" published on April 23, 2020.

These tax incentives have enabled Jinko Solar to invest heavily in research and development (R&D). The company has collaborated with renowned institutes and agencies to improve its R&D capabilities. For instance, in December 2013, it partnered with Beijing University's Solar Power Engineering Center to construct an experimental PV power plant on campus, which was used to collect and analyze data on the power generation capabilities of PV modules under various conditions.

In subsequent years, Jinko Solar established a long-term cooperative relationship with several institutions, including the State Key Laboratory of Silicon Materials of Zhejiang University, the Australian National University, Sun Yat-Sen University, and the National University of Singapore. These collaborations focus on cutting-edge cell technologies, solar modules, and solar cells. In 2017, the company partnered with TÜV Rheinland to develop standardized testing methods for bifacial PV technology. In 2018, it participated in three projects with the Institute of Electrical Engineering of the Chinese Academy of Sciences, Zhejiang University, and Nanchang University, focusing on module recycling, high-efficiency P-type poly, and N-type bifacial cells.

In 2019, Jinko Solar signed a memorandum of understanding with the Shanghai Institute of Space Power Sources to co-develop high-efficiency solar cell technology for space and terrestrial applications. The company led two national key R&D programs in China, relating to the decline of the N-type multicrystalline cell industry and the recycling of end-of-life solar products.

As a result of its R&D collaborations, Jinko Solar Holding Co., LTD increased its budget allocations over the years, with RMB 461.6 million ($72.4 million), RMB 724.8 million ($105.1 million), RMB 911.9 million ($128.4 million), RMB 920.5 million ($126.1 million) and RMB 896.9 million ($128.3 million) allocated in 2021, 2022, 2023, 2024 and 2025 respectively. This has enabled the company to gain a competitive edge in the market.

Source: Jinko Solar Holding Co., LTD annual report 2025

Vietnam

Emerging nation

Vietnam has emerged as a HubSpot for expansion of PV manufacturing. It accounted for 3% of the module global capacity in 2024. It was responsible for 10%[108] of the global PV exports. The factors driving the share are skilling programs which have enabled the country to gain edge over its south Asian neighbours. Further, the country's land border with the PRC is perceived as a significant benefit as delivery time for input materials is reduced from weeks to days.

Free trade agreements:

Table 31: Vietnam's push to PV manufacturing industry

European Union-Vietnam[109]	Eliminates tariffs on a wide range of goods, including solar panels and components. The agreement also encourages European companies to invest in Vietnam, bringing advanced solar technologies and expertise.
ASEAN-Vietnam[44]	Benefits from reduced tariffs and simplified trade procedures within the region. Players have benefitted from duty free access to raw materials like polysilicon from Malaysia and Thailand, reducing production cost and ensuring a steady supply.
Vietnam-Korea[44]	Provides tariff reductions on solar PV products and related components. The FTA has allowed Vina solar to import cutting-edge solar manufacturing equipment from South Korea at reduced cost, enhancing their production capabilities and product qualities.
Regional Comprehensive Economic Partnership[44]	Includes 14 other Asia Pacific nations other than China. While tariff cuts varied among countries, the harmonized standards facilitate smoother trade and regulatory compliance making exports easy
Vietnam-Japan Economic Partnership Agreement[44]	Provides access to Japanese market for Vietnamese solar PV products. Has helped foster joint ventures and collaborative projects in RE, encouraging technology sharing and innovation. Japanese firms like Sharp have engaged in JVs with Vietnamese companies, sharing the PV technology and contributing to local capacity building.

[108] ITC Trademap
[109] Vietnam Briefing

Tax incentives:

Corporate Income Tax[110]	Corporate income tax (CIT) incentives for solar PV projects, including a reduced tax rate of 10% for 15 years (extendable to 30 years) and full exemption for the first 4 years followed by a 50% reduction for the next 9 years. These tax incentives have helped attract significant investment in the solar PV sector. As of 2023, Vietnam had an installed solar PV capacity of around 17,077 MW, up from just 134 MW in 2018
Import Duty Exemptions[45]	Solar PV projects are exempt from import duty for 5 years on raw materials and components that cannot be produced domestically. This imports duty exemption has made it more affordable for solar PV manufacturers to import necessary inputs, reducing production costs and improving competitiveness. As a result, Vietnam is home to many major solar panel producers, including First Solar, HT Solar, Irex Solar, Trina Solar, Vina Solar, and Ja Solar

End user drivers:

Streamlined Approval Process	Streamlined the approval process for solar PV projects, reducing the time and bureaucracy involved. In 2020, the Vietnamese government approved a 450 MW solar PV project developed by Trung Nam Group in Ninh Thuan province in just 102 days111
Power Purchase Agreement (PPA) Incentives	Offers attractive PPA incentives for solar PV projects, including a fixed tariff of $0.0935/kWh112 for projects connected to the grid before June 30, 2019, and a competitive bidding process for projects after that date. These PPA incentives have helped drive the rapid growth of the solar PV sector in Vietnam. As of 2023, the country had over 17 GW of installed solar PV capacity, making it a regional leader in solar energy

Skilling incentives:

Government funded training centers	Specialised training centers that offer courses in Solar PV installations, maintenance, and manufacturing techniques. The Vietnam-Germany Renewable Energy Training Center113 provides comprehensive training programs tailored to the needs of the solar industry

[110] VILAF
[111] PV magazine
[112] ADB
[113] VietnamNewsMagazine

Subsidised courses	Companies sending employees to these training programs can benefit from subsidies covering up of the training costs, making it affordable for firms to upskill their workforce.
Industry Academia Collaboration	Encourages collaboration between solar PV and academia for curating specialized curricula that include hands-on training in solar PV technology. Boviet Solar114 has partnered with local universities and technical schools. They offer internships and apprenticeships to students, providing real-world experience.
International collaboration	Partnerships with international organisations and agencies to provide training and knowledge transfer. The German development agency GIZ115 has partnered with the Vietnamese Ministry of Industry and Trade to provide technical training programs for solar PV technicians.

Additionally, Vietnam is uniquely positioned to extract benefits in PV manufacturing from trade agreements like EVFTA and CPTPP. First, EVFTA commits to the elimination of over 99%[116] of tariffs between Vietnam and the EU over a ten-year schedule, offering Vietnamese solar equipment (modules, hardware, components) much lower trade barriers into one of the world's premium markets.

These agreements also imbibe strong legal, regulatory, and institutional commitments that reduce risk for long-term capital investment in green manufacturing. For example, EVFTA's binding provisions on standards and trade facilitation help ensure smoother conformity, transparent and efficient paths for solar products. Despite this, the US accounted for 85% of the Vietnam solar cell and module exports in 2024. However, after the US initiated an antidumping and countervailing investigation on Vietnam in 2024, the export from the country were impact. The share of US in Vietnam's exports basket fall to 70% in H1 2025. The tariffs of 68% to 543%[117] on Vietnam's manufacturers were ratified and imposed in June 2025. This is expected to impact the exports from Vietnam to the US.

[114] Boviet Solar
[115] GIZ
[116] Trade.ec.europa
[117] FederalRegister US

India

The march for next decade

India's PV chapter picked up pace in the 2010-20 decade with incorporation of Solar Energy Corporation of India. The capacity in March 2014 touched 2,821 MW[118] and has grown to 1,05,646 GW[119] as of March 2025. However, this growth in capacity was largely fueled by imported modules as solar manufacturing remained muted till 2014 with an operational 1,300 MW of module and 300 MW of cell capacity. This was on account of availability of cheaper modules from China. Further, absence of upstream capacity also exposed India to exchange rate fluctuations and diplomatic risks. Over the years, the module, cell and wafer capacity has grown to 1,00,000 MW[4], 25,000 MW[5] and 2000 MW[5] respectively resulting in a rise in export opportunities. A slew of measures has enabled this growth over the period.

Regulatory environment and government policies in India

The journey of Indian solar PV manufacturing has witnessed several government interventions to protect the domestic base and enhance the demand. While some of the measures' relevancy remained challenged, the journey and lessons through the years have resulted in implementation of relevant measures in the recent period. Thus, despite the sector's activeness since 2010, it is now truly at the cusp of multifold expansion becoming one of the sunrise sectors in India.

Imposition of safeguard duties[120]

India's solar energy sector has experienced rapid growth during fiscal 2018, with annual deployment increasing from 3 GW in 2015-2016 to 9.4 GW in 2017-2018. Despite this growth, the country's solar photovoltaic (PV) manufacturing industry has struggled to compete with imported modules, which accounted for over 90% of the market share between 2015 and 2018. To address this issue, the Indian government-imposed safeguard duties on imported cells and modules to protect the domestic industry from foreign competition.

The imposition of safeguard duties aims to provide Indian PV manufacturers with protection against cheap imports and facilitate structural improvements to enhance their competitiveness. However, the effectiveness of these duties depends on their interaction with other policies and market developments. The duties are intended to address the underlying reasons for the competitive disadvantage of the local PV industry, but their impact on industry's competitiveness remains to be seen.

The impact of safeguard duties on the Indian solar energy ecosystem, including the challenges faced by the PV manufacturing industry and the effectiveness of the duties in protecting the industry. The analysis also considers the potential negative effects of the duties on project deployment, including regulatory uncertainty and higher module costs, which could lead to higher tariffs and resistance from distribution companies (discoms). The study provides a comprehensive picture of the impact of safeguard duties on the Indian solar energy sector, including the legal framework, international trade protection measures, and the challenges facing the PV manufacturing industry.

It would be interesting to understand the circumstances under which Safeguard Duties are permitted in order to protect the domestic industries.

[118] Yearly achievements MNRE
[119] Installed Capacity MNRE (Mar 25)
[120] Ceew

The World Trade Organization (WTO) allows for several trade protection measures to be implemented under certain circumstances. This section provides an in-depth examination of the legal framework governing safeguard duties, a specific trade protection measure that has been utilized in India.

Table 32:Motivations for applying various trade protection measures

	Anti-dumping duty	Countervailing duty	Safeguard duty
What strategies does it utilize to protect the domestic industry?	Seeks to eliminate the effects of dumping, which refers to the sale of an imported product at a price lower than that in its domestic market.	Seeks to eliminate the effects of subsidies provided in the domestic market for the imported product.	Seeks to safeguard the local industry from an influx of imports of a rival product.

Source: World Trade Organization

The WTO regime on safeguard duties

Under the World Trade Organization (WTO) regime, safeguard duties are governed by the WTO Agreement on Safeguards and Article XIX of the General Agreement on Tariffs and Trade (GATT) 1994. These emergency measures allow member countries to protect their domestic industries from a sudden surge in imports of similar or competing products. The increase in imports that justifies the application of safeguard measures can be either absolute or relative, such as in a shrinking market where imports gain a larger market share without an actual increase in quantity.

To impose safeguard measures, an investigation must be conducted by the relevant authorities. The process for initiating an investigation varies by country; in India, for example, an investigation can be started by a petition from a domestic producer or by the authorities themselves. Safeguard measures can only be imposed if the investigation finds that increased imports have caused or threaten to cause significant harm to the domestic industry, as evidenced by changes in market share, profitability, sales, and production.

Moreover, safeguard measures can only be employed if the increase in imports is due to unforeseen developments that could not have been anticipated when the import tariffs were set. The party initiating the investigation must also submit a plan outlining the steps the domestic industry will take to become more competitive. Safeguard measures can take the form of quantitative import restrictions, higher tariffs, or a combination of both, but are supposed to be applied non-discriminatorily to all countries. However, imports from developing countries that account for less than 3% of the product are exempt, as long as these countries collectively do not account for more than 9% of imports.

If safeguard measures are imposed for more than a year, they must be gradually reduced at regular intervals. The maximum duration of safeguard measures is four years, or six years for developing countries. However, this period can be extended if a new investigation finds that the measures are still necessary to prevent or remedy harm, and if the domestic industry can demonstrate evidence of structural adjustments. The total period of application, including extensions, cannot exceed eight years for developed countries or ten years for developing countries.

The Indian regime on safeguard duties

Following the withdrawal of an anti-dumping petition against solar imports from China, Taiwan, and Malaysia in 2017, Indian solar manufacturers turned to safeguard duties as their primary trade remedy. In December 2017, they petitioned the DGTR, which recommended a provisional 70% safeguard duty in January 2018. However, legal challenges and uncertainty around the duty's implementation and cost pass-through delayed its notification, leading to weak developer participation in solar tenders during early 2018.

To address these concerns, the MNRE clarified in April 2018 that safeguard duties could be treated as a "change in law" under solar PPAs, enabling cost recovery where contract provisions allowed. This reduced uncertainty and improved market activity. On July 16, 2018, the DGTR issued its final recommendation for a two-year safeguard duty on imported solar cells and modules. Unlike the preliminary findings, the final ruling excluded SEZ-based manufacturers from the definition of domestic industry.

Although the safeguard duty faced further legal challenges in the Odisha High Court, the Ministry of Finance notified the duty on July 30, 2018. After the government appealed, the Supreme Court lifted the stay on its implementation, allowing the collection of safeguard duties and completing the process of introducing import protection for India's domestic solar manufacturing industry.

Table 33:Directorate general of trade remedies' recommendations on safeguard duties

Period	Safeguard Duty
30th July 2018 – 29th July, 2019	25%
30th July 2019 – 29th January, 2020	20%
30th January 2020 – 29th July, 2020	15%
30th July 2020 to 29th January 2021	14.9%
30th January 2021 to 29th July 2021.	14.5%

Source: CEEW

Therefore, Safeguard duty imposed on solar cells and modules to protect the domestic manufacturing industry. While applicable on all countries, the measure impacted majorly imports from China, Malaysia and Taiwan. A safeguard duty of 25% was imposed with progressive reduction to 20% by Jan and 15% by July 2020. While the imposition favourably enhanced the manufacturers' cost competitiveness, the move largely failed to address the challenge of lack of low-cost debt and R&D that plagued the industry. It also resulted in a surge in imports from Vietnam and Thailand who were exempt from the application of duty due to virtue of being developing countries that accounted less than 3% of imports of the product to India.

Further, extended the safeguard duty to 15% by July 2021 on imports from specific countries namely, China, Vietnam, Thailand and other developed countries. The move helped bring parity in the cost, however, it increased the cost of projects.

Basic custom duty

Notification on Change-in-Law: Imposition of Basic Customs Duty and GST Rate Hike on Solar PV Cells and Modules

The imposition of Basic Customs Duty (BCD) on imported solar cells and modules, along with the increase in the Goods and Services Tax (GST) rate on renewable energy equipment, represented a key policy measure to support domestic solar manufacturing and reduce dependence on imports. Effective 1 April 2022, the Government of India imposed a 25% BCD on solar PV cells and a 40% BCD on solar PV modules, while the GST rate applicable to specified renewable energy devices and components was increased from 5% to 12% with effect from 1 October 2021. These measures increased project costs for renewable energy developers, leading to industry requests for their recognition as a Change-in-Law event under existing power procurement frameworks.

Table 34:Application of basic customs duty due to change in law

Particular	Basic Custom Duty
Solar PV cells	25%
Solar PV modules	40%

Source: CEEW

Subsequently, the Ministry of New and Renewable Energy (MNRE) directed Renewable Energy Implementing Agencies (REIAs) to treat the imposition of BCD as a Change-in-Law event for solar PV and solar-wind hybrid projects where the bid submission deadline was on or before 9 March 2021 and the Scheduled Commissioning Date (SCD) was on or after 1 April 2022. Similarly, the increase in the GST rate was recognized as a Change-in-Law event for renewable energy projects with bid submission dates on or before 30 September 2021 and SCDs on or after 1 October 2021, unless explicitly excluded under the relevant tender or contractual provisions. These provisions enabled affected developers to seek compensation for the additional costs arising from the policy changes.

The introduction of BCD significantly reduced the pricing advantage of imported solar equipment and contributed to improving the competitiveness of domestic manufacturers. The differential between domestic and imported module prices declined considerably, supporting the growth of indigenous manufacturing capacity. In conjunction with other policy measures, including the Approved List of Models and Manufacturers (ALMM) and the Production Linked Incentive (PLI) Scheme, the BCD framework strengthened the domestic solar manufacturing ecosystem by improving the balance between domestic demand and supply. The customs duty structure was subsequently rationalized under the Union Budget 2025-26, with duties on solar modules restructured to 20% BCD and 20% Agriculture Infrastructure and Development Cess (AIDC), and duties on solar cells revised to 20% BCD and 7.5% AIDC.

Budget 2025-2026: Changes in Tariff Rates for Solar Cells and Modules

The Budget 2025-2026, presented by Finance Minister Nirmala Sitharaman on February 1, 2025, brought significant changes to the tariff rates for solar cells and modules. These changes aim to promote the growth of the solar industry in India, while also generating revenue for the government. The new tariff rates came into effect on February 2, 2025, and are expected to have a significant impact on industry.

Figure 86: Custom duties for solar cells and modules

	Duties	$cents/wp
Cell price		3.7
BCD	25%	0.9
SWS	2.5%	0.02
Landed price		**4.6**

	Duties	$/wp	New over old duty structure
Cell price		3.7	
BCD	20%	0.7	
AIDC	7.5%	0.3	
Landed price		**4.7**	**1%**

	Duties	$cents/wp
Module price		8.7
BCD	40%	3.5
SWS	4%	0.1
Landed price		**12.3**

	Duties	$/wp	New over old duty structure
Module price		8.7	
BCD	20%	1.7	
AIDC	20%	1.7	
Landed price		**12.1**	**-1%**

Source: Crisil Intelligence

Cells: The tariff rate for solar cells, covered under tariff heading 8541, has decreased from 25% to 20%. However, this decrease is accompanied by an increase in the Agriculture Infrastructure and Development Cess from 2.5% (Social Welfare Surcharge) to 7.5%. As a result, the effective tariff rate for solar cells remains unchanged. This shift in the cess structure is notable, as it indicates a change in the way the government is choosing to tax solar cells. The reduction in the basic tariff rate may make solar cells more competitive in the market, but the increase in the cess may offset some of these gains. The impact of this change on the solar industry will depend on various factors, including the response of manufacturers and the demand for solar cells.

Modules: Similar to the change in the tariff rate for solar cells, this decrease is accompanied by an increase in the Agriculture Infrastructure and Development Cess from 4% (Social Welfare Surcharge) to 20%. As a result, the effective tariff rate for solar modules remains unchanged. This change in the tariff rate and cess structure may have a significant impact on the solar module industry, as it could affect the competitiveness of Indian manufacturers in the global market. The reduction in the basic tariff rate may make solar modules more attractive to buyers, but the increase in the cess may increase the cost of production for manufacturers. The industry will need to adapt to these changes and find ways to remain competitive in the market.

GST Reduction on Renewable Energy Components

The 56th GST Council's decision to reduce GST on renewable energy devices and their manufacturing parts from 12% to 5% represents a strategic fiscal intervention aimed at strengthening India's clean energy industrial ecosystem. By lowering the tax burden on components such as photovoltaic cells, modules, solar generators, and solar based devices, the reform directly improves manufacturing cost structures, project affordability, and long-term sectoral competitiveness.

Anti-dumping investigation in India

Case 1

Anti-dumping duty on imports of "Ethylene Vinyl Acetate (EVA) Sheet for Solar Module" from China PR.[121]

The Designated Authority has initiated a sunset review investigation into the anti-dumping duty imposed on imports of Ethylene Vinyl Acetate (EVA) Sheet for Solar Module from China PR. This investigation was prompted by an application from M/s RenewSys India Pvt. Ltd., which alleged that the expiry of the anti-dumping duty would likely lead to the continuation or recurrence of dumping and injury to the domestic industry.

The anti-dumping duty was initially imposed on imports of EVA Sheet for Solar Module from China, Malaysia, Thailand, and Saudi Arabia in 2019, following an investigation that found dumping and injury to the domestic industry. The duty was imposed for a period of five years, and the current investigation aims to determine whether the expiry of the duty would lead to a resurgence of dumping and injury. The domestic industry has requested that the duty be continued, but only with respect to imports from China PR, as imports from the other countries subject to the duty have significantly declined.

EVA

Ethylene Vinyl Acetate (EVA) Sheet for Solar Module" is a crucial polymer-based component utilized in the production of solar photovoltaic (PV) modules. Its primary function is to encapsulate solar PV cells, providing adhesion and cushioning properties. As a vital element, the EVA sheet plays a key role in

[121] DGTR (Dec 2023)

integrating and supporting the module's components, including the glass, cells, and backsheet, ensuring their mechanical stability and durability throughout the module's lifespan.

The Authority has concluded its investigation into the continuation of anti-dumping duties on imports of Ethylene Vinyl Acetate (EVA) sheets from China, Malaysia, Thailand, and Saudi Arabia. The investigation was initiated to determine whether the cessation of existing duties would lead to a continuation or recurrence of dumping and injury to the domestic industry.

The Authority has recommended the continuation of anti-dumping duties on imports of EVA sheets from China, citing evidence of dumping and injury to the domestic industry. The investigation found that the domestic industry has improved significantly since the imposition of duties, but that the cessation of duties would likely lead to a surge in dumped imports from China. The Authority also noted that there are significant unutilized capacities available with Chinese exporters, and that the revocation of duties would lead to further aggravated dumping and injury to the domestic industry. The duties will be continued for an additional period of five years to provide a level playing field to domestic producers. The Authority has recommended the following duties:

- China PR: The existing quantum of anti-dumping duty will be continued.
- Non-cooperating producers/exporters: The duty will be imposed at the same rate as the "any others" rate in the original investigation.

The Authority's decision is based on its findings that the domestic industry constitutes a domestic industry under the Rules, and that the application filed by the domestic producer satisfies the criteria of standing. The investigation also found that the product under consideration continues to be exported to India at prices below the normal value, resulting in dumping of the subject goods. The Authority has concluded that the continuation of duties is necessary to prevent further injury to the domestic industry.

The Indian government has imposed an antidumping duty on EVA sheets for solar modules imported from China to protect the domestic industry from cheap imports. The duty is applicable on EVA sheets with specific tariff items, including 3920 1011, 3920 1019, and 3920 1099, among others. The duty amount varies depending on the producer, with a specific duty of $590 per metric ton for Changzhou Sveck Photovoltaic New Material Co., Ltd. and a general duty of $897 per metric ton for all other producers. The duty is intended to prevent dumping of EVA sheets from China and to promote the domestic production of these sheets.

The imposition of the antidumping duty is expected to have a significant impact on the Indian solar industry, as EVA sheets are a critical component of solar modules. The duty may lead to an increase in the cost of solar modules, which could affect the competitiveness of Indian solar manufacturers in the global market. However, it may also promote the domestic production of EVA sheets and other solar module components, which could lead to the growth of the Indian solar industry in the long term.

Case 2

Anti-dumping investigation concerning imports of “anodized aluminium frames for solar panels/modules” originating in or exported from China PR.[122]

The Indian government has initiated an anti-dumping investigation into imports of anodized aluminum frames for solar panels/modules from China. The investigation was initiated after Vishakha Metals Pvt. Ltd., a domestic manufacturer of anodized aluminum frames for solar panels/modules, filed a complaint with the

[122] DGTR (June 24)

Designated Authority, alleging that imports from China were being dumped in India, causing injury to the domestic industry.

The investigation will examine whether the imports from China are being sold in India at a price lower than their normal value in China, and whether this is causing harm to the domestic industry. The investigation will also consider factors such as the volume of imports, the price of the imports, and the impact of the imports on the domestic industry. The investigation is being conducted under the Customs Tariff Act, 1975, and the Customs Tariff (Identification, Assessment and Collection of Anti-dumping Duty on Dumped Articles and for Determination of Injury) Rules, 1995. These rules provide the framework for conducting anti-dumping investigations in India.

The Authority has investigated the dumping of solar cells and modules from China and has found that the product has been exported to India at a price below the normal value, resulting in dumping. The Authority has also found that the dumping has caused material injury to the domestic industry, including retarding the establishment of the industry, underutilization of capacity, and preventing the industry from achieving a reasonable price. The Authority has concluded that the imposition of anti-dumping duty is necessary to offset the dumping and consequent injury, and that it will not be against the public interest.

The Authority recommends imposing an anti-dumping duty on imports of the subject goods from the specified country to prevent harm to the domestic industry. The duty will be set at the lower of the two calculated margins: the margin of dumping or the margin of injury. The recommended duty will be in effect for a period of five years from the date of notification by the Central Government, with the specific duty amounts listed in the appended table.

Table 35:Anti-dumping duty on solar panel frames from China

S. No.	Heading/ subheading*	Description of goods	Country of origin	Country of Export	Producer/ exporter	Amount $USD/MT
1	7610 9010, 7610 9030, 7616 9990	Anodized Aluminium Frames for Solar Panels/Modules	China PR	Any Country including China PR	Jiangyin Tinze New Energy Technology Co., Ltd	433
2			China PR	Any Country including China PR	Jiangyin Yuanshuo Metal Technology Co., Ltd	505
3			China PR	Any Country including China PR	Jiangsu Yuejia Metallic Technology Co., Ltd	403
4			China PR	Any Country including China PR	Jiangyin Haihong New Energy Technology Co., Ltd, and Jiangyin Haihong Solid-FSW Co., Ltd.	418
5			China PR	Any Country including China PR	Zhejiang Jiaxing Taihe New Energy Technology Co., Ltd, And Jiaxing Youjia Metal products Co, Ltd	511
6			China PR	Any Country including China PR	Any other than S. No 1-5 above	577
7			Any Country other than China PR	China PR	Any other than S. No 1-5 above	577

Case 3

Anti-dumping investigation concerning imports of 'Solar Cells whether or not assembled in Modules or made up into Panels' originating in or exported from China PR.[123]

The Indian government has launched an anti-dumping investigation into imports of solar cells and modules from China, following a complaint from several Indian manufacturers, including FS India Solar Ventures Private Ltd., Jupiter International Ltd., Tata Power Solar System Ltd., and TP Solar Ltd. The investigation will examine whether the imports from China are being sold at a price lower than their normal value, causing injury to the domestic industry. The investigation is being conducted in accordance with the Customs Tariff Act, 1975, and the Customs Tariff (Identification, Assessment, and Collection of Anti-Dumping Duty on Dumped Articles and for Determination of Injury) Rules, 1995.

The conclusion of the investigation is that the domestic solar photovoltaic industry has been injured by the dumping of solar cells and modules from other countries. The investigation has found that the subject goods have been exported to India at a price below the normal value, resulting in dumping, and that the volume of subject imports has increased significantly over the injury period. The domestic industry has been forced to sell at losses, and its profitability has deteriorated over the injury period. The investigation has also found that the subject imports are threatening to cause further injury to the domestic industry, and that the imposition of anti-dumping duty is in the larger public interest.

The Authority recommends the imposition of anti-dumping duties on imports of solar cells and modules from certain countries to protect the domestic industry from injury caused by dumping. The duties will be imposed for a period of 3 years and will be calculated as a percentage of the CIF value of the goods. The Authority has followed the lesser duty rule, which means that the duty will be imposed at a level that is sufficient to remove the injury to the domestic industry, but not higher than the margin of dumping.

Table 36:Anti-dumping duty recommended on solar cells and modules

S. No.	Heading/ subheading*	Description of goods	Country of origin	Country of Export	Producer/ exporter	Duty as % of CIF
1	85414200 and 85414300	Solar cells or photovoltaic cells whether or not assembled in modules or made up into panels, produced using c-Si or thin film technology, including solar modules or panels made up of solar cells	China PR	Any country, including China PR	Jinko Group	Nil
2			China PR	Any country, including China PR	Aiko Group	23%
3			China PR	Any country, including China PR	Trina Group	Nil
4			China PR	Any country, including China PR	Non-sampled cooperative producers, as per list below	23%
5			China PR	Any country, including China PR	Any producer other than 1 to 4 above	30%
6			Any country other than China PR	China PR	Any	30%

[123] DGTR (Sep 2025)

Case: 4

Multi-Country Anti-Dumping Probe: Solar Encapsulants from South Korea, Thailand, and Vietnam[124]

The Directorate General of Trade Remedies has initiated an anti-dumping investigation concerning imports of Solar Encapsulants originating in or exported from South Korea, Thailand, and Vietnam. The investigation has been initiated based on an application filed by M/s RenewSys India Pvt. Limited, who have claimed that the subject goods are being dumped into India, causing injury to the domestic industry. The applicant has provided prima facie evidence that the normal value of the subject goods in the subject countries is higher than the export price, resulting in a significant dumping margin.

The Authority has considered the applicant as the domestic industry within the meaning of Rule 2(b) of the Rules and has satisfied the criteria of standing in terms of Rule 5(b) of the Rules. The investigation will cover the period from 1st April 2024 to 31st March 2025, and all interested parties have been advised to intimate their interest and file their questionnaire responses within 30 days from the date of receipt of the notice. The subject countries for the present investigation are South Korea, Thailand, and Vietnam.

The applicant has claimed that the imports have caused material injury to the domestic industry, as the imports are undercutting the prices of the domestic industry, depressing the prices, and preventing price increases. This has adversely impacted on the profitability of the domestic industry, which has deteriorated in the injury period. The capacity utilization of the domestic industry has declined, and it has underutilized capacities. The inventories of the domestic industry have increased, and there is sufficient prima facie evidence to justify the initiation of the anti-dumping investigation.

Case: 5

Initiation of Anti-Dumping Investigation: Solar Encapsulants from China PR[125]

The Directorate General of Trade Remedies has initiated an anti-dumping investigation concerning imports of Solar Encapsulants, excluding EVA Encapsulants, originating in or exported from China PR. The investigation has been initiated based on an application filed by M/s RenewSys India Pvt. Limited, who have claimed that the subject goods are being dumped into India, causing injury to the domestic industry. The applicant has provided prima facie evidence that the normal value of the subject goods in China PR is higher than the export price, resulting in a significant dumping margin.

The Authority has considered the applicant as the domestic industry within the meaning of Rule 2(b) of the Rules and has satisfied the criteria of standing in terms of Rule 5(b) of the Rules. The investigation will cover the period from 1st April 2024 to 31st March 2025, and all interested parties have been advised to intimate their interest and file their questionnaire responses within 30 days from the date of receipt of the notice. The applicant has claimed that the subject goods, which are being dumped into India, are identical to the goods produced by the domestic industry, with no differences in technical specifications, functions, or end-uses.

The Authority has noted that the applicant alone holds a major proportion in the total domestic production in the country and has imported the subject goods from the subject countries nor is it related to any exporter or importer of the subject goods from the subject countries. The investigation aims to determine the existence, degree, and effect of alleged dumping and to recommend the amount of dumping duty, which if levied would be adequate to remove the injury to the Domestic Industry.

The applicant alleges that the imported goods have harmed the domestic industry by undercutting their prices, leading to decreased profitability and preventing price increases. As a result, the domestic industry's capacity utilization has decreased, leaving them with underutilized capacities and increased inventories, providing sufficient evidence to warrant an anti-dumping investigation.

---

[124] DGTR (Sep 2025)
[125] DGTR (Sep 2025)

Production Linked Incentive (PLI) Scheme:

National Programme on High Efficiency Solar PV Modules[126]

The Ministry of New and Renewable Energy, Government of India, has launched the Production Linked Incentive (PLI) Scheme as part of the National Programme on High Efficiency Solar PV Modules. This initiative aims to establish a significant manufacturing capacity of high-efficiency solar photovoltaic (PV) modules in the country, with a total outlay of Rs. 24,000 crore ($2.7 billion[127]). To achieve this goal, solar PV manufacturers are selected through a transparent and competitive process. Once selected, these manufacturers will be eligible for a Production Linked Incentive (PLI) for a period of five years after commissioning, provided they manufacture and sell high-efficiency solar PV modules. This scheme is designed to promote the domestic production of high-quality solar modules, reduce dependence on imports, and contribute to the growth of the renewable energy sector in India.

The primary objective of the scheme is to establish a robust ecosystem for the manufacture of high-efficiency solar photovoltaic (PV) modules in India, thereby reducing the country's dependence on imports in the renewable energy sector. The key goals of the initiative include developing a substantial solar PV manufacturing capacity for high-efficiency modules, introducing cutting-edge technology to India to produce these modules, and promoting the establishment of integrated plants to ensure better quality control and competitiveness. Additionally, the scheme aims to foster an ecosystem that supports the local sourcing of materials for solar manufacturing, generate employment opportunities, and ultimately achieve technological self-sufficiency in the solar energy domain.

Production Linked Incentive Scheme (Tranche I)[128]

The Cabinet had approved the introduction of the Production Linked Incentive (PLI) Scheme for 10 key sectors on November 11, 2020, to enhance India's manufacturing capabilities and exports under the Atmanirbhar Bharat initiative. One of the 10 sectors for which the introduction of the PLI had been approved was 'High Efficiency Solar PV Modules', with the Ministry of New & Renewable Energy (MNRE) designated as the implementing ministry. The financial outlay for the PLI for 'High Efficiency Solar PV Modules', as approved by the Cabinet and communicated via NITI Aayog's Order No. 13(176)/2020-I&M (I) dated November 20, 2020, over a five-year period, was Rs 4,500 crore ($510 million[129]).

India had set an ambitious target of setting up 1,75,000 MW capacity of renewable energy by 2022 and 4,50,000 MW by 2030. Based on a techno-economic analysis, the Central Electricity Authority (CEA) had indicated in its Optimum Energy Mix report that 2,80,000 MW capacity from solar energy would be needed by 2029-30. To achieve the target, around 25,000 MW of solar energy capacity needed to be installed every year until 2030. Solar capacity addition had largely depended on imported solar PV cells and modules, as the domestic manufacturing industry had limited operational annual capacities of around 2,500 MW for solar PV cells and 9,000-10,000 MW for solar PV modules.

Implementation

The PLI scheme was implemented by the Ministry of New and Renewable Energy (MNRE) through the Indian Renewable Energy Development Agency (IREDA) as the Project Management Unit. IREDA was responsible for providing secretarial, managerial, and implementation support, and carried out other

---

[126] PLI Scheme MNRE
[127] USD is arrived using an exchange rate of 88.3 (average of fiscal 2026)
[128] PLI Scheme T1 MNRE
[129] USD is arrived at using an exchange rate of 88.3 (average of fiscal 2026).

responsibilities assigned by MNRE. IREDA also examined claims for disbursement of PLI, verified and reconciled disbursement claims, and submitted progress reports to MNRE on a quarterly basis.

The selection of beneficiaries was done through a transparent bidding process, with applications shortlisted based on parameters such as extent of integration, manufacturing capacity, and minimum module performance. Preference was given to manufacturers who proposed to set up fully integrated solar PV manufacturing plants, and those who set up higher capacity plants. To qualify for the bid, applicant manufacturers had to promise minimum integration across solar cells and modules and undertake to set up a manufacturing plant of minimum 1,000 MW capacity.

The minimum performance parameters for manufacturers included a minimum module efficiency of 19.50% with a temperature coefficient of Pmax better than -0.30% per degree Celsius, or a minimum module efficiency of 20% with a temperature coefficient of Pmax equal to or better than -0.40% per degree Celsius. IREDA was eligible to receive 1% of the PLI amount disbursed as administrative charges on an annual basis.

Calculation of Production Linked Incentive (PLI)[64]

The Production Linked Incentive (PLI) was calculated using a formula that considered the sales volume, base PLI rate, tapering factor, and local value addition. The formula was: PLI (₹) = Sales Volume (Wp) × Base PLI Rate (₹/Wp) × Tapering Factor × Local Value Addition. The tapering factor varied from 1.4 to 0.6 over the five-year period, and the local value addition was expressed as a fraction of one.

The actual PLI paid to a manufacturer depended on their actual sales or maximum capacity awarded, whichever was less, as well as their position in the Performance Matrix and actual local value addition. However, manufacturers were not eligible for any PLI beyond what they had quoted for a particular year. If a selected manufacturer failed to meet the promised extent of integration or manufacturing capacity, they did not receive any PLI until they overcame these deficiencies. If they achieved the promised levels later, they became eligible for PLI from the next month, but they could not receive PLI for the full five years.

Manufacturers who failed to meet the minimum performance parameters for their modules did not receive any PLI for those modules. The PLI requirement for each year was calculated based on estimated values of the parameters in the formula, and manufacturers had to submit their total PLI requirement for the five-year period post-commissioning of the manufacturing unit at the time of bidding.

Impact of PLI Scheme (Tranche I)[64]

As part of the Production-Linked Incentive (PLI) Scheme's first tranche, the Indian Renewable Energy Development Agency Limited (IREDA) released bid documents on behalf of the Ministry of New and Renewable Energy (MNRE) to select manufacturers for setting up high-efficiency solar photovoltaic (PV) module production facilities. Following a competitive bidding process, IREDA issued Letters of Award in November and December 2021 to three successful bidders, who will establish fully integrated solar PV module manufacturing units with a combined capacity of 8,737 megawatts (MW) under the PLI scheme, which has an outlay of ₹4,500 crore ($510 million).

Production Linked Incentive Scheme (Tranche II)[130]

To further expand the manufacturing base for solar PV modules, an additional allocation of Rs 19,500 crore/$ 2.2 billion[131] (Tranche II) was announced in the Budget 2022-23 on February 1, 2022, with priority given to fully integrated manufacturing units from polysilicon to solar PV modules.

Implementation[65]

The PLI Scheme (Tranche-II) was implemented by the Ministry of New and Renewable Energy (MNRE) with the Solar Energy Corporation of India Limited (SECI) as the Project Management Unit. SECI was responsible for providing secretarial, managerial, and implementation support, and carried out other responsibilities assigned by MNRE. The agency received applications, examined and appraised them, issued acknowledgments and letters of award, examined claims for disbursement of PLI, verified and reconciled disbursement claims, and compiled data on the scheme's progress and performance.

SECI had the right to conduct physical inspections of applicants manufacturing units and offices and could seek help from the National Institute of Solar Energy (NISE) to verify the efficiency and temperature coefficient of modules. If required, MNRE could also designate National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited labs for such verification. A Project Management Unit (PMU) was established in MNRE to assist MNRE and SECI in implementing the scheme, with its expenditure met from the administrative charges.

SECI was eligible to receive 0.50% of the PLI amount disbursed as administrative charges on an annual basis. The agency submitted progress reports to MNRE on a quarterly basis, including details of disbursement claims received, amounts disbursed, and reasons for any delays in disbursement.

Impact of PLI Scheme (Tranche II)[65]

The Solar Energy Corporation of India (SECI), acting on behalf of the Ministry of New and Renewable Energy (MNRE), has issued a tender for the selection of solar PV manufacturers under the second tranche of the Production-Linked Incentive (PLI) Scheme. This initiative aims to promote the development of high-efficiency solar PV modules. Following a competitive bidding process, SECI issued Letters of Award (LoAs) to 11 successful bidders in April 2023, authorizing them to establish a combined 39,600 megawatts of fully or partially integrated solar PV module manufacturing capacity.

Approved List of Models and Manufacturers (ALMM)

The Approved List of Models and Manufacturers (ALMM) is a comprehensive list compiled by the Ministry of New and Renewable Energy (MNRE) that features approved models and manufacturers of solar photovoltaic (PV) modules. This list plays a crucial role in regulating the solar industry in India, as it stipulates that only the listed solar PV models and module manufacturers can be utilized for various solar projects across the country. These projects encompass a wide range, including government-initiated projects, government-assisted projects, and those undertaken under government schemes and programs, as well as open access and net-metering projects. In essence, the ALMM list applies to a broad spectrum of solar projects, including utility-scale solar projects tendered by the government, rooftop solar installations with net metering, corporate power purchase agreements (PPA) market, and government-backed schemes such as KUSUM, thereby ensuring that only approved and reliable solar PV modules are used in these projects.

---

[130] PLI Scheme T2 MNRE

[131] USD is arrived at using an exchange rate of 88.3 (average of fiscal 2026)

The Approved List of Models and Manufacturers (ALMM) is a registry that allows both domestic and foreign solar module manufacturers to have their products listed, with the primary goal of ensuring the quality and reliability of solar panels. By introducing this list, the aim is to provide a benchmark for the industry, guaranteeing that only high-standard products are used. Notably, as of now, the list exclusively features domestic manufacturers, with no foreign entities included, highlighting an opportunity for international manufacturers to explore and comply with the necessary standards to be enlisted. To be included on the Approved List of Models and Manufacturers (ALMM), manufacturers must obtain a product and performance certificate from the Bureau of Indian Standards (BIS). This certification is valid for a period of two years. The BIS is responsible for ensuring the quality of the product, while the ALMM provides certification for the manufacturing process, the manufacturer itself, and the manufacturing facility, offering a comprehensive evaluation of the manufacturer's capabilities and adherence to standards.

ALMM consists of two lists:

- List-I (Solar PV models and manufacturers)
- List-II (Solar PV cells and manufacturers)
- List-III (Solar PV wafers and manufacturers) (proposed)

The Ministry of New and Renewable Energy (MNRE) has been regularly updating List I under the Approved List of Models and Manufacturers (ALMM) order, with the latest update being on October 13th, 2025. As per this update, a total of 93 domestic module manufacturers, collectively having a capacity of 1,16,500 MW, have been included in the list.[132]

The Ministry of New and Renewable Energy (MNRE) has recently updated the Approved List of Models and Manufacturers (ALMM) order, with the latest revision taking place on September 23rd, 2025. This update of 11 domestic cell manufacturers to List II, bringing the total capacity of these manufacturers to 17,880 MW. This move is expected to promote the growth of the domestic solar industry and encourage the use of locally manufactured cells in solar projects.[133]

Backward Integration Push[134]

The government had accelerated its push for creating domestic manufacturing capacities across the solar value chain by proposing to mandate the use of India-made wafers under the Approved List of Models and Manufacturers (ALMM) starting June 1, 2028. The Ministry of New and Renewable Energy (MNRE) had issued a draft amendment to the ALMM order, which proposed creating an ALMM List-III for wafers, similar to solar modules and cells. Stakeholders were invited to submit their comments and suggestions by October 11, 2025. The amendment had proposed that all projects falling under ALMM's purview must mandatorily source their modules from ALMM List-I, which in turn had to use solar cells from the ALMM List-II for solar cells, and these cells had to use wafers from ALMM List-III. As part of its backward integration drive for the manufacture of all components of the solar component ecosystem, MNRE had announced in December that the ALMM List-II for cells would be effective from June 1, 2026. The ALMM for solar wafers was not issued unless it contained at least three wafer manufacturing units, which had to operate independently and not be under common ownership or control, with an aggregate wafer manufacturing capacity of 15 GW a year. The ALMM mandate for modules had succeeded in putting in place a robust manufacturing capacity in a little over four years, with India's module manufacturing capacity crossing 100 GW. In August, the MNRE had released the first ALMM List-II, which included a solar cell manufacturing capacity of 13 GW.

---

[132] ALMM I MNRE
[133] ALMM II MNRE
[134] ALMM III MNRE

India previously lacked significant wafer manufacturing capacity. The enlistment in the Approved List of Models and Manufacturers (ALMM) List-III required wafer manufacturers to also possess ingot manufacturing capacity equivalent to their intended wafer manufacturing capacity. This meant that the authorized wafer manufacturing capacity under ALMM List-III reflected the manufacturing capacity of both wafers and ingots. Thin film technology-based modules listed in ALMM List-I, which were manufactured in integrated solar module manufacturing units, were deemed compliant with the requirement of using wafers from ALMM List-III and cells from ALMM List-II.

Projects that had submitted bids on or before the designated "cut-off date" were exempt from using ALMM-listed wafers. The cut-off date was set as one month after the first ALMM List-III for wafers was issued, and this exemption applied regardless of the project's commissioning date. Additionally, projects that were exempt from using ALMM-enlisted solar cells were also automatically exempt from using ALMM-enlisted wafers. The exemption for using ALMM-III wafers extended to projects where bids were submitted or power purchase agreements were signed before the cut-off date, and subsequent tenders for engineering, procurement, and construction, solar module supply, or solar cell supply were issued.

Projects covered under ALMM, with bid submission dates falling after the cut-off date, were required to include a clause in their tender stating that the solar modules, cells, and wafers used must align with the requirements of ALMM-I, II, and III. Only solar modules that used cells from ALMM List-II, which in turn used wafers from ALMM List-III, were allowed to remain in ALMM List-I. Module manufacturers that failed to comply with this condition were removed from the ALMM List-I.

From June 1, 2028, three additional lists will be maintained: ALMM List-I

(a) for solar modules using solar cells and wafers not enlisted in ALMM, ALMM List-I
(b) for solar modules using solar cells enlisted in ALMM but wafers not enlisted in ALMM, and ALMM List-II
(c) for solar PV cells using wafers not enlisted in ALMM.

These lists contained modules and cells catering to different project categories that were exempted from using ALMM enlisted wafers but were mandated to use either ALMM enlisted modules or cells.

Guidelines for open access projects

The Indian government has introduced new guidelines for open access projects and net-metering, particularly with regards to the use of modules, cells, and wafers from the Approved List of Models and Manufacturers (ALMM). For projects commissioned before June 1, 2028, there is an exemption from using wafers from ALMM List-III, but these projects must still utilize cells and modules that are enlisted in the ALMM. However, for projects commissioned after June 1, 2028, the rules become stricter, requiring the use of modules, cells, and wafers from all three ALMM lists. This implies that any new net-metering or open access projects initiated after the specified date must adhere to the more stringent criteria, promoting the use of domestically manufactured components.

Furthermore, the amendment also addresses behind-the-meter and captive projects owned by government entities. For these projects, if they are commissioned after June 1, 2028, they will be subject to the requirements of ALMM List-III. This means that government-owned projects will also need to comply with the domestic content requirements, ensuring that they use approved and locally sourced components. Notably, there are no exemptions from the Domestic Content Requirement provisions for certain programs initiated by the Ministry of New and Renewable Energy (MNRE), such as Components B and C of the Pradhan Mantri-Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme, the PM Surya Ghar: Muft Bijli Yojana, and the CPSU Program Phase-II. This underscores the government's commitment to promoting domestic manufacturing and reducing reliance on imported components for renewable energy projects.

The International Solar Alliance (ISA)[135]

The International Solar Alliance (ISA) is a collaborative intergovernmental organization that was inaugurated in 2015 by the Prime Minister of India and the President of France at the United Nations Climate Change Conference in Paris. As an action-oriented and member-driven platform, the ISA aims to accelerate the global deployment of solar energy technologies. The organization's strategic framework, known as the 'Towards 1000' strategy, outlines ambitious objectives, including mobilizing $1 trillion in investments in solar energy solutions by 2030, providing clean energy access to 1 billion people, installing 1,000 gigawatts of solar energy capacity, and reducing global carbon emissions by 1 billion tonnes annually. Guided by its vision of making the sun's energy brighter for all and its mission of illuminating every home, the ISA operates from its headquarters at the National Institute of Solar Energy (NISE) in Gurugram, India, driving global efforts to harness the power of solar energy for a sustainable future.

The goals and key focus areas of ISA

The International Solar Alliance (ISA) has set forth several key objectives aimed at promoting the widespread adoption of solar energy globally. By 2030, the ISA seeks to facilitate the deployment of 1000 gigawatts of solar energy capacity worldwide and mobilize over $1 trillion in investments for solar energy projects in its member countries. To achieve these goals, the ISA aims to develop innovative financial mechanisms that can help reduce the costs associated with solar energy deployment, as well as encourage research and development in solar energy technologies. Ultimately, the ISA's mission is to establish solar energy as a primary source of energy for all, making it a mainstream and accessible option globally. To drive progress in these areas, the ISA's programs focus on four priority areas: analytics and advocacy, capacity building, programmatic support, and readiness and enabling activities, which collectively provide a comprehensive framework for advancing the solar energy agenda.

The governance framework of the ISA

The International Solar Alliance (ISA) has a well-defined governance structure, with the ISA Assembly serving as the supreme decision-making body. Comprising representatives from each member country, the Assembly is responsible for making key decisions, such as selecting the Director General, overseeing the functioning of the ISA, and approving the operating budget. The first ISA Assembly was held in October 2018 in Greater Noida, India. The Steering Committee provides strategic guidance to the ISA and monitors its operations, meeting regularly to review progress and make recommendations to the Assembly. The Secretariat, headed by the Director General, is the administrative arm of the ISA, responsible for implementing the decisions of the Assembly and the Steering Committee. The Director General leads the ISA's operations, carries out the functions of the Secretariat, and is accountable to the ISA Assembly, with a tenure of four years and eligibility for re-election, ensuring continuity and stability in the organization's leadership.

How did the ISA originate and evolve over time

The International Solar Alliance (ISA) was born out of a collaborative initiative between India and France to combat climate change by promoting the adoption of solar energy solutions. The concept of the ISA was first introduced on the sidelines of the 2015 United Nations Climate Change Conference (COP21) in Paris, marking a significant step towards global cooperation on renewable energy. Following the amendment of its Framework Agreement in 2020, the ISA has become a truly global entity, with all member states of the United Nations now eligible to join. As of now, over 110 countries have signed the ISA Framework Agreement, with 90 countries having ratified the agreement to become full-fledged members of the alliance. This widespread participation underscores the growing recognition of the importance of solar energy in

[135] ISA

addressing the global climate crisis and the ISA's role in facilitating international cooperation to achieve a sustainable energy future.

The significance of ISA

India's involvement in the International Solar Alliance (ISA) presents a unique opportunity for the country to demonstrate its leadership in the renewable energy sector. With an ambitious target of achieving 450 gigawatts of renewable energy capacity by 2030, India can leverage the ISA platform to promote solar energy deployment not only domestically but also among its member countries, thereby accelerating its progress towards this goal. Furthermore, by taking a leading role in the ISA, India can enhance its global reputation as a responsible and committed player in the pursuit of sustainable development, exercising its soft power in the international arena. Additionally, as a developing country highly vulnerable to the impacts of climate change, India's participation in the ISA can facilitate its efforts to mitigate and adapt to the challenges posed by climate change, ultimately contributing to a more sustainable and resilient future for the nation.

The International Solar Alliance (ISA) plays a vital role in promoting clean energy globally, with a primary objective of advancing the use of solar energy as a clean, renewable, and sustainable source of energy. This endeavor is crucial for achieving climate change goals and mitigating the impacts of global warming. Furthermore, the ISA aims to mobilize over $1 trillion in investments in solar energy by 2030, which can create new business opportunities, stimulate economic growth, and generate employment. Additionally, the ISA's focus on solar energy can help increase access to energy, particularly in rural and remote areas, thereby contributing to poverty reduction and overall human development. By promoting solar energy, the ISA can help bridge the energy gap and ensure that everyone has access to reliable, affordable, and sustainable energy, ultimately contributing to a more equitable and sustainable future for all.

Various projects and initiatives of ISA

Solar Technology Application Resource Centre (STAR C)

The Solar Technology Application Resource Centre (STAR C) initiative is a key capacity-building and institutional strengthening program launched by the International Solar Alliance (ISA) to support its developing member countries. The primary objective of the STAR C initiative is to foster the development of human capacity and skills within member countries, enabling them to undertake significant energy transition activities, create new job opportunities, and contribute to their overall economic growth. These centers serve as hubs of technology, knowledge, and expertise on solar energy, providing a go-to platform for member countries at both regional and national levels. By establishing these centers, the ISA aims to empower its member countries with the necessary resources and expertise to accelerate their transition to solar energy, driving sustainable development and economic prosperity.

Indian Technical and Economic Cooperation (ITEC) Scheme.

The Government of India has been actively supporting the International Solar Alliance (ISA) through the Indian Technical and Economic Cooperation (ITEC) Scheme, which provides training to master trainers in the field of solar energy. Under this initiative, the Government of India bears all costs for a 21-day training program, aimed at enhancing the skills and knowledge of participants in solar energy technologies. In the 2018-2019 period, the ITEC program facilitated the training of 133 candidates from 25 countries at the National Institute of Solar Energy in Gurugram, India. This capacity-building effort not only contributes to the global dissemination of solar energy expertise but also underscores India's commitment to supporting the ISA's mission of promoting solar energy deployment worldwide.

ISA solar fellowship for mid-career professionals

The International Solar Alliance (ISA) offers a fellowship program designed for mid-career professionals, aiming to enhance the long-term development capabilities of its member countries by creating a pool of skilled and qualified professionals who can effectively manage solar energy projects, programs, and policies. The fellowship is awarded to mid-career professionals from ISA member countries, with the expectation that they will contribute to policy development in their home countries upon completion of the program, thereby supporting the ISA's objectives. The inaugural batch of the fellowship program, which commenced on July 22, 2019, comprises 21 candidates from 18 ISA member countries, who are pursuing master's degrees in Renewable Energy Management and Economics. This initiative not only fosters capacity building and knowledge sharing among member countries but also plays a crucial role in achieving the ISA's mission of promoting solar energy globally.

One Sun, One World, One Grid (OSOWOG) initiative.

The concept of One Sun, One World, One Grid (OSOWOG) was first proposed by India in 2018, with the ambitious goal of creating a global network that connects energy supplies across international borders. The underlying vision of OSOWOG is rooted in the idea that "the sun never sets," symbolizing the constant availability of solar energy somewhere in the world. By establishing a common grid that interlinks regional grids, the OSOWOG initiative aims to facilitate the transfer of renewable energy, particularly solar power, across the globe. This innovative approach seeks to harness the full potential of renewable energy sources, promoting a more sustainable and interconnected energy landscape worldwide.

The International Solar Alliance (ISA) is working to increase access to affordable and sustainable energy solutions through various initiatives. One key area of focus is on providing affordable finance on a scale, leveraging innovative financing mechanisms such as the Green Climate Fund and the World Bank's International Finance Corporation to make solar power more accessible and affordable for all. Additionally, the ISA is promoting the development of mini-grids powered by solar energy, which can provide electricity to communities that are off-grid or have limited access to electricity, thereby enhancing energy access and promoting economic development. The ISA is also involved in a range of other projects, including the promotion of solar-powered agriculture pumps, solar rooftop installations, solar water heaters, and solar street lighting, among others, aiming to harness the potential of solar energy to transform lives and communities worldwide.

The challenges and limitations of the ISA

Despite the significant strides made by the International Solar Alliance (ISA) since its establishment, the organization faces several challenges that hinder its progress and effectiveness. One of the primary concerns is funding, as the ISA requires substantial financial resources to achieve its ambitious objectives of promoting solar energy in developing countries, and while it has received support from countries like France and India, more funding is needed. Another challenge is the limited participation of countries, with only over 100 nations having signed the ISA Framework Agreement, which restricts the organization's ability to achieve its goals and expand its impact globally. Furthermore, the diverse energy policies and regulations among countries create a hurdle in harmonizing them and establishing a level playing field for solar energy, making policy coordination a significant challenge. Lastly, the implementation of solar energy projects is often hindered by factors such as inadequate infrastructure, political instability, and insufficient financing, leading to a lack of successful project implementation and undermining the ISA's overall impact.

How can ISA effectively guide its future direction

To chart a successful future course, the International Solar Alliance (ISA) can consider several strategic approaches. Firstly, enhancing collaboration with international organizations, governments, and private sector entities can help the ISA leverage a broader range of resources and expertise in the solar energy sector, thereby amplifying its impact. Secondly, expanding its membership by engaging with more countries, particularly those with significant potential for solar energy adoption, can increase the organization's reach and influence. Implementing policy reforms in member countries is also crucial, as this can involve providing incentives for solar energy adoption and reducing subsidies for fossil fuels, thereby creating a more favorable environment for solar energy growth. Furthermore, the ISA can play a pivotal role in facilitating financing for solar energy projects in member countries, potentially by establishing a dedicated fund or collaborating with international financial institutions. Lastly, fostering innovation in the solar energy sector is essential, and the ISA can achieve this by supporting research and development activities, as well as providing a platform for the sharing of best practices and knowledge, which can help drive the development of more efficient and affordable solar energy technologies.

R&D incentives:

SERIIUS (2012)[136]	Was a collaborative effort between India and the US aimed at foresting high impact research on development of next-generation solar photovoltaics, specially focusing on advanced materials and novel device architectures. The partnership includes several leading research institutes and universities such as Indian Institute of Science, National Renewable Energy Laboratory and others.
Indo-German Partnership[137]	Established to foster cooperation between India and Germany in the field of solar energy, including PV manufacturing. It included focus on developing advanced PV technologies, improving efficiencies and reducing cost.

Industrial incentives:

Domestic content requirement (2010-2016 and 2024 onwards)[138]	Introduced as a part of JNNSM to protect domestic Solar PV manufacturing by mandating use of domestically manufactured solar cells and modules. The move, however, faced several challenges as it led to increased costs in the absence of a large manufacturing base. A 2016 WTO ruling resulted in progressive phase out of the measure. However, the announced PM Surya Ghar Yojana mandates use of DCR modules to solarise 1 crore[139] households in India
Modified – Special Incentive Package scheme (2012)[140]	Notified with the objective of incentivizing investments in the electronic systems design and manufacturing (ESDM) industries. Solar PV

[136] US-India Partnership to Advance Clean Energy
[137] Bundesverband Solarwirtschaft e.V.
[138] MNRE
[139] PM Surya Ghar MNRE (June 2024)
[140] Special incentive Package MEITY (Feb 2016)

	manufacturing constituted one of the eligible verticals. The scheme provided 25% capex subsidy for solar PV plants (polysilicon, ingot, wafer, or cells) set up outside SEZs, and a 20% subsidy in the case of plants with SEZs. It also reimbursed excise or countervailing duty on imports of capital equipment for non-SEZ plants. A 10% subsidy was also provided on production turnover for both SEZ and non-SEZ facilities. The scheme had an approved incentive outlay of Rs 10,000 crore, applications till 31st Dec 2018. However, only Rs 1,781 crore ($202 million[141]) was till Dec 2022. Though the M-SIPs received applications from Solar PV developers, it was not effective in providing significant support as it was not particularly targeted towards solar PV and applicants had to compete with applicants from the broader ESDM sector for incentives.
Approved List of Models and Manufacturers (FY20 to present)[142]	Introduced by MNRE to mandate usage of only listed models and manufacturers for the government utility-scale, net metering and open access projects from April 2022. The measure, while in abeyance for years, was aimed to provide a demand boost to domestic manufacturing industry which was at the cusp of witnessing an exponential demand of 38-42 GW per annum by the end of the decade. The measure was reimposed from April 2024 onward. Over the years. MNRE has frequently aimed at updating the list by improving the minimum efficiency of listed modules and increasing enlisted capacity. The capacity doubled by April 2024 to 44 GW from 22 GW in September 2022, providing comfort for the developers. Despite 4 years of announcement, the list has only restricted to domestic players thereby limiting foreign competition and has touched 100 GW[4] in August 2025. The ministry also rolled out ALMM II in July 2025 with 13 GW[143] enlistment to develop cell manufacturing capacity
Production linked incentive scheme (2021 – Present)[144]	Introduced in an effort to improve localisation in the manufacturing industry, the MNRE allocated Rs 24,000 crore ($2.7 billion) performance-based incentive to install high efficiency solar capacities of 48.3 GW in two tranches. The scheme targets expansion across various levels of P-M (24.1 GW), W-M (40.9 GW) and C-M (48.3 GW). The move is expected to reduce import reliance on downstream components and act as a kickstarter to the capex intensive upstream value chain of polysilicon and wafers.

[141] USD arrived using an exchange rate of 88.3 (average of fiscal 2026)
[142] ALMM MNRE (Mar 2021)
[143] ALMM II MNRE (July 2025)
[144] PLI Scheme MNRE (Apr 2021)

Skilling incentives:

Skill development initiative under NSM (2009)[145]	The National Institute of Solar Energy under MNRE launched various training programs for solar PV technicians and engineers that helped train a significant workforce in solar PV installations, maintenance, and manufacturing process, supporting the growing solar energy
Skill council for green jobs (2015)[146]	The skill council for green jobs (SCGJ) collaborated with the industry stakeholders to develop national occupational standards and certifications programs for solar PV installers and technicians.
Green skill development program (2017)[147]	It collaborated with training institutes to develop courses on environmental sustainability and green technologies, including solar.

International cooperation and platforms

India also co-founded and hosts the International Solar Alliance (ISA) a 107-member[148], treaty-based body driving global solar deployment - which gives India both convening power and practical toolkits that Indian PV firms can already use. ISA has moved from dialogue to execution through PV-centric programs like Scaling Solar Rooftops and Scaling Solar Mini-grids, plus the Global Solar Facility (GSF)- a blended-finance platform. ISA is operationalising with the World Bank's Multilateral Investment Agency (MIGA). On the finance side- India tied ISA cooperation to concessional Lines of Credit - $1.4 billion announced at the founding conference for 27 solar projects in 15 countries[149], and a further USD 2 billion set aside for solar in Africa- implemented via EXIM Bank[150] in coordination with ISA member countries. In December 2024, India signed an agreement with ISA to implement solar energy project in Fiji. This initiative was valued at $2 million and was funded by India as part of its commitments under the Quad Climate Working Group

[145] Ministry of Skill Development and Entrepreneurship
[146] Skill India
[147] Ministry of Environment, Forest & Climate Change
[148] ISA
[149] PIB (Feb 2019)
[150] ISA MNRE (Oct 19)

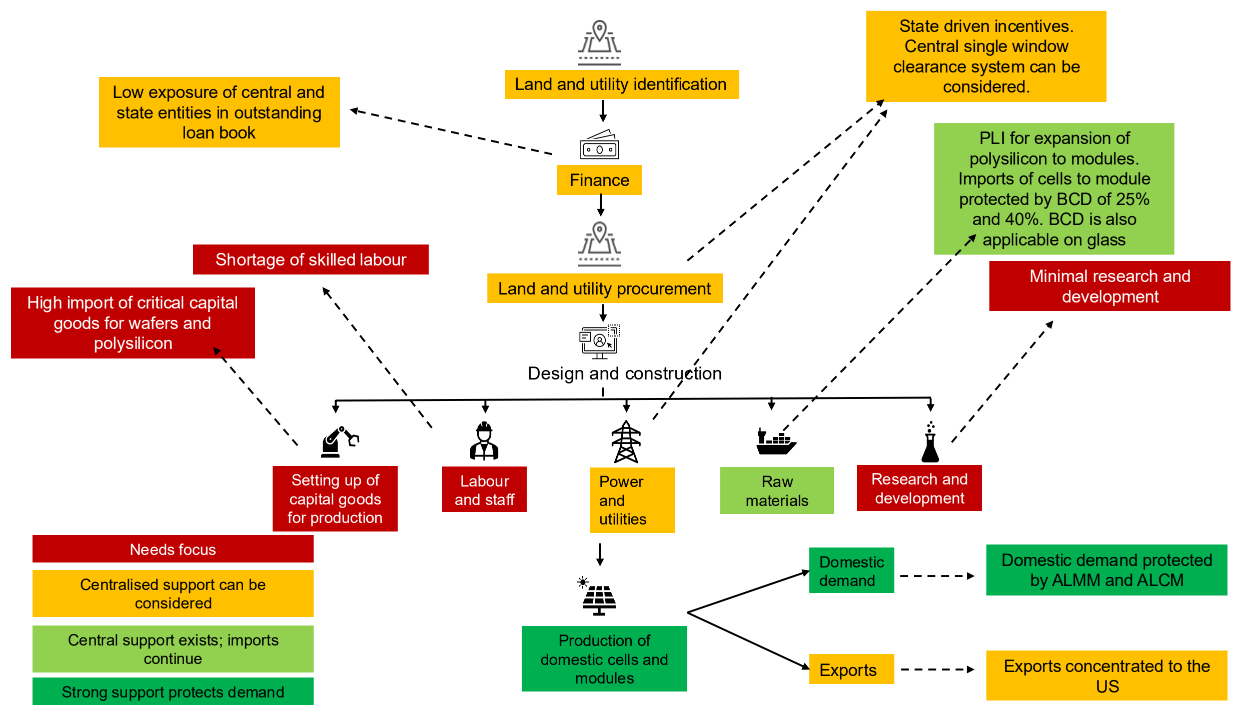
Challenges and Recommendations

Overall Landscape

India's solar manufacturing sector has witnessed significant growth, driven by comprehensive government initiatives and policies. The solar module manufacturing capacity has increased to 100 GW by August 2025, up from less than 3 GW in 2014. To boost local manufacturing, the government has implemented several monetary and non-monetary benefits across capital expenditures (capex) and operating expenses (opex) for the entire value chain. However, much of this growth has occurred over the past four fiscal years, following the introduction of the Production Linked Incentive scheme and the Approved List of Models and Manufacturers. Furthermore, capacity expansion has been largely concentrated on the downstream value chain, with the upstream chain still heavily reliant on imports. Furthermore, as per CEA's NEP Transmission Plan 2024, the country's solar installations are expected to reach 365 GW by fiscal 2032, resulting in demand of 283 GW between fiscals 2025 and 2032. Thus, increasing upstream capacity will be crucial to reducing import dependence. In addition to expanding upstream capacities, the value chain will require timely protection to maintain a level playing field, as more than 80% of the value, along with the necessary capital goods, is currently concentrated in China.

While the growth in domestic solar manufacturing capacity represents a significant milestone, the sector is now entering a phase where the focus extends beyond capacity creation alone. The development of a competitive and resilient solar PV manufacturing ecosystem will depend on several interconnected factors across the value chain. These include access to specialised manufacturing equipment, continued investment in research and development, availability of skilled manpower, a supportive industrial and regulatory environment, and access to diversified export markets. The following sections examine these areas and outline opportunities to strengthen domestic value addition, support upstream manufacturing, and enhance the long-term competitiveness of India's solar PV sector.

Figure 87: Need to focus on ancillary parameters after incentivising the production



Source: Crisil Intelligence

1. Access to machinery and equipment:

Access to capital goods for the manufacturing of polysilicon, wafers, and solar cells is crucial for the long-term growth and competitiveness of India's solar manufacturing sector. Without these critical inputs, domestic manufacturers remain heavily reliant on imports, leaving them vulnerable to supply chain disruptions, price fluctuations, and geopolitical risks. To mitigate this challenge, the Indian government has introduced the Production Linked Incentive (PLI) scheme for High-Efficiency Solar PV Modules, with a total outlay of Rs 24,000 crore ($2.7 billion). The scheme aims to establish a comprehensive, end-to-end solar manufacturing ecosystem in India. However, while the PLI scheme provides essential financial support, its ultimate success depends on manufacturers' ability to access the necessary capital goods to produce polysilicon, wafers, and cells on a large scale.

As the industry seeks to deepen domestic value addition and expand into upstream segments such as polysilicon, ingots, and wafers, the availability of specialised manufacturing equipment assumes increasing importance. Unlike module assembly, upstream manufacturing requires highly sophisticated production lines, specialised engineering expertise, and access to advanced process technologies. Consequently, the pace at which India can expand its upstream manufacturing base will depend not only on policy support and investment appetite, but also on the industry's ability to procure, install, and operationalise the necessary capital goods in a timely manner.

Challenges:

Majority of the capital goods market for the solar value chain is concentrated in China, which has resulted in restricted access to these essential goods for Indian manufacturers. Prominent industry players have expressed concerns about the access to the supply of W-C-M equipment by Chinese companies. Further, industry leaders have also voiced similar concerns in the stakeholder consultation round. Limited access to capital goods could lead to a shortfall in capacity expansion in the upstream segments, creating bottlenecks for self-reliance and potentially delaying the nation's renewable energy targets. Furthermore, this could perpetuate the dependence of manufacturers on imports. The consequences of continuing this could further impact the commissioning timelines under the PLI scheme, potentially hindering the growth of India's solar manufacturing sector. It should be noted that developments in global supply chains, evolving trade relationships, and ongoing investments by industry participants may have improved the availability of certain categories of equipment since this challenge was first identified. In parallel, policy measures aimed at strengthening domestic manufacturing capabilities continue to evolve. Nevertheless, procurement of specialised capital goods for upstream solar manufacturing remains an important consideration for the long-term development of a fully integrated domestic solar PV value chain.

Recommendations

1. Industry players may look to expand their global presence to identify alternative sources for procuring capital goods and reduce dependence on a limited supplier base.

   To bridge gaps in the domestic supply chain, Indian companies may adopt a collaborative approach by forming joint ventures and strategic partnerships for upstream manufacturing, particularly in polysilicon, ingots, and wafers.

   This is especially important given India’s currently limited upstream manufacturing capacity and constrained access to specialised capital goods, both of which hinder the development of a self-reliant solar PV ecosystem. Given that upstream production is highly capital-intensive and requires specialised technical expertise, joint ventures can help mitigate financial risk, accelerate technology transfer, and support the creation of a sustainable indigenous manufacturing base.

Such partnerships would not only help address critical supply bottlenecks but also enhance the competitiveness of India's domestic solar PV industry by fostering innovation, resilience, and scale. Over time, this could position India as a more significant player in the global renewable energy manufacturing landscape.

The countries listed below present promising opportunities for diversifying capital goods procurement and strengthening supply-chain resilience:

Table 37: India shares positive relations with most countries that possess capital goods

Country	Technology
Germany	Silicon purification and wafer slicing machinery
United states	High quality silicon production and innovative wafer technologies
Japan	Wafer slicing and automation technologies
South Korea	Silicon technologies
Taiwan	Solar wafer
Norway	Silicon processing

Source: Crisil Intelligence

Figure 88: Players can increase their presence through multiple strategies below

Joint ventures

Premier Energies partnered with Heline (Canada) to set up a 1 GW of solar cell plant in USA

Acquisitions

Reliance New Energy acquired REC solar to strengthen its global solar supply chain

Source: Company filings

2. Indian companies may also selectively explore partnerships with established Chinese firms, particularly where such collaborations can provide access to advanced technology, process know-how, equipment integration capabilities, and operational expertise. While supply-chain diversification remains a strategic priority, carefully structured partnerships could help shorten the learning curve and build domestic capabilities more efficiently, subject to regulatory, geopolitical, and commercial considerations.

   The industry has already witnessed the emergence of joint ventures and acquisitions as a means to expand strategic presence. However, to further accelerate growth, this strategy needs to be scaled up and replicated in alternative geographies, enabling access to critical capital goods and research and development (R&D) capabilities.

   While access to machinery and equipment forms the foundation for manufacturing capacity creation, long-term competitiveness increasingly depends on technological capabilities and continuous innovation. As global solar manufacturers continue to improve cell efficiencies, optimise production processes, and reduce manufacturing costs, technology development has become an increasingly important differentiator. Consequently, alongside investments in physical infrastructure, sustained focus on research and development will be critical to strengthening India's position across the solar PV value chain and supporting the transition towards higher-value manufacturing activities.

2. R&D spending:

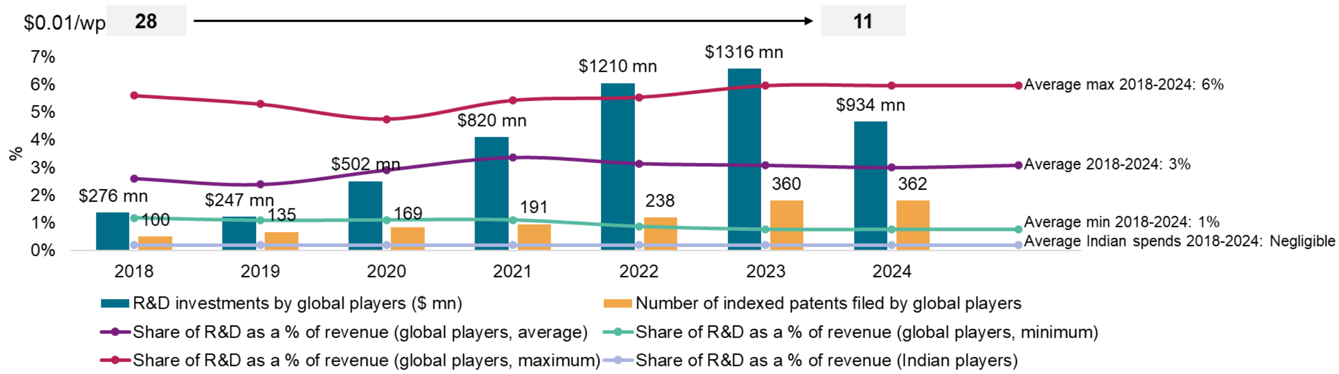
R&D has been pivotal in advancing solar cell technology, leading to significant improvements in efficiency, cost-effectiveness, and environmental impact. Initially, solar cells were primarily composed of silicon, offering limited efficiency. Through dedicated R&D, alternative materials such as perovskite have been explored, resulting in higher efficiency rates. For instance, Qcells (South Korea) achieved a world record by developing a large-area silicon solar cell with a perovskite top layer that reached 28.6% efficiency. These advancements not only enhance energy output but also reduce the space required for installation, making solar power more accessible and practical. The Chinese players have applied this principle over the value chain by reinvesting the cost savings from government grants into R&D. This has resulted in a significant fall in module prices over the years.

As India seeks to strengthen its position across the solar PV value chain, technological leadership is becoming an increasingly important source of competitive advantage. Improvements in manufacturing processes, cell efficiencies, material utilisation, and product reliability have enabled leading manufacturers globally to reduce costs while improving performance. Consequently, sustained investment in research and development is emerging as a key factor in determining long-term competitiveness across the solar PV value chain, particularly as manufacturers' transition towards more advanced technologies.

Challenges:

The R&D spend as a share of revenue by Indian players was negligible compared to their Chinese counterparts, which, on average, has been 3% of revenue and extends to 6% for some players. High in-house R&D spending has enabled significant evolution in technology and a reduction in costs over the period. Over the past six years, the prices of solar modules have fallen by 61% to $0.11/Wp in 2024, compared to 2018. Consequently, the number of patents filed by Indian players is minimal compared to their Chinese counterparts.

Figure 89: R&D investments critical to reduce cost of production

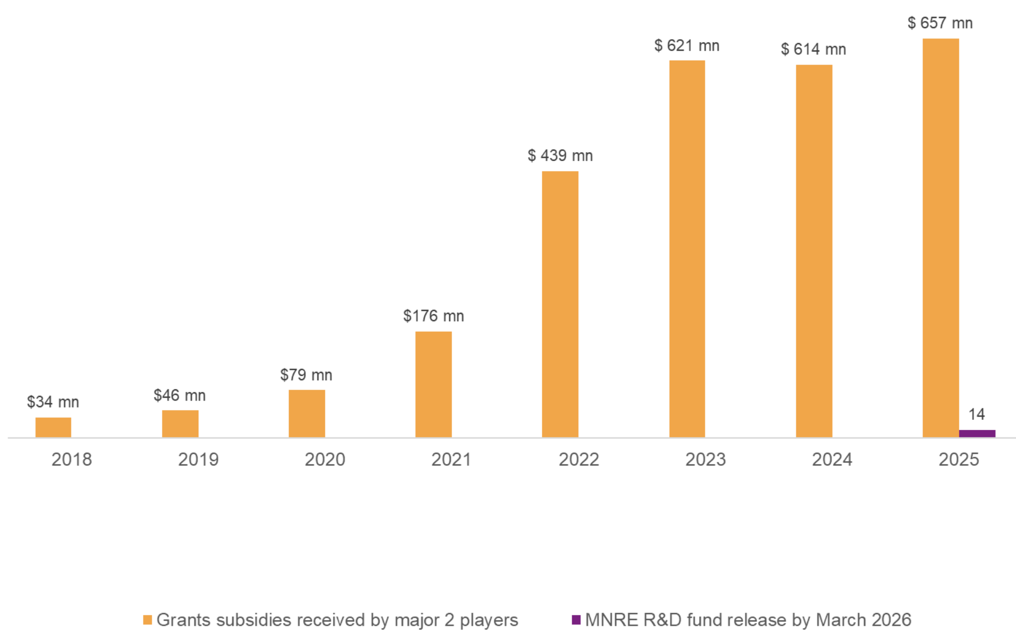


Note: Players considered for global analysis are LONGi Solar, Jinko Solar, and Canadian Solar. The above information is on CY basis while that for Indian players is on fiscal year basis

The government has attempted to foster academia-industry partnerships. However, the spending on R&D has been low. Between FY2021-22 and FY2026-27, MNRE's dedicated Research and Development budget remained a very small component of the Ministry's overall expenditure, averaging approximately 0.28% of its revenue budget over the period. The total funds disbursed for R&D by the MNRE till March 2026 were $14 million, as opposed to the $2.7 billion in total grants disbursed by the Chinese government.

It is important to note that efforts to strengthen domestic innovation capabilities have evolved over recent years. Both government and industry stakeholders have increasingly recognised the importance of research, technology development, and academia-industry collaboration in supporting the growth of the solar manufacturing sector. While some of the challenges identified in this section may be gradually addressed through ongoing initiatives and future policy interventions, continued focus on R&D will remain important as solar technologies, manufacturing processes, and industry requirements continue to evolve.

Figure 90: Government subsidies enable more R&D investments



Notes: Players considered for global analysis are LONGi Solar and Jinko Solar. The above information is on a CY basis.

Exchange rate of INR 84/USD used for MNRE R&D funds released.

The grant subsidies received by Chinese players is total grants. India's grants released are for R&D. Beyond R&D, India has also announced $2.9 billion incentive under the production linked incentive scheme. Incentives are yet to be disbursed as of March 2026.

Source: MNRE, Annual filings

Recommendations

1. A performance-based R&D incentive may be considered to encourage R&D among domestic players. The MNRE can expand financial support under the Renewable Energy Research and Technology Development (RE-RTD) Programme, which received a cumulative allocation of only $17 million over FY2021-22 to FY2026-27—equivalent to just 0.28% of the Ministry's total budgetary allocation for the entire six-year period.

   A mechanism suggested below could be followed:

   - **Increase budgetary allocation for solar R&D:**
     MNRE could consider increasing its budgetary allocation for solar R&D in line with global best practices. The focus could be on developing advanced cell technologies such as TOPCon, HJT, and Perovskite, as well as promoting innovation to reduce the production cost of existing technologies such as mono-crystalline and thin-film solar PV.

   - **Leverage ANRF funding for solar technology commercialisation:**
     MNRE could facilitate access for domestic solar manufacturers and technology developers to the ₹1 lakh crore Research, Development and Innovation Fund under ANRF. Eligible projects—particularly those involving next-generation solar cells, indigenous materials and equipment, higher-efficiency technologies, and process innovations at Technology Readiness Level 4 or above—could receive long-term, concessional financing through approved fund managers, helping bridge the gap between laboratory research, pilot-scale validation and commercial deployment.

   - **Introduce a production-linked R&D mandate:**
     While the PLI scheme aims to incentivize higher-efficiency solar PV manufacturing, the R&D-linked component could be enhanced to reward manufacturers that actively invest in research and innovation. In addition, a milestone-based incentive programme could be introduced to encourage manufacturers to invest in R&D and capacity building. Under this model, manufacturers could receive incentives upon achieving pre-defined outcomes such as setting up pilot production lines, developing indigenous process technologies, filing patents, improving module efficiency, localising capital equipment, or collaborating with academic and research institutions. This would encourage private-sector investment, support the creation of domestic intellectual property, and help India move beyond assembly-led manufacturing towards technology-led competitiveness.

   - **Facilitate public-private partnerships in R&D:**
     Collaboration between government laboratories, academic institutions, and private manufacturers could be strengthened by incentivizing a larger number of R&D projects annually, beyond the recent list of five projects announced up to December 2024.

   - **Establish a dedicated solar R&D fund:**
     A dedicated fund could be considered to finance cutting-edge solar research, with a focus on scaling up indigenous capabilities in polysilicon, wafer, and cell production.

- **Fast-track intellectual property protection:**
  Intellectual property protection could be fast-tracked to encourage innovation, reduce uncertainty for investors, and promote greater private-sector participation in solar R&D.

- **Establish an industry-led Solar PV Manufacturing R&D Consortium:**
  MNRE may facilitate a consortium of domestic solar manufacturers, equipment and material suppliers, NISE, NCPRE, IITs and other relevant research institutions to undertake mission-oriented R&D aimed at commercial manufacturing outcomes. The consortium may focus on production-line challenges such as improving cell efficiency and yield, reducing critical-material consumption, developing indigenous equipment and process technologies, improving module reliability under Indian climatic conditions, and advancing TOPCon, HJT and tandem technologies to pilot-manufacturing readiness. Projects would require participation and co-funding from at least one domestic manufacturer, access to a production line for validation, and clearly defined commercialisation milestones. Government may provide support against measurable outcomes—laboratory validation, pilot-line demonstration, reliability certification and commercial-line deployment—rather than research expenditure alone.

2. While the government strengthens mechanisms to incentivize R&D, players may consider increasing their R&D spend as a percentage of revenue to keep up with their Chinese counterparts. This will ensure innovation and safeguard the industry from any potential patent wars in the future. To do so, the players can exercise:

- Strategic ties with global players to bring in in-house R&D programs.
- Increase R&D spending to an average of 3% of revenue, as seen in the global market.

While investments in research and development are critical to advancing technology and improving manufacturing competitiveness, the successful adoption of these innovations ultimately depends on the availability of a suitably skilled workforce. As solar manufacturing technologies continue to evolve from conventional cell architectures towards advanced technologies such as TOPCon, HJT, and future tandem configurations, the demand for specialised technical capabilities is expected to increase. Accordingly, workforce development becomes an important complement to technology development and will play a key role in supporting the long-term growth of India's solar PV manufacturing sector.

3. Availability of skilled labour:

India’s solar photovoltaic industry employs approximately 3.2 lakh people, across grid-connected and off-grid applications. As per IRENA (International Renewable Energy Agency), 1 GW of solar module generation creates anywhere between 1,085 to 2,020 jobs. With India set to expand its cell-to-module capacity base by 48.3 GW under the PLI, the next few years will result in at least 1 lakh direct and indirect jobs. Thus, the availability of skilled labour will be crucial. This is because manufacturers are expected to focus on evolving technologies, such as Mono PERC, TOPCon, and HJT, to maximise efficiencies. As technology evolves, the manufacturing process becomes complex. This is because the fabrication of solar cells relies on a multitude of high-purity, semiconductor-grade gases and chemicals, which are critical inputs at each stage of the manufacturing process. To ensure safe, efficient, and high-yielding solar cell production, the effective management of utilities is paramount.

As manufacturing facilities become larger and technologies become more sophisticated, workforce capabilities assume increasing importance across production, quality control, equipment maintenance, process optimisation, and research functions. The transition towards advanced cell technologies is expected to increase demand for specialised technical expertise, making skill development an important enabler of both manufacturing scale-up and operational efficiency across the solar PV value chain.

Table 38: PV technologies - Complexities and efficiency

Technology	Mono PERC	TOPCon	HJT	Tandem
Manufacturing complexity	Least complex. Leverages mature technology with minimal additional process like passivation layers and rear side contact	More complex than PERC, requires precise deposition of ultra-thin tunnel oxide and polysilicon layers	High complexity due to the integration of both crystalline silicon and amorphous silicon layers, requiring advanced deposition and curing equipment	Most complex, involving stacked cells, e.g. perovskite-silicon, with precise material engineering to optimise efficiency and bandgap alignment.
Losses and damages	p-type MONO PERC cells are prone to LID and PID losses. Such losses are high compared to peers	PID and LID losses in TOPCon are lower compared to MONO PERC	Not prone to PID and LID losses, since general cell construction is n-type	Affected by LID and PIC moderately
Temperature Co-efficient of Power	-0.35% / °C PERC cells experience a more noticeable power decline at elevated temperatures	-0.29% / °C Offers a significant power improvement over PERC cells at elevated temperatures	-0.24% to -0.26% / °C Lowest temperature coefficient – HJT cells experience minimal power loss even at high temperatures	Limited data
Efficiency	23-24%	24.5-25%	25-25.5%	26-28%

Note: LID – Light-induced degradation. PID – Potential-induced degradation

Source: ITRPV, Industry

Challenges:

- The challenge of complexity could be further exacerbated by low productivity. The average productivity of an employee per MW in India is lower than that of major global players. The productivity of an employee per MW (measured by dividing total capacity by the number of employees) for major global players has increased between 2020 to 2023 by ~3 times owing to increase in scale where the PV capacity (P-W-C-M) of three major global players (LONGi solar, Jinko Solar and Canadian Solar has increased ~5 times between 2020 to 2023 to 803 GW. While India's cumulative PV capacity (W-C-M) has too grown at a sharp pace, estimated over 100 GW by August 2025 productivity levels are only a about a third presently compared to global peers mainly due to scale effect and integrated processes.
- The industry witnesses a continuous evolution in technology, where cells have evolved from Polycrystalline to HJT. The availability of skilled labour thus becomes a critical parameter to drive innovation in R&D. Hence, availability of labour will be crucial to scale manufacturing technologies in the future.

While the government offers a grant-in-aid of up to Rs 50 lakh ($56,625[151]) to educational institutions for upgrading laboratory facilities, the same is limited to 2 institutes per annum.

It should be noted that workforce development has received increasing attention from both industry participants and government agencies in recent years. Various training, skilling, and vocational initiatives have been introduced or expanded to support emerging manufacturing sectors. In parallel, several manufacturers have strengthened internal training programmes to support evolving operational requirements. While skill availability continues to be an important consideration as the industry scales, these ongoing efforts may help address some of the capability gaps identified in this section over time.

Recommendations:

1. An increase in the budgetary allocation to training and increase the limit on the recipients for grants in aid beyond 2 institutes per annum could be considered.
   a. The government could consider establishing a dedicated fund, with the allocation determined based on sectoral needs, alongside a routine oversight mechanism to monitor implementation. Participating institutes may be required to submit quarterly financial and performance reports to ensure alignment with grant objectives. Accountability could be further strengthened through third-party independent audits, similar to practices adopted by the National Skills Development Corporation. An outcome-based funding model may also be adopted, similar to the PM-KUSUM scheme, where fund disbursement is linked to clearly defined milestones such as training targets achieved, industry collaborations established, publications, patents filed, prototypes developed, and technology commercialisation outcomes.
   b. Training may be provided to institute personnel in project management, curriculum design, and industry engagement. Curricula should be developed in collaboration with industry to ensure practical relevance, with higher weightage assigned to hands-on training, internships, apprenticeships, and industry-based projects.
   c. A combination of data-backed decision-making, milestone-linked incentives, and strong accountability mechanisms can help MNRE bridge skill gaps, promote domestic innovation, encourage manufacturers to invest in capability development, and ensure the judicious use of grant-in-aid funding.

2. The industry stakeholders could consider setting up an industry-led solar skills development council. The following framework can be used:
   a. Setting up of dedicated council under Skill India Mission and MNRE, led by key industry players to ensure collaboration with ITIs, polytechnic institutes and engineering colleges to create industry-relevant curricula with frequent revision as per evolution in the industry.
   b. Introducing structured training programs for key manufacturing roles such as polysilicon and wafer processing, solar cell and module assembly and quality control and automation in solar factories with government backed certifications
   c. The proposed council could collaborate with MSDE, NSDC and MNRE to deliver solar-manufacturing courses under PMKVY 4.0, using “Short-Term Training and Special Projects” for new entrants and “Recognition of Prior Learning” to upskill and certify the existing workforce. These interventions could be complemented by on-the-job training and apprenticeships under the National Apprenticeship Promotion Scheme.

[151] USD arrived at using an exchange rate of 88.3 (average of fiscal 2026)

d. Partner with global solar leaders (Germany, USA, South Korea) to train Indian workers in cutting-edge manufacturing techniques. A precedent is seen in automobiles sector with Japan and Germany for EV skilling. Partnerships could also be explored with China to access solar-manufacturing know-how and accelerate technology transfer for workforce training.

e. Develop e-learning platforms and certifications.

Access to capital goods, investment in innovation, and the availability of skilled manpower collectively form the foundational building blocks of a competitive manufacturing ecosystem. However, the pace at which manufacturing capacity is established and expanded also depends on the broader business environment. Factors such as land availability, infrastructure readiness, regulatory approvals, power access, and policy clarity can influence investment decisions and project execution timelines. Consequently, ease of doing business remains an important consideration in supporting the continued growth of India's solar PV manufacturing sector.

4. Ease of doing business:

While the ease of doing business varies across states, the thrust from government initiatives such as PLI, BCD, and ALMM I and II has created a conducive policy landscape for Indian manufacturers to scale up their operations rapidly. In addition to the above, the regulators could consider taking two additional steps to support Indian manufacturers in setting and scaling up their factories.

As the industry moves towards larger and more integrated manufacturing facilities, the importance of supporting industrial infrastructure and efficient regulatory processes is expected to increase. In addition to policy incentives, factors such as land availability, utility access, connectivity, approval timelines, and infrastructure readiness can influence the speed and scale of manufacturing investments. Strengthening these enablers can help improve project execution, support capacity expansion, and enhance the overall competitiveness of India's solar PV manufacturing ecosystem.

i. Identifying manufacturing clusters

Need: Manufacturing hubs concentrate manufacturers and suppliers in the same location, driving cost reduction, subsidy utilities, improve supplier options and innovation.

Recommendation:

A precedent has been established in the China for the same. Infrastructure on these lines was set up in China (Pearl River Delta) and Malaysia (Kulim and Penang) for solar. In India, the cluster-based manufacturing model has already delivered significant benefits across sectors such as automobiles, electronics and chemicals, providing a strong domestic precedent for establishing a similar integrated manufacturing ecosystem for the solar industry.

State governments could consider attracting investments from solar manufacturers and their suppliers by developing manufacturing hubs. Given the scale of anticipated investment, multiple states have an opportunity to attract manufacturers and create multi-gigawatt scale hubs.

a. **Deemed approval of open-access renewable energy and removal of net metering limits:** States could consider providing deemed approval for open-access renewable energy projects and reviewing net metering limits. This may help manufacturers access affordable and reliable clean power, potentially supporting operational efficiency and sustainability goals.

b. **Identification of suitably sized land parcels:** By identifying and aggregating land parcels with competitive leasing rates and ensuring connectivity to road, port, and air infrastructure, states might lower entry barriers for investors. Such steps could enhance the attractiveness of the state for potential manufacturers.

c. **Including solar manufacturing as a thrust/priority sector:** States could explore designating solar manufacturing as a thrust or priority sector in their industrial policies. This could unlock targeted incentives and signal policy intent, potentially encouraging both anchor investments and the development of supporting supply chains.

d. **Support for labour requirements:** Labour availability may be enhanced through skill-training initiatives tailored to the solar manufacturing sector, and by developing residential facilities for workers, particularly in underdeveloped regions. Such measures might help ensure a steady supply of skilled labour and support wider community development.

e. **Long-term tie-ups and anchoring hubs to solar parks:** As state-owned utilities account for a significant share of power procurement and distribution, they could evaluate the possibility of long-term tie-ups with developers and manufacturers in the state to secure solar module supplies, possibly at favourable costs. States might also consider anchoring manufacturing hub development to large-scale upcoming solar parks, which could provide integrated infrastructure and shared benefits.

f. **Co-located common R&D facility:** Establish co-located common R&D and testing facilities within each manufacturing hub, anchored by India's National Institute of Solar Energy (NISE) – which already operates solar PV module test laboratories, reliability and performance test rigs, and certification, standardization and skill development capabilities at its 200-acre Gurugram campus. Replicating these shared facilities at hub level would compress certification turnaround times, lower per unit testing costs for small and mid-sized manufacturers, and provide a platform for collaborative innovation in cells, modules and capital BoS components as Indian manufacturers deepen their presence in the upstream value chain.

While infrastructure and industrial ecosystem development can support the establishment of manufacturing facilities, long-term investments across the solar value chain are also influenced by policy visibility and market certainty. Given the capital-intensive nature of solar manufacturing, particularly in upstream segments such as polysilicon and wafers, investors typically require clarity on the regulatory and trade environment over an extended period. Accordingly, the predictability of measures relating to import protection and domestic manufacturing support can play an important role in facilitating investment decisions, particularly in capital-intensive upstream segments of the value chain.

Transitioning from market protection to long-term competitiveness

ii. Balancing industry support with competitive market development

Recommendation:

The implementation of ALMM I has facilitated the scaling of downstream components and is likely to yield benefits for upstream segments. However, its effects should be monitored closely to guard against potential oversupply and to sustain market competitiveness. Accordingly, it is recommended that policymakers consider including a sunset clause or a conditional phase-down mechanism for ALMM I once pre-defined market indicators are met. Such an approach would allow the policy to be relaxed when appropriate—thereby incentivizing competition and preventing market complacency—while retaining the ability to extend or reintroduce support if market conditions warrant.

Supporting Grid and Storage Infrastructure

Focus on grid storage and infrastructure development is also critical. India's installed solar capacity, and the additional capacity planned through 2030 and beyond, will generate power that is concentrated in daylight hours and subject to seasonal and weather-related variation. The ability to utilise this power reliably across demand cycles depends on the availability of adequate transmission infrastructure to evacuate power from generation-rich states to load centres, and storage infrastructure to shift surplus generation to periods of peak demand. Without continued and scaled focus on both, additions to generation capacity alone will not translate into grid reliability or energy security.

The consequences of an infrastructure deficit with India's renewable energy growth outpacing its transmission infrastructure, the impact may be witnessed in form of curtailments and underutilised capacity, especially in renewable-rich states. The lack of evacuation infrastructure may also delay the commissioning of new projects as they await grid connection. Continued and scaled focus on grid storage and transmission is therefore not a downstream policy concern — it is a prerequisite for the effective utilisation of every megawatt of solar capacity that is or will be installed.

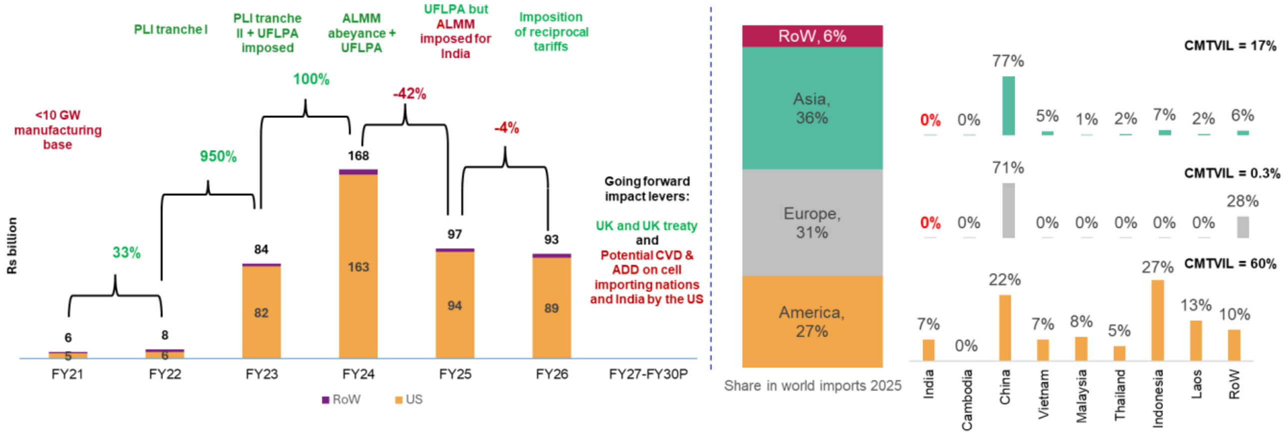
While strengthening domestic manufacturing capabilities and supporting infrastructure remain important priorities, the long-term sustainability of the sector will also depend on access to sufficiently large and diversified markets. As manufacturing capacities continue to expand across the value chain, exports can play an important role in supporting capacity utilisation, diversifying revenue streams, reducing dependence on individual markets, and improving the resilience of the domestic manufacturing ecosystem. Consequently, alongside domestic demand growth, the development of diversified export opportunities assumes increasing importance for India's solar PV manufacturing sector.

5. Export agreements:

Exports are crucial for solar module manufacturers as they support premium revenue growth, improve capacity utilisation, and expand market reach beyond domestic demand. The increase in India's module manufacturing capacity to 173 GW by March 2026 created a stronger platform for export-led growth. However, India's solar module exports remain highly concentrated in a single destination market—the US. Overall, the US accounted for 97% of India's solar module exports between fiscal 2020 to 2026, underscoring the sector's heavy dependence on one geography. In contrast, India's share in other key regions such as Europe, Asia, and the rest of the world remains negligible, limiting its ability to diversify revenue streams and reduce exposure to market-specific risks. This high concentration exposes Indian manufacturers to demand fluctuations, trade policy changes, tariff actions, and procurement shifts in the US market.

As India's manufacturing capacity continues to expand, maintaining access to multiple export destinations will become increasingly important for sustaining capacity utilisation and reducing market concentration risks. Diversified export markets can provide greater resilience against changes in trade policies, demand cycles, and geopolitical developments in any single geography. Consequently, the ability to establish a broader international presence and diversify export destinations is likely to become an important factor in supporting the long-term competitiveness and stability of India's solar PV manufacturing sector.

Figure 91: Trade sanctions by US on China opens door for Indian exports; results in geographic concentration



Note: UFLPA stands for Uyghur Forced Labor Prevention Act. CVD and ADD refer to countervailing duties and anti-dumping duties, respectively. Green indicates favourable outcomes, while red indicates unfavourable outcomes.

Source: Ministry of Commerce

While exports have supported capacity utilisation and revenue growth, the concentration of exports in a limited number of markets creates exposure to evolving trade and policy developments.

Challenges:

1. As of the current date, India lacks an export agreement with the US for the supply of solar technologies, including cells and modules. This is significant as the US remained the largest global importer of solar cells and modules in CY2025, accounting for nearly 21% of global imports. At the same time, the US has adopted an increasingly protectionist trade stance, imposing anti-dumping duties (ADD), countervailing duties (CVD), and reciprocal tariffs on several exporting nations. It has imposed ADD and CVD in the range of 15% to 3,404% on Cambodia, Vietnam, Thailand, and Malaysia, while also proposing duties of 103% to 249% on India, Laos, and Indonesia over the reciprocal tariff. These measures have raised the landed cost of imported solar cells and modules in the US, contributing to a decline in exports from India and other affected markets.
2. Against this backdrop, India's rapidly expanding manufacturing base faces heightened market-access risk. With 90-100 GW of cell-to-module capacity additions announced, the industry could face oversupply pressures at the module stage of the value chain if export channels remain constrained. As the domestic capacity base rises, diversification of export markets beyond the US becomes critical to reduce policy-driven demand shocks, protect capacity utilization, and support the long-term viability of India's solar manufacturing ecosystem.

Furthermore, barring the US, India's supply to top importers such as Netherland, Brazil and Spain remain negligible.

Figure 92: India's share is limited in top importer's basket

PV trade dynamics 2025		Top World Importers (% share)					
		USA	Germany	Netherlands	Brazil	Spain	Share in world exports
Top World Exporter (% share)	China	0.1%	88%	84%	98%	81%	61%
	Malaysia	10%	0%	0%	0%	0.2%	2%
	Thailand	7%	0%	0%	0.1%	0.1%	3%
	Vietnam	9%	0.2%	0%	0%	0.3%	3%
	India	9%	0%	0%	0%	0%	3%
	Share in world imports	21%	5%	4%	3%	3%	

Note: Above trade statistics are for CY 2025

Source: ITC Trademap

It should be noted that trade relationships, market access discussions, and international cooperation frameworks continue to evolve. In recent years, both the Government of India and industry participants have increased their engagement with global markets through trade dialogues, commercial partnerships, and investment initiatives. While some of the market-access challenges identified in this section may be addressed gradually through ongoing negotiations and evolving trade arrangements, continued efforts towards export diversification remain important for reducing concentration risks and supporting long-term growth in the solar PV manufacturing sector.

Recommendations:

1. The government could consider helping trade and market expansion through bilateral and multilateral trade agreements. Negotiate favourable trade agreements to reduce tariffs and trade barriers with the key importers.
2. Focus on signing MoUs with key importers. A precedent has been established in the green hydrogen sector where the government has signed an MoU with Saudi Arabia in electrical interconnections, green/clean hydrogen and supply chains in October 2024.
3. Diversifying Export destinations: The global solar market is poised for significant growth, with an expected addition of 5 TW of solar capacity by 2030. Excluding China, India, and some advanced economies, the rest of the world is anticipated to add approximately 624 GW of solar capacity over the next six years, starting from 2025. This translates to a substantial annual addition of around 104 GW. India, which already contributes 3% to the US solar PV export basket, can tap into this growing market. India can potentially extend Lines of Credit to developing countries. This can be done in line of Export-Import Bank of India (EXIM Bank), entering into agreement with government of Guyana to provide a Line of Credit worth $2.5 million[152] for installation of a solar photo voltaic powerplant at Cheddi Jagan International Airport.
4. The industry stakeholders could consider the recommendations provided in point 1 of recommendations (enhancing their presence in the global market through JV and acquisitions) for the key importing nations. Apart from this, industry stakeholders are also encouraged to expand in the global market by setting up assembling/manufacturing plants to increase their presence. A precedent has been established by Premier Energies and Waaree Energies to improve their presence in the US market.

[152] India-Guyana

5. Apart from this, both the government and industry stakeholders could focus on organising trade missions and expos to form export and strategic alliances with not only the top importers but also countries with solar power targets. With the capacity expansion planned in India, the country can be become the second largest PV manufacturer with the required upstream value chain, after China. India is already the second largest module manufacturer in the world with an enlisted capacity of 183 GW in ALMM release dated May 1st 2026.
6. The India-EU free trade agreement, whose negotiations were concluded on January 27, 2026, against the backdrop of EUR 120 billion[153] in bilateral goods trade in 2024, eliminates or reduces tariffs on over 96% of EU goods exports and reciprocal Indian exports, and contains explicit commitments on cooperation in renewable energy, low carbon goods, and the easing of trade and environmental goods and services. Industry stakeholders could therefore consider routing module and cells exports to UK and EU offtakers under the preferential tariffs once both agreements enter into force. They could also form joint ventures with European project developers, given that EU's required annual solar deployment may continue to outstrip the European solar PV industry.

Conclusion

India's solar PV manufacturing sector has made significant progress over the past decade, supported by targeted policy interventions, increasing domestic demand, and substantial capacity additions across the downstream value chain. The rapid expansion in module and cell manufacturing demonstrates the sector's ability to scale and support the country's renewable energy ambitions.

At the same time, the next phase of growth is likely to depend on the continued development of upstream manufacturing capabilities, technology leadership, workforce readiness, industrial infrastructure, and diversified export markets. While considerable progress has been made across several of these areas, many of the challenges identified in this report remain interconnected and require coordinated action from policymakers, industry participants, research institutions, and other stakeholders.

It is also important to recognise that policy and market developments continue to evolve. In several areas, measures introduced by central and state governments, as well as strategic initiatives undertaken by industry participants, may already be contributing towards addressing some of the challenges highlighted in this assessment. Nevertheless, continued focus on strengthening domestic value addition, improving competitiveness, and enhancing ecosystem resilience will remain important as India advances towards its renewable energy and manufacturing objectives.

Taken together, the challenges and recommendations presented in this report should be viewed not as isolated interventions, but as complementary elements of a broader effort to establish a competitive, integrated, and globally competitive solar PV manufacturing ecosystem in India.

153 EU Europa

Conclusion

India's aspiration of becoming a global manufacturing hub by 2047 will require a focused strategy that combines scale, competitiveness, innovation, and integration into global value chains. The analysis presented in this volume demonstrates that Chemicals, Textiles, Telecom & Network Equipment, and Solar PV Manufacturing represent four distinct yet complementary pathways through which India can accelerate industrial growth, generate employment, enhance technological capabilities, strengthen self-reliance, and expand its presence in international markets. Together, these sectors capture the breadth of India's manufacturing opportunity: from employment-intensive industries and foundational industrial inputs to advanced technology products and strategic sectors of the future.

A common theme emerging across all four sectors is that India possesses significant inherent advantages, including a large domestic market, a favourable demographic profile, an improving policy environment, growing infrastructure investments, and increasing global interest in supply-chain diversification. However, these strengths alone will not be sufficient to secure global leadership. Across sectors, challenges such as import dependence on critical inputs, fragmented supply chains, infrastructure and logistics gaps, limited domestic value addition, technology constraints, and skill shortages continue to constrain competitiveness. Addressing these bottlenecks will require a coordinated approach involving the Union and State Governments, industry, academia, financial institutions, and the broader innovation ecosystem.

The sectoral analyses also reinforce the importance of moving beyond assembly-led or low-value manufacturing towards deeper and more resilient value-chain participation. In chemicals, the priority lies in strengthening domestic feedstock availability, developing integrated manufacturing clusters, and increasing downstream value addition. In textiles, enhancing competitiveness in man-made fibres, improving productivity, modernising MSMEs, and expanding market access will be critical. In telecom equipment, the focus must shift towards localisation of components, technology development, and export-oriented manufacturing ecosystems. In solar PV, scaling upstream capabilities, strengthening research and development, and reducing dependence on imported inputs will be essential to building a globally competitive industry.

The experiences of global manufacturing leaders examined in this report further highlight that sustained success is rarely the result of a single policy intervention. Rather, it is achieved through long-term policy consistency, industrial clustering, infrastructure readiness, targeted incentives, investment in technology and skills, and strong linkages between domestic firms and global markets. The lessons drawn from countries such as China, Vietnam, South Korea, Singapore, and others underscore the importance of execution, institutional coordination, and the creation of complete industrial ecosystems rather than isolated manufacturing capacities.

As India seeks to increase the contribution of manufacturing to economic growth, exports, and employment, the recommendations outlined in this volume provide a practical roadmap for action. If implemented in a coordinated and time-bound manner, they can help strengthen domestic capabilities, attract investments, enhance productivity, improve export competitiveness, and create quality employment at scale. More importantly, they can enable India to secure stronger positions in global value chains while building the resilience and technological depth necessary for long-term industrial leadership.

This volume marks the first step in a broader effort to identify and develop the sectors that can drive India's manufacturing transformation. The opportunities presented by Chemicals, Textiles, Telecom & Network Equipment, and Solar PV Manufacturing are substantial, but equally significant is the broader message that emerges from the study: India has the potential to become a globally competitive manufacturing powerhouse, provided it combines ambition with sustained reforms, targeted investments, and disciplined execution. The subsequent volumes will extend this analysis to the remaining priority sectors, completing a comprehensive roadmap to support India's journey towards becoming a leading global manufacturing hub and realizing the vision of Viksit Bharat@2047.