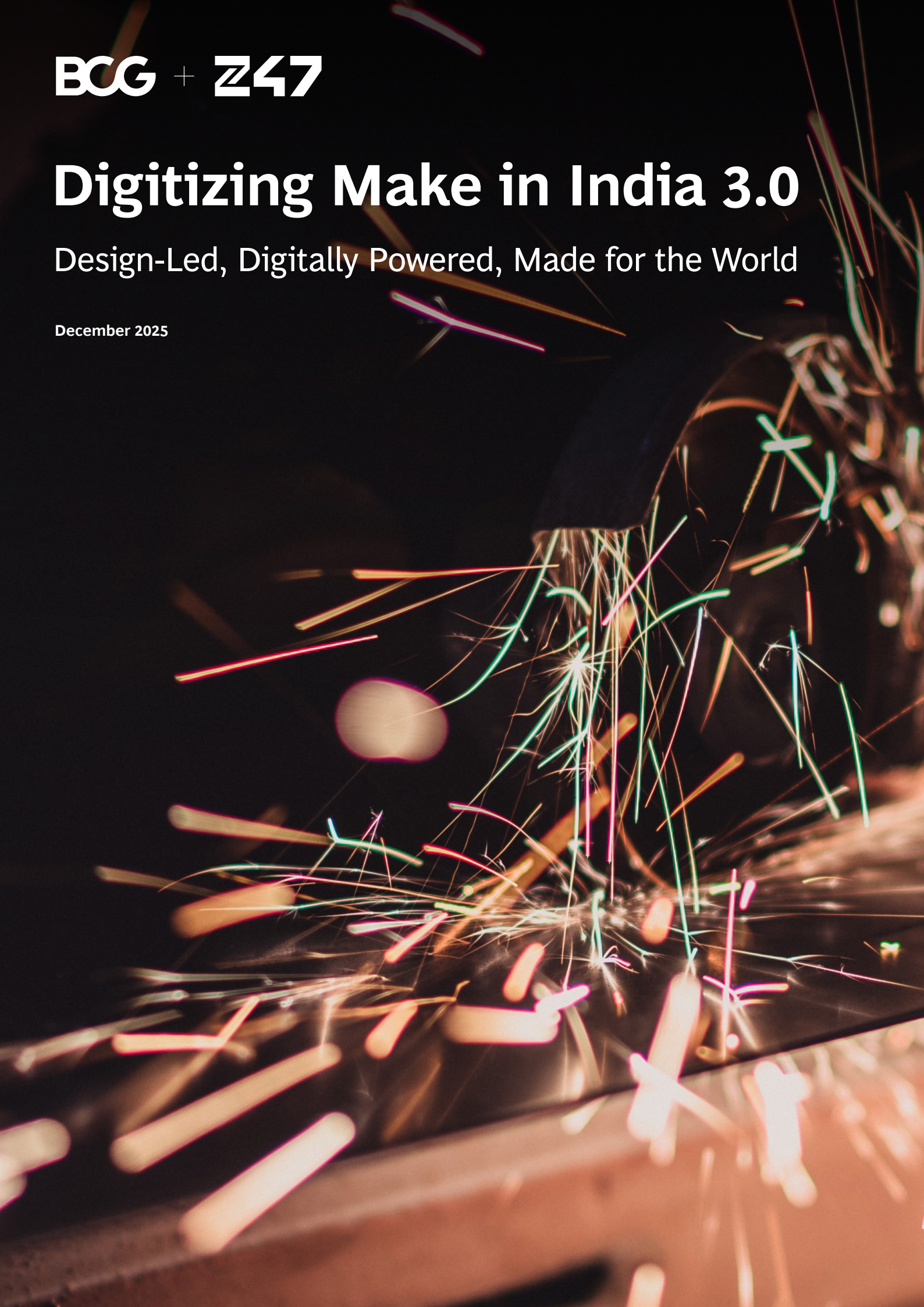
BCG + Z47

Digitizing Make in India 3.0

Design-Led, Digitally Powered, Made for the World

December 2025



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Established in 2006, Z47 is a venture capital firm investing across Fintech, Consumer, B2B Manufacturing, Deeptech and Enterprise AI companies, with an AUM of USD 3.5 Bn. Guided by a ‘founders first' approach, Z47 has partnered with over 100 companies shaping India’s growth story, including Five Star Business Finance, OfBusiness, Ola, Razorpay, and Ola Electric, as well as Captain Fresh, FarMart, Vegrow, Neysa, and Krutrim.

The name Z47 reflects two ideas that define the firm’s mission: Z for Zen, symbolizing the mindfulness, balance, and long-term conviction that guide its investment philosophy; and 47 for 2047, representing the shared dream of a Viksit Bharat: a developed nation by India’s centenary of independence.

At Z47, founders always come first. The firm partners closely with entrepreneurs, from those nurturing nascent ideas to those scaling established ventures, helping them turn ambition into reality and build businesses that shape India’s future.

Contents

Approach

Foundational Research and Expert Consultations

We began with an extensive exploration of the ecosystem, engaging global experts and industry specialists. Through in-depth desk research, secondary sources, and domain insights, we established a foundational understanding of the landscape, its defining categories, and market dynamics.

Trend Synthesis and Industry Outlook

Insights from primary and secondary research were synthesized to identify priority sectors and emerging themes. These were benchmarked against global nations to contextualize India's trajectory.

Validation and Collaborative Review

We validated findings through iterative reviews with Industry domain experts and external advisors. This cross-functional collaboration ensured balanced perspectives, and actionable insights for industry stakeholders, investors, and policymakers.

Executive Summary

Overview

India's Vision 2047 pivots manufacturing from assembly-led growth to technology-led value creation. India targets manufacturing's share of GDP to rise towards ~25% by 2047. Government programs such as Make in India, Atmanirbhar Bharat, PLIs are intended to act as enablers and shift India towards design, R&D and global value-chain integration.

Multiple priority areas emerge for India's growth vision in the manufacturing sector going forward such as—Electronics & Semiconductors, Defence, Automotive & EV, Energy Manufacturing & Transition, Pharmaceuticals—as they combine strong growth, industry push and a clear policy/investment runway. Electronics shows the largest import dependence yet centrality to digital/AI; defence is a critical domain with Make in India push; auto/EV anchors mobility scale; energy tackles the import bill while enabling the green transition; pharma leverages India's R&D and vaccine strengths.

What's working, What's Missing and Where do Opportunities lie

Electronics and Semiconductors: A >USD 3 Tn global industry foundational to AI, data centres, EVs, telecom and industrial/consumer electronics, semiconductors are also a large domestic demand story: India's end-market was ~USD 33 Bn (2022) and is projected to reach ~USD 117 Bn in 2030. A case emerges for local capability in the sector as ~75% of global fab capacity sits in Mainland China-South Korea-Japan and nearly all sub-10 nm in South Korea, indicating high concentration.

Over the last decade India scaled EMS (now #2 by mobile volume; 99.2% of phones sold are made in India) and began an early DC/compute build-out (~1.3 GW live; ~2.7 GW pipeline; ~USD 20 Bn), with hyperscaler projects and multiple policy levers (PLI, ISM, DLI, C2S, IndiaAI, ECMS).

However, some gaps still exist – domestic wafer and display fabrication capacity remains limited, while the materials and equipment base (including specialty gases, photomasks, and precision tools) relies on imports. Component manufacturing (HDI/ML PCBs, IC substrates, passives) and localization of data-center and AI hardware such as servers and power systems are at nascent stages. Moreover, India-owned chip IP and venture investment activity are expanding but require further depth.

Defence: Global defence outlays reached ~USD 2.7 Tn (2024); India allocated INR 6.81 Lakh Cr budget (FY25-26), doubled over a decade, with a clear Make-in-India push. Imports have declined ~9.3% (vs. 2015-19), ~92% of FY25 contracts were awarded to domestic industry. Exports have reached ~INR 23,000 Cr and a USD 160-190 Bn+ domestic pipeline currently exists across 75+ platforms.

India's defence manufacturing has made significant strides toward self-reliance with indigenous platforms like the Tejas, Prachand helicopter, INS Arihant submarine, and INS Vikrant carrier showcase advanced local design and production capability. Participation from private players are growing and startups under iDEX and ADITI are driving innovation in AI, drones, and autonomy. India's defence exports continue to grow significantly.

India should now consider moving up the value chain-building deeper capability in propulsion, advanced electronics, and components. Accelerating indigenous engine programs and developing export-grade subsystems will be key to reducing import reliance. Further development of defence clusters, along with continued strengthening of industrial corridors and export facilitation mechanisms, could play an important role in enhancing India's global competitiveness.

Automotive and EV: India's auto industry is the anchor of manufacturing—~7.1% of GDP and ~49% of manufacturing GDP—with ~28 Mn vehicles produced in FY2024 across 2W/3W/PV/CV. Ownership (~58 cars per 1,000 people) leaves ample headroom for growth. On electrification, India has built momentum: EV sales climbed from ~50,000 (2016) to 2.08 Mn in 2024, taking stock to ~5.45 Mn—~9% of the global EV park—creating a platform to scale domestic industry and exports.

A coherent push–pull policy architecture is now in place—Make in India; PLI (Auto: INR 25,938 Cr; ACC: INR 18,100 Cr); early stage demand programs (FAME I/II); and PM E DRIVE (INR 10,900 Cr; Oct 1 2024–Mar 31 2026) – aimed at deepening local value add while sustaining demand formation.

India should look at capturing the electronification wave: scale export plays in wiring harnesses, ECUs/infotainment and advanced driver-assistance, and localize high-value EV electronics with advanced packaging and high-density PCB clusters. Underpin this with outcomebased R&D that shifts suppliers from buildtoprint to buildtodesign, plus shared worldclass toolrooms in major clusters.

Energy: India's total installed power capacity is ~480 GW (Mar 2025); clean energy buildout is accelerating amid record global energy investment (>~USD 3 Tn in 2024; ~USD 2 Tn in clean energy). India added a record ~29.5 GW RE in FY2024 25, taking total RE to ~220 GW (ex large hydro), signaling rapid grid scale transition.

Going forward, opportunities lie in local HVDC-equipment production, backward integration in solar value chain up to polysilicon, and indigenization of wind-turbine components such as gearboxes. In batteries, India is projected to add

Source: Secondary Research

50-70 GWh of capacity annually, creating scope for localization across cells, materials, and recycling. Strengthening R&D and manufacturing capabilities will enable India to participate in the global grid-infrastructure super-cycle and consolidate its clean-energy leadership.

Pharmaceuticals: India is the world's largest supplier of generics (~20% of global volume) and produces ~60% of global vaccines, supported by the highest number of US-FDA-compliant plants outside the US and exports to 150+ countries. While the industry - valued at USD 130 Bn by 2030—retains strong cost and quality advantages, import dependence on APIs/KSMs from China (~60-70% across critical molecules) remains a key vulnerability. Beyond generics, the CRDMO segment has emerged as India's next growth engine, accounting for ~2-3% of the USD 140 Bn global market and growing twice the global average (15% CAGR).

With cost-efficient small-molecule expertise, rapid turnaround times, and rising biologics capabilities, Indian CRDMOs could scale to USD 22-25 Bn by 2035, moving from outsourcing to co-innovation. The opportunity lies in strengthening upstream API production, fostering innovation in biologics and new modalities, and building integrated discovery-to-manufacturing ecosystems to anchor India's position in global life sciences.

Chemicals (including Specialty): India is the 6th largest chemical producer globally and 3rd in Asia; the sector contributes ~7% to GDP and spans 80,000+ products. India's specialty chemicals players benefit from global China+1 resourcing and long term contracts, sustaining a strong outlook.

Potential areas for further unlock include reducing import dependence on feedstock and intermediates. High import dependence (trade deficit ~USD 31 Bn in 2023) and limited upstream intermediates constrain value capture. Additionally, R&D intensity remains lower at only 0.7% investment against the global average of 2.3%—hampering indigenous innovation in high-value chemicals.

Multiple Policy Initiatives have been introduced to Strengthen India's Manufacturing Ecosystem

In electronics, a cohesive stack—including the PLI, the Electronics Components & Manufacturing Scheme (ECMS 2025), DLI and C2S—is intended to deepen the value chain from assembly into components, PCBs and design.

In defence, measures such as DPM-2025 (five-year assured orders, removal of NoC requirements, and relaxed LDs), DPEPP-2020, iDEX/ADITI/TDF, SRIJAN, the Defence Industrial Corridors are introduced to lower entry barriers, accelerated procurement processes, and increase visibility of future demand.

In automotive and EVs, initiatives including PLI (Auto/ACC) and FAME-III are designed to catalyze investment and support demand creation. The PLI-Auto (INR 25,938 Cr) and ACC Battery PLI (INR 18,100 Cr; 40 GWh already awarded) aim to anchor advanced auto and cell manufacturing capacity.

In energy, the clean-energy manufacturing push (solar/storage/green-H_2) and a visible investment pipeline are aligning industry to net-zero. Policy thrust spans Green Hydrogen (INR 19,744 Cr), grid/storage, and RE manufacturing, building the backbone for EVs, data centers and industry.

In pharmaceuticals, the PLI-Pharma program (INR 15,000 Cr) supports high-value formulations, while the Bulk Drugs PLI (INR 6,940 Cr) is facilitating commissioning of API and KSM capacity.

Potential Pathways for India going forward

India's next manufacturing leap could revolve around four potential pillars: (1) Fostering Innovation, (2) Strengthening strategic depth, (3) Enhancing competitiveness and (4) Driving efficiency through technology adoption. Each pathway represents a set of options for policymakers and industry participants to consider in enabling India's manufacturing transformation.

Fostering Innovation

- **Deepen R&D and Design Intensity:** Policymakers could consider mechanisms such as multi-year, mission-led R&D budgets with industry co-funding to strengthen research outcomes. India's current R&D spending, at ~0.9% of GDP, trails peers such as the United States (3.5%) and China (2.4%)
- **Attract and embed top research talent in industry:** Increasing the share of PhD-level talent in manufacturing and enabling return programs for global Indian researchers. Competitive fellowships and re-entry pathways—similar to China's Thousand Talents and South Korea's KIAT programs—could be explored to draw diaspora expertise into national innovation ecosystems
- **Ease start-up participation:** Evaluate simplifying procurement, vendor registration, and eligibility norms to allow startups to supply subsystems and co-develop with OEMs and DPSUs

Establish Strategic Dominance

- **Build the Mid-Stack and Deepen Indigenization:** Pathway is to move from final assembly toward greater capability in components, materials, and subsystems. Policies could evaluate shifting incentives (e.g., DLI

Sources: PIB, Govt. Data, BCG Analysis, Secondary Research

focus) toward upstream areas and adopt standardized design frameworks that allow for production scalability

Encourage standard design frameworks to allow for scale in production

- **Design for Global Markets from Day One:** Creating national export-readiness checklists and establishing joint testing protocols with global OEMs could help Indian manufacturers align with international standards

  In parallel, deepening global manufacturing corridors could strengthen supply-chain promotion and regulatory cooperation

Improve Competitiveness by lowering factor costs

- **Double Down on Cluster-Led Growth:** Support the creation of dense multi-sector industrial clusters with shared testing labs, logistics, and training to reduce costs and speed up innovation velocity
- **Scale Testing and Skilling:** Launch process-engineering academies in key manufacturing domains (set up dedicated training hubs for skills such as PCB fabrication, chip packaging (OSAT), and precision machining). For e.g. Singapore's SkillsFuture and South Korea's Meister schools integrate skilling directly into cluster ecosystems
- **Developing Risk Capital at Scale:** Large growth-stage and supplier-finance funds for component and subsystem makers will allow these players to scale capacity (For e.g. Japan's JIC and China's big fund catalyzed mid-stack scale-ups via similar routes)

Drive efficiencies through AI

- **Adopt AI and Industry 4.0 in Factories and Design Flows:** AI-driven automation and digital factory tools could be key levers for improving yield, quality, and productivity. Policymakers could evaluate linking PLI disbursements to measurable adoption of AI and smart manufacturing technologies. For instance, China's Smart Factory 2025 initiative reportedly achieved ~20% productivity gains through AI–MES integration

1. Manufacturing Focus Areas in India's 2047 Roadmap

India's Vision 2047 outlines a transformative journey toward becoming a developed, self-reliant, and globally competitive economy, powered by advanced manufacturing, innovation, and sustainability. With a current GDP exceeding USD 3.7 Tn, India stands as the fifth-largest economy globally and is projected to grow to USD 30 Tn by 2047. Manufacturing, which today contributes roughly 17% to India's GDP, is envisioned to expand to 25% by 2047, underpinned by record FDI inflows amounting to ~INR 4,22,000 Cr (USD 49.3 Bn) in FY25 a 15% increase over FY24.

Structural reform initiatives such as Make in India, Atmanirbhar Bharat, and the Production Linked Incentive (PLI) schemes have been introduced to strengthen the foundation for industrial growth and attract higher foreign direct investment (FDI). India's manufacturing landscape is now viewed as gradually evolving from assembly-led expansion toward technology-led value creation, with a stronger focus on design, R&D, and integration into global value chains.

Within this transformation, multiple sectors emerge as strategic priorities for realizing the Viksit Bharat @2047 vision: Electronics & Semiconductors, Defence, Automotive & EV, Energy, Pharmaceuticals, and Chemicals & Chemical Products. These sectors collectively demonstrate strong growth potential, high value addition, and opportunities for self-reliance and export expansion.

Sector	GVA (INR Mn) 2022-23	Growth% 2022-23	FDI (USD Mn) 2023	Import (USD Mn) 2023-24	Budget allocation (INR Mn) 2025-26	Startup Funding (USD Mn) since 2021	Opportunity areas
Electronics & Semiconductors							Large market with high FDI and very high import dependence; strong policy tailwinds (PLI/DLI/Semiconductor Mission) enable shift from assembly to design/ATMP/OSAT, positioning for technology-led exports and supply-chain resilience
Auto and EV							Largest GVA with fast growth; global shift to sustainable mobility aligns with PLI-Auto/ACC & FAME; strong base to localize cells, magnets, power electronics and build exportable EV components
Pharmaceuticals							High value-add and R&D/patent intensity; API self-reliance and research-linked PLIS strengthen position; growth from biologics/ biosimilars/CRAMS sustains innovation-led exports and health security
Defence Manufacturing							Strategic autonomy priority backed by very high public outlay and domestic procurement norms; start-up/MSME programs (iDEX/TDF) and export momentum support indigenization and dual-use innovation
Energy							System-critical with a massive import bill; clean-energy push (solar, storage, green H2) + cost edge in grid equipment create localization and export runway; investment pipeline supports scale manufacturing
Wearing Apparel							Labor-intensive employment and export niche; fragmentation and compliance pressures limit tech-led value add; steady but not a scale driver for 2047
Textiles							Integrated supply chains and export links; energy/capex intensity and legacy tech constrain step-change; targeted modernization rather than broad push
Basic Metals							Large, infra-linked backbone with cyclical margins and decarbonization costs; incremental modernization expected, limited tech disruption upside

Sources: BCG Analysis, Secondary Research

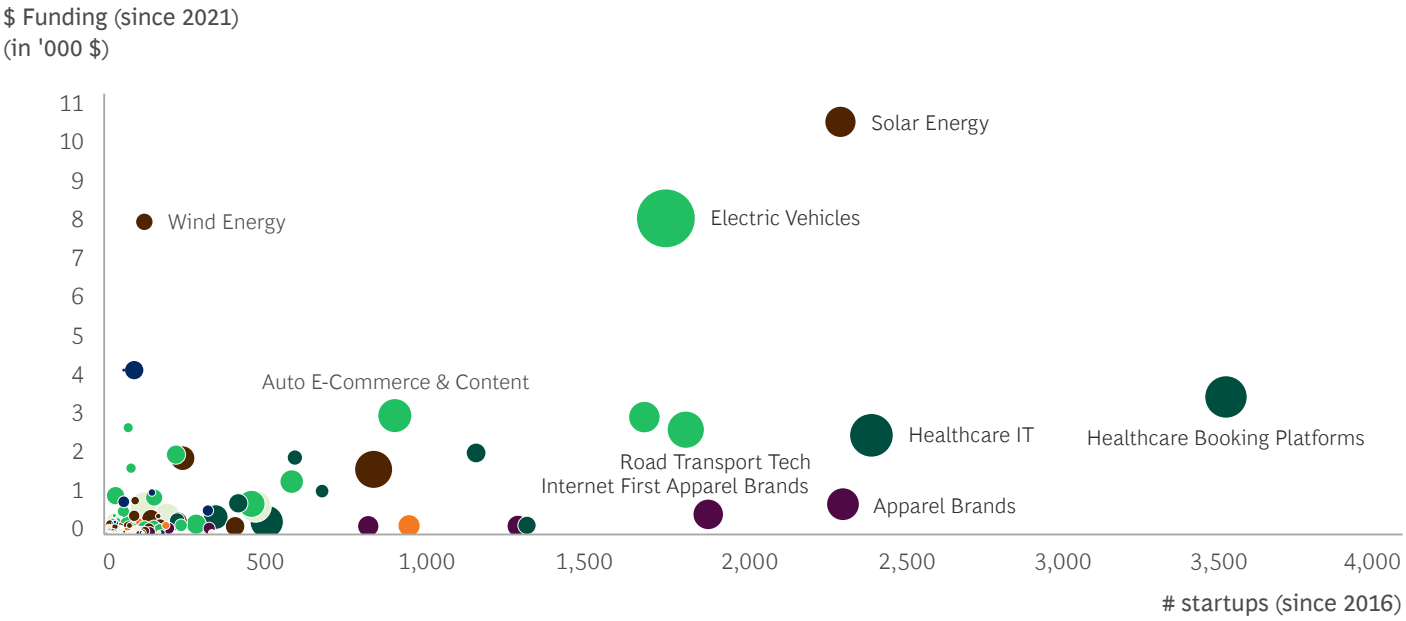
Sector	GVA (INR Mn) 2022-23	Growth% 2022-23	FDI (USD Mn) 2023	Import (USD Mn) 2023-24	Budget allocation (INR Mn) 2025-26	Startup Funding (USD Mn) since 2021	Opportunity areas
Other Non-metallic Mineral Products							Construction-dependent (cement, glass, etc.); moderate value add; structural limits on tech impact despite efficiency gains
Machinery and Equipment n.e.c							Double-digit growth and capital-goods depth; enabler for focus sectors (EV, energy, defence) more than standalone growth engine; selective promotion warranted
Chemicals and Chemical Products							High GVA; specialty chemicals show export momentum, but feedstock/ energy and regulatory complexity temper broad push; strong adjacent play to electronics/EV/energy value chains
Rubber and Plastic Products							Key inputs to auto/electronics; exposure to petro feedstocks and compliance costs; supplier-tier upgrades rather than headline sector push

EV, Energy and Healthcare lead in Funding and Startup activity in recent years

Key Takeaways:

Solar Energy and EVs have attracted the highest funding volumes, supported by a moderately large startup base, reflecting strong investor confidence and scalable market potential

Wind Energy demonstrates high funding concentration but limited startup depth, while Healthcare Booking Platforms exhibit broad ecosystem participation with moderate funding intensity



Category:

Electronics · Auto & EV · Healthcare/Pharma · Aerospace, Maritime & Defense · Chemicals and Materials
Energy · Apparel · Textiles · Machinery and Equipment
100 Bubble size = # Funding events

2. Charting the Future of India's Electronics & Semiconductor sector

Why this Matters for India

Large global market:

Electronics and Semiconductors is a USD 3 Tn+ global industry—foundational to almost all end-sectors such as AI, Data Centres, EVs, Telecom, Defence, Auto, and Consumer and Industrial Electronics

Large domestic market:

India's semiconductor end-market demand was ~USD 33 Bn in 2022 and is projected to reach ~USD 65 Bn by 2026 and ~USD 117 Bn by 2030, led by applications in Mobiles, Telecom and IT sectors

Vulnerability due to global supply concentration and India's imports dependence:

About 75% of the semiconductor manufacturing capacity is in Mainland China, South Korea, and Japan. Further, nearly all advanced semiconductor manufacturing capacity (i.e., nodes below 10 nanometers) is in South Korea

Such high supply concentration, along with India's imports dependency for semiconductor chips, makes it vulnerable to supply chain disruptions due to natural disasters, infrastructure shutdowns, tariff uncertainty, and other geopolitical tensions in the current global context

Important for India's manufacturing and employment growth:

Electronics and Semiconductors is a critical industry to support India's growing exports (especially in electronics), high-quality job creation for a large and growing workforce, technological self-reliance (especially in the age of AI) and upstream value capture in manufacturing

Where does India stand today

Achievements in last 10 years

Scaled EMS operations:

99.2% of all mobile phones sold in India are made in India today, vs. only 26% in 2014-15

Multiple global EMS players (e.g., Foxconn, Pegatron) have moved production to India as well as many domestic EMS companies have been strengthened (e.g., Dixon, Kaynes, Syrma, etc.) - benefiting from PLI and China+3 shifts

Early data centre/compute buildout:

Capacity growth: India accounts for ~11% market share of APAC region's total IT load capacity, 1.3 GW live as of Mar 2025 and ~2.7 GW pipeline with USD 20 Bn investment over the next 5 years

Power-secure, sustainable backbone: India reached zero power deficit by 2025 with 452 GW generation capacity, of which 46% is renewable; data centres consume <0.5%, enabling multi-GW expansion with stable pricing.

Large-scale hyperscaler and AI-compute investments are transforming India into a regional hub:

- Reliance plans a 3 GW AI-driven data centre in Jamnagar in partnership with NVIDIA (investment≈INR 2.5 Lakh Cr)
- Meta is developing a 100 MW Chennai facility with Reliance Brookfield, and Digital Realty
- NTT Data is expanding 400 MW across India
- Blackstone-Panchshil Realty are building a 500 MW Navi Mumbai campus powered 65% by renewables

These, together with new subsea cable systems (MIST, Project Waterworth, IAX/IEX), are now positioning India's emergence as an AI-compute hub with high-density cooling

Multiple policy initiatives launched to propel sectoral growth

Production-Linked Incentive (PLI) Scheme (2020):

INR 1.97 Lakh Cr outlay supporting electronics, auto, and component localization attracting a cumulative investment of INR 12,492 Cr, production value of INR 8.8 Lakh Cr, and 1.3 Lakh additional direct jobs

India Semiconductor Mission (2021):

INR 22,919 Cr program to localize semiconductor and display manufacturing ecosystem offering 50% capex subsidy upfront; 10 projects approved worth ~USD 18.5 Bn in total investment (ISM 2.0 also in the works, expected to be announced in early 2026)

Sources: SEBI Report, BCG Analysis, Government Data, Secondary Research

Design-Linked Incentive (DLI - 2021):

23 chip-design projects sanctioned; 72 companies with EDA tool access to accelerate indigenous chip IP development

Chips-to-Startup (C2S, 2022):

Training 85,000 VLSI and Embedded engineers; building 175 ASICs, 20 SoC prototypes, and an open IP repository

IndiaAI Mission (2024):

INR 10,300 Cr program to establish national AI compute (~34,381 GPUs) and support AI-driven semiconductor and design innovation

Electronics Component Manufacturing Scheme (ECMS, 2025):

INR 22,919 Cr incentive to localize critical sub-assemblies and PCBs and build supplier depth; 249 applications received with INR 1.15 Tn Cr investments and 7 applications worth INR 5,532 Cr so far

Challenges

Need for more depth in upstream segment:

Semiconductor/Display manufacturing:

- Minimal domestic manufacturing of chips yet; approved packaging units, most of which are based on conventional packaging technologies, are likely to take 1-2 years to get mass-production ready
- Advanced fabs typically require >USD 10 Bn capex and have longer execution cycles (10-20 years); Apart from setting up a few silicon and display fabs to achieve a critical mass for domestic supply chain resilience, India can focus on setting up advanced packaging units, specialty fabs like compound semiconductors, and design companies
- Domestic material ecosystem is still in early stages—impacting logistics costs for domestic manufacturers
- Domestic design of edge-AI and inference SoCs and modules is still evolving, with growing potential to address India-specific workloads such as vernacular voice, offline vision, and industrial IoT applications

Electronic components:

- Small HDI/ML base; IC substrates nearly absent (Proposals under ECMS scheme are likely to take another 2-3 years to start commercial production)
- Import dependence in Passives/Interconnects/Materials owing to lack of a localized component ecosystem

Need to reduce imports dependence in key areas:

Auto-electronics:

- Weak in SiC power modules/BMS design for enabling at-scale domestic supplies/exports

DC/AI hardware:

- Server/rack/PSU assembly is still nascent; thermal and power components are not localized

Need to improve logistics infrastructure:

- Need to enhance connectivity infrastructure between ports and industrial centers for minimal damage in transit

Need of locally-owned IP/design and higher VC funding in Indian chip startups:

- India hosts ~20% of global design talent, yet accounts for <1% of semiconductor patents published in 2023 as foreign MNCs own the IP underlying chip design
- Only 1/3rd of Indian chip startups own/develop their own IP
- Indian startups got <1% semiconductor VC funding in 2024, ranked 15th globally

Global Success Stories

China - Scale, Clusters, and Ecosystem Integration

What they achieved:

Built end-to-end scale across assembly, packaging, components, and increasingly scaling-up fabrication/inputs ecosystem; China's SMIC among top 5 foundries globally, Chinese OSAT players (JCET, Tongfu, HT-Tech among top 10 OSAT players globally)

How they got there:

- Supplier co location with massive upstream depth
- Cluster led scaling that pulled in talent and equipment
- Long-running policy push over 50+ years (e.g., 'Outline for Science and Technology

Sources: Government Data, Secondary Research

- State-backed capital for JVs/acquisitions (e.g., government supported JVs with global cost. Like NEC, Philips, Lucent Tech)
- Development (1956-67)' where semicon was identified as a "key priority area", Dual FDI strategy in 2014's National IC Fund, 'Made-in-China' 2025 big fund, etc.)

South Korea - Deep Specialization in Memory, then Diversification

What they achieved:

>70% global DRAM share by 2020 via chaebol led investment (Samsung, SK Hynix); Samsung and SK Hynix among world's top 3 IDMs later moving to diversify; recent K belt strategy targets the world's largest semi supply network by 2030

How they got there:

- Large private capex and vertical integration around DRAM (Private capex led by 3 large chaebols – Samsung, Hyundai and LG)
- U.S. partnerships for Tech Transfer (e.g., Fairchild and Motorola invested in 1965, Samsung-Micron partnership in 1983)
- Continuous policy push to build end-to-end ecosystem (e.g., K-Belt semiconductor strategy (2015) with USD 44 Bn+ incentives to build world's largest semicon supply network by 2030)

Emerging Opportunities

Multiple emerging plays in India across the semiconductor and advanced electronics manufacturing value-chain:

Segment	Opportunity	Details
Design/IP	Fabless semiconductor and embedded-design leadership	Fabless and embedded design now capture **>60% of global semiconductor value**
Fabrication/Semicon Equipment	Regional equipment manufacturing hub	Global front-end + back-end equipment market **≈ USD 100 Bn**, dominated by Asia; SEA gaining share
Compound Semiconductor Fab (SiC/GaN)	Power & RF devices for EV/ Renewables/Industrial	Compound-semi market growing **~ 35% CAGR (2022–30)**—6X faster than mainstream semis—with **>60% demand from EV, renewable and industrial** sectors
Chipset Packaging & Testing (OSAT/ Advanced Packaging)	Advanced packaging & test clusters	Back-end adds **15–20%** of semiconductor value; advanced packaging (Flip-Chip, 2.5D/3D ICs) expanding with AI/HPC chips
Board level electronics	HDI & Flexible PCB manufacturing + domestic components ecosystem	• India PCB market projected at **USD 15 Bn by 2030 (~20% CAGR)**, led by **HDI & Flexible segments (30–40% CAGR)** • The India PCB components projected to reach **USD 3 Bn by 2033**, at a growth rate (CAGR) of 11.20%
Module Development and edge AI (EV, Display, Camera, Defence)	On-device inference platforms and India first modules	• Rapid emergence of **IP-based modules** for EV powertrains, display and camera systems, and defence electronics • Edge workloads for India (vernacular voice, smart metering, agri/industrial IoT) driving demand for locally designed inference chips

Potential Pathways

Policy landscape

Strengthen policy backbone across the value-chain:

- Continue to support areas like Silicon fabs, Display fabs, Compound fabs, Advanced Packaging Units—areas with strong demand but import dependance
- Focus on incentivizing upstream segments of materials and equipment manufacturing. A resilient localized

Sources: BCG Analysis, Expert Discussions, Secondary Research

supply chain of critical input materials such as silicon wafers, photomasks, photoresists, specialty gases and chemicals; and of specialized, very high value capital equipment that requires a full-service eco-system is needed for the fabs and packaging units to operate at high yields and low costs

Accelerate Commercialization of Domestic R&D:

- Encourage global R&D players to establish India campuses
- Support domestic R&D fabs that develop India-owned IP for commercial sales
- Augment industry-academia partnerships to accelerate commercialization of university-developed IP

Develop Skills and Attract Global Talent:

- Setup process-engineering academies (focusing on PCB, Semiconductor OSAT, Compound Fabs, etc.) and evaluate fast-track of grants/ESOP tax clarity to attract returnees
- Policymakers may also evaluate targeted visa and apprenticeship programs to attract overseas talent and encourage knowledge transfer
- Semiconductor skilling missions—focused on curriculum design, faculty development, and regional training hubs – could align with national education frameworks through coordination with NSDC, AICTE, and UGC
- Promote industry-academia MoUs for hands-on training, internships, and R&D

Adopt Cluster-based industrial development strategy:

- Explore expanding electronics manufacturing clusters with plug-and-play infrastructure
- Emerging corridors such as Noida–Chennai–Hosur may serve as models for Tier-2/3 vendor hubs
- Shared reliability, metrology, and EMC laboratories, along with bonded logistics and supplier networks, will help in enhancing ecosystem depth and efficiency

Industry Pathways

Promote Domestic Sourcing and Value Addition:

- Engage with existing and upcoming India-based design/ electronics firms to source electronic components, raw materials, and design services in domestic manufacturing operations

Create ecosystem plays across value-chain:

- Scale up OSAT play by creating advanced-packaging clusters with assembly and test equipment capabilities
- Anchor HDI/Flex PCB parks near EMS zones; localize laminates and substrate materials to capture mid-stream value
- Build ODM and design ecosystems for EV, display and defence modules under PLI and Semicon India schemes

Scale R&D and Design (Fabless + Embedded + Packaging):

- Companies could explore co-located clusters combining EDA tools, prototyping, OSAT, and OEM/EMS anchors.
- Strengthening linkages between DLI and C2S initiatives, academia, and startups could enhance innovation density
- Attract returnee compiler/EDA talent to design/develop in India for India and for the world
- Creating growth-stage capital pools for USD 50–150 Mn scale-up rounds could help bridge the funding gap in mid-stage innovation

Adopt AI-first factories and design flows:

- Industry players could consider adopting AI-based systems for inspection, yield management, predictive maintenance, and design automation to enhance productivity and quality

Startup and Funding Ecosystem

- Expanding growth-stage capital programs and localization-linked incentives could strengthen Tier-2 and Tier-3 supplier ecosystem
- Establishing a “DLI Bridge” to help approved startups access advanced design infrastructure and blended financing (e.g., convertible instruments) may sustain early-stage momentum
- Boosting private capital ecosystem to build in-house design expertise will strengthen India’s technology base
- Finance and Scale the Middle (Tier-2/3 + Growth Capital) (Series-B+ growth funding (~USD 100 Mn+) still scarce)

Sources: Expert Discussions, Secondary Research

3. Forging Strength in India's Defence Manufacturing

Why this matters for India

Growth in Defence Spending: Global Defence Spending has grown by 51% over the past decade reaching USD 2.7 Tn in 2024, up 9.4% YoY; the top five spenders-US (USD 997 Bn), China (USD 314 Bn), Russia (USD 149 Bn), Germany (USD 89 Bn), India (USD 86 Bn)—accounted for ~60% of spend

High allocation of budget: India's FY2025-26 total defence budget was INR 6.81 Lakh Cr (USD 78.8 Bn)

- 9.5% increase over FY25; 13.45% of overall union budget; highest amongst the ministries
- Defence budget has doubled over the last 10 years

Priority sector for Make in India: Strong push to reduce import dependence

- Imports fell ~9.3% between 2015-19 and 2020-24
- 177 of 193 MoD contracts in FY2024-25 (~92%) were awarded to domestic industry
- USD 160-190 Bn+ domestic pipeline of projects across 75+ platforms (across aero/marine/land/weapons/space)
- India's defence export footprint has expanded 12x over last decade (India's exports accounted for INR 23,000+ Cr in FY25)

Where does India stand today

Policy push: Multiple policy initiatives have been introduced to support India's manufacturing sector. These programs are intended to encourage investment, enhance domestic production, and strengthen sectoral competitiveness across strategic industries

Defence Procurement Manual (DPM)-2025

Revenue procurement of INR 1 Lakh Cr annually; assured orders for 5 years

NOC requirement from DPSUs is removed, leveling playing field for private players

Relaxed LDs: Liquidated damages relaxed from a previous 10% penalty to no LD during the prototype phase and maximum 5% post development

Innovations for Defence Excellence (iDEX) - 2018

Challenge-based program funding startups and MSMEs; Goal is to drive start up pipeline for projects

Offers grants up to INR 1.5 Cr (via SPARK) and INR 10 Cr (via iDEX Prime)

Since then, iDEX has supported over 350 startups and MSMEs and launched multiple innovation challenges

Defence Production and Export Promotion Policy (DPEPP) - 2020

Umbrella policy targeting INR 1.75 Lakh Cr production and INR 35,000 Cr exports

Covers FDI liberalization (Raises FDI limit from 49% to 74% (auto mode) and 100% (via government approval); enables JVs bringing capital and advanced technology

SRIJAN Portal – 2020

Marketplace connecting DPSUs with private industry for indigenization

More than 19,000 defence items listed; encourages MSME/startup participation

Drone PLI (Production lined incentive)

20% incentive on value-addition for drones and components; ban on finished drone imports

Sources: PIB, BCG Analysis, SIPRI, Government Data, Secondary Research

Domain	Key Achievements/Progress	Focus Areas/Gaps
AERO (Aerospace & Avionics)	• Design and build of own **Light Combat Aircraft - Tejas** (60% indigenous content) • Indigenous helicopters like **HAL Dhruv (advanced light helicopter) & HAL Prachand (light combat helicopter)** are now operational • Transport aircraft: **C-295 transport line (Airbus–TASL)** now set up in Vadodara—India's first private aircraft assembly line • **DRDO and France's Safran** to begin building engines for AMCA fighters • The **Kaveri jet-engine program**—undertaken by DRDO's Gas Turbine Research Establishment (GTRE)—INR 2,200 Cr project is under development (started FY25) (Long term plan to integrate Kaveri engine in Tejas)	• **Engine Development:** Fighter-class engines not indigenous (LCA Tejas currently uses GE's F404). *(Kaveri engine under development)* • **Export Capability:** Few export-grade LRUs (Line Replaceable Units) certified to STANAG/ AQAP/EN9100 or NSN codes • **Design & Development:** Need for concurrent D&D to significantly reduce NPD timeframe and field integrated weapons platforms
MARINE (Naval & Submarine Systems)	• Developed and deployed **INS Arihant-class SSBN**—100% Indian-built nuclear-powered ballistic missile submarine • Modern destroyers and frigates (P-15B and P-17A) are now **60-70% built in India** • IAC Breakthrough: INS Vikrant (IAC-1) commissioned in 2022 marks India's entry into a select group of nations capable of building large-deck carriers • Green shoots in Indigenous Propulsion Technology (AIP)—Navy successfully tested AIP to extend submarine endurance—DRDO and Naval Group France sign agreement to safely integrate the indigenous system in Kalvari-class submarines	• **Propulsion dependance:** Naval propulsion engines (notably gas turbines) are import dependent • **Export Capability:** Align with IMO SOLAS/IEC naval electronics standards (dual use) • **Design & Development—**Single vessel delivery can take longer lead time (up to 8-10 years) due to multiple changes in design requirements • **Shipbuilding—**Warships/submarines taking longer than global standard for delivery
Land (Platforms & Vehicles)	• India **produces own tanks, artillery and armored vehicles**, including Arjun and K9 Vajra • Green shoots in private participation (e.g., L&T, Bharat Forge) now support serial production of advanced land systems	• **Import Dependency:** Advanced fire-control, and thermal imaging systems remain import-dependent • **Design & Development—**Frequent design changes, opportunity to adopt stage-gated design reviews and early certification testing • **Production capacity:** Need to expand production capacity of private players and strengthen MRO ecosystem • **FICV and FRCV Platforms:** Two major programs, Futuristic Infantry Combat Vehicle & Future Ready Combat Vehicle (approx. 3,000-4,000) in number are in the very initial stages of the acquisition pipeline. Important to Fastrack induction through Indian primes

Sources: PIB, BCG Analysis, Secondary Research

Domain	Key Achievements/Progress	Focus Areas/Gaps
Armory (Ammunition & Missiles)	• **Small-caliber** ammunition largely domestically produced • **Pinaka rockets, Akash (surface to air) & Astra (air to air) missiles** fully indigenous • **Adani Kanpur complex—**South Asia's largest integrated ammunition and missile complex—started producing small & medium-caliber ammunition	• **Medium and Large Caliber:** Artillery, tank rounds are still partly imported • **Export Gaps:** Need to ensure NATO STANAG and APQP compliance for medium/large caliber systems
Sophisticated Warfare (AI, EW, Precision, Materials)	• **DRDO** has initiated 200+ R&D projects (AI, missiles, radars) • **iDEX and ADITI** programs supporting 400+ startups in AI, drones, autonomy	• **Slower conversion to fielded projects:** Fewer defence patents; scope to increase pace of innovation • **Dependance in advanced sub-systems:** Imports for precision seekers, actuators, EW suites, radar modules, and long-range munitions
Drones and Anti-Drones	• **Large number of defence tech startups;** and start-ups focused on drones and anti-drones account for 70%+ of defence tech funding raised • Systems like SWITCH UAV (surveillance) and Nagastra-1 (precision attack) are **in service**	• **Critical parts still imported:** India's drone makers remain reliant on imported cores, creating cost and security risk • **Production capacity for loitering munitions:** Scaling domestic production capacity for loitering munitions will help meet growing operational demand and reduce reliance on imports • **High-end UAV platforms—**particularly those with extended range, endurance, and autonomous capabilities**—**remain import dependent (India's Medium Altitude Long Endurance (MALE) UAV program involves a planned INR 30,000 Cr tender for 87 drones)
Space and Satellites	• India now has **full-spectrum space capability,** from launch vehicles (PSLV/GSLV) to human-space missions (Gaganyaan) • **Private players** like Skyroot, Agnikul, Dhruva, and Pixxel are developing launch vehicles and satellites under IN-SPACe	• **Private R&D/dual use participation nascent:** India only opened the sector to private players recently; funding remains volatile; space-tech funding fell ~55% in 2024 • **Heavy reliance on imported space-grade electronics and composites:** Need to cut down on electronic imports in line with directive of ISRO leadership
Advanced Materials	• Indigenization of high-strength aluminum alloys for aircraft and maraging steels for strategic systems has begun under DRDO and HAL supply programs	• India still depends on imports for a wide range of **high-performance alloys**—titanium, Inconel, nickel-based superalloys, and specialized steels used in turbines, engines, and armor systems. • **Rare earth processing and recycling capabilities** are nascent

Sources: PIB, BCG Analysis, Secondary Research

Emerging Opportunities

Indigenization of propulsion (Aero + Naval):

Large whitespace in developing domestic propulsion technologies

Indigenization and co-development in civil aviation, MRO scale up:

Large commercial aircraft orderbook and rising fleet sizes are driving demand up and need full-scale MRO capability

Naval platform exports and maritime electronics:

Growing global interest in OPVs/corvettes, alongside rising global demand for sonar, radar and maritime electronics

Drones and anti-drone leadership:

Rising adoption of ISR drones, loitering munitions and counter-UAS systems

Improved component manufacturing:

Significant whitespace in actuators, seekers, RF modules, composites and other high-value components

Military robots and autonomous units:

Opportunity to build unmanned ground vehicles (UGVs) and quadrupedal robotic dogs for surveillance and high-risk missions

Potential pathways

Reduce import dependence—build a stronger domestic supply ecosystem

Focus on core import-heavy areas like propulsion, sensors, and avionics

One pathway is to provide production scale and design standardization to Indian OEMs

- Encourage common platform architectures and standardized design frameworks across the services to enable higher production volumes
- Stage-gate development models will help streamline specifications and reduce redesign cycles
- According to industry assessments, offering standardized or “build-to-stock” patrol vessels and small frigates – modeled on successful global designs (e.g., FREMM-class)—could improve delivery timelines and export readiness

Promote partnerships with larger OEMs–enable co-development co-production

Evaluate mechanisms to enable co-production and licensed manufacturing with global OEMs

- Encourage F-OEM investments by promoting PPP frameworks for key Indian platforms (e.g. AMCA / P75i)
- Accelerate co-development of aero-engine and propulsion systems (fighter, transport, UAVs) through global partnerships and indigenous programs (Kaveri, AIP, marine gas turbines)
- Civil aviation expansion also offers potential for joint development opportunities

Consider fiscal and regulatory incentives to encourage long-term co-development collaborations

Adopt a cluster-based approach—strengthen regional manufacturing ecosystems

Defence Industrial Corridors (DICs) could be scaled as anchor clusters to improve ecosystem density

- Accelerating the development of the Uttar Pradesh and Tamil Nadu DICs by deepening OEM participation and integrating Tier-1 and Tier-2 suppliers could enhance outcomes
- Establish institutes for global testing certifications will help to support export compliance

Developing maritime manufacturing clusters around existing shipyards could help build regional specialization

MSMEs can be supported through Common Facility Centres (CFCs) located within each corridor or cluster

Strengthening of Defence Corridors and Export Promotion Mechanisms

Policymakers may evaluate establishing a council dedicated to defence corridors to coordinate supply-chain promotion, regulatory alignment, and collaboration opportunities

Creation of centralized export promotion agency (under MoD) will help market Indian products abroad

Make defence procurement start up friendly and lower entry barriers

Potential to Enable OTA-style pilots under iDEX/ADITI

- OTA-style contracting, as seen in the United States, could enable faster pilot initiation and reduce procurement timelines for startups
- For e.g. multiple companies in US such as Anduril and Saildrone have scaled through rapid contracting

Policymakers could also evaluate simplifying eligibility criteria – such as years of incorporation or turnover requirements – while maintaining quality standards to broaden startup participation

Create platform for startups to interface with large buyers

A unified digital interface could aggregate demand, pilot opportunities, and co-development projects. This marketplace could connect:

- Startups and MSMEs: who have new tech or prototypes (verified registry of startups for buyers)
- Big Buyers: Armed forces, DRDO and Defence PSUs (all at one place for startups)
- Enablers: Test labs (DTIS), certifying agencies etc.
- Global OEMs and Offset partners: Enabling foreign OEM and MSME partnerships

Broaden Indigenous Content (IC) Definition

Policymakers could consider expanding the IC framework to include a broader range of "indigenous value" parameters consistent with international benchmarks

- The IC metric could evolve from a "manufacture-only" measure to a capability-based model that rewards design and IP ownership
- Scope to include parameters like design and engineering IP, software and digital components, testing, integration and after-sales maintenance

Enhance R&D investment across defence and aerospace

R&D can be increased by ring-fencing multi-year R&D budgets and encouraging internal R&D allocation for DPSU

DRDO's R&D allocation for FY26 is approximately INR 26,800 Cr (~3.9% of the defence budget), compared to higher levels in leading defence economies (US DoD: ~15% of budget on RDT&E , France: ~12-15%)

Sources: PIB, Secondary Research

4.1 Re-imagining Auto and EV

Why this matters for India

Big share of GDP and anchor of manufacturing:

The auto industry is a cornerstone of Indian manufacturing–about 7.1% of GDP and ~49% of manufacturing GDP–with ~28 Mn vehicles produced in FY2024 (across 2W/3W/PV/CV); Current car ownership (~58 per 1,000 people) leaves further headroom for growth

High FDI inflow:

India drew USD 36.26 Bn in cumulative FDI into autos (April 2000–June 2024; ~5.3% of total equity FDI)

Significant contributor to export earnings:

In 2024, automobile exports were USD 22.1 Bn (net surplus of USD 14.2 Bn—up from USD 8.6 Bn in 2020)

Large and fast growing EV base:

EV sales in India rose from ~50,000 (2016) to 2.08 Mn in 2024, taking EV stock to ~5.45 Mn—about 9% of global EV stock in 2024

Where does India stand today

Automotive

Two wheeler dominance: India is the world's largest 2-wheeler producer with >21 Mn 2Ws made in FY2024; 3-wheelers and quadricycles add ~1 Mn units

Auto component Exports are rising, led by critical parts. India's auto component exports reached USD 21.2 Bn in FY24 (1.4× vs USD 15.2 Bn in FY19). The export mix is increasingly "critical components"—e.g., engine components (~USD 3.7 Bn in 2023), wiring harness (~USD 1.9 Bn), brakes and components (~USD 1.3 Bn)—with North America and Europe as the largest destination markets where India already holds >4% share

EV

Electric cars (e-4W) are growing from a low base: ~1,58,000 e-cars were sold in 2024 (India), up sharply but still a small share of total car sales

Electric buses (e-bus) inching up: ~3,740 e-buses were sold in 2024 (India), reflecting visible progress but needs improvement

Electric trucks: Some progress in light duty trucks, of 6,220 e-trucks sold in 2024, ~95% were <3.5 ton, the crucial long haul segment needs to improve

Favorable policy push:

India now has a coherent "push–pull" policy architecture—industrial policies to build domestic supply (Make in India; PLI for Auto INR 25,938 Cr; PLI-ACC INR 18,100 Cr) plus demand programs that seeded EV adoption (FAME-I/II) and the new PM E-DRIVE (INR 10,900 Cr; October 1, 2024–March 31, 2026)

Emerging Opportunities

Ride the electronification wave:

Auto electronics are set to reach USD 450–500 Bn by 2030, with electronics rising to ~50% of vehicle cost; India should target export plays in harnesses, ECUs/infotainment and ADAS sub-systems

Light weighting components and materials:

Global OEMs aim to cut kerb weight ~30% by 2030 vs 2019, boosting demand for aluminum/specialty steels and advanced forming/simulation—capabilities Indian suppliers can build for export

Electrify buses and trucks through finance + corridor charging:

Use a blended pooled fund and leasing to overcome capex barriers, and stand up charging hubs on ~20 highdensity corridors to unlock long-haul freight and city bus adoption

Charging and digital platforms as a services business:

Improve viability with TOD tariffs, openaccess RE, RWAsafe building rules, and a unified app for discovery/booking/payments, focusing on "hot spot" clusters not thinly spread chargers

Build the full battery value chain:

The ACC Battery PLI has a budget outlay of INR 1,81,000 Mn (INR 18,100 Cr) to create gigascale ACC and battery manufacturing with rising domestic value add requirements. Cathode/anode materials, pack assembly, BMS, power electronics, thermal management, and related EV electronics can be priority sectors for exports

Sources: Government Data, Secondary Research

Potential Pathways

Invest in outcome-based R&D

Consider creating an outcome-based R&D fund on eligible components (with case-by-case support for IP acquisition); This can help transition from “build-to-print” to “build-to-design” models

Evaluate applied research institutes on a cost-sharing model with the government. This will help reduce individual firm risk and accelerate commercialization

Building an R&D-to-factory bridge for batteries and powertrains could also be explored (Similar example seen where – The UKBIC (UK) and the DOE Grid Storage Launchpad (US) provide pilot lines and test bays that take chemistries and packs from TRL 4/5 to manufacturing)

Driving Exports in Auto Components

Industry participants may evaluate scaling India’s auto-component export opportunity (estimated at USD 100 billion) by prioritizing product families, ensuring quality and service SLAs, and addressing cost differentials with peer exporters

Localise high value electronics

Policymakers could consider aligning PLI schemes and cluster incentives toward high-value areas such as SiC power modules, inverters, BMS, motors/magnets, OSAT/advanced packaging, and HDI/PCB manufacturing (Electronics is set to reach ~50% of vehicle cost by 2030 and the global auto electronics market could reach USD 450–500 Bn)

Develop world-class tooling infrastructure

Another pathway is to establish shared, modern toolrooms in major auto clusters (e.g., Pune–Aurangabad, Chennai–Hosur, NCR, Sanand) on a “toolroom-as-a-service” model

Finance what moves—unlock affordable capital for high km segments

Policymakers may evaluate setting up blended finance funds for e-buses and e-trucks, enabling priority-sector lending, extending loan tenors, and supporting vehicle or battery-leasing models. This will aid low-cost operators and make segment more financially accessible

Develop charging corridors and hubs

Mapping approximately 20 high-density freight and bus corridors could help identify optimal charging locations where vehicles already halt. Hub and corridor design will avoid underused chargers and speed up heavy-duty electrification

Sources: Government Data, Secondary Research

4.2 Re-imagining Energy

Why this matters for India

Energy security and growth:

India has committed to net zero by 2070 and to reduce emissions intensity by 45% vs. 2005 and reach ~50% non-fossil installed power capacity by 2030

Inflection in India's capacity mix:

As of 2025, non-fossil installed capacity reached ~259.4 GW (solar ~129.9 GW, wind ~53.6 GW), and India crossed the 50% non-fossil share milestone in 2025—ahead of the 2030 NDC target

Global super-cycle in grids and clean tech:

Global energy investment is >USD 3 Tn in 2024, with ~USD 2 Tn in clean energy (renewables, grids, storage) and renewables provided ~86% of 2023 power additions (over 90% in 2024)—driving a worldwide surge in demand for HVDC, transformers, cables, and grid-software

Supply chain risk and opportunity:

Global reports flag rising component prices and doubled lead times for transformers and cables, while HVDC and cable capacity is concentrated among few suppliers—opening a window for India's capital goods makers to participate in the grid build out

Where does India stand today

Multiple programs launched to strengthen ecosystem at scale:

- National Green Hydrogen Mission (initial INR 19,744 Cr; includes SIGHT incentives)
- ACC batteries PLI (INR 18,100 Cr for 50 GWh)
- PM Surya Ghar: Muft Bijli Yojana (INR 75,021 Cr for 1 Cr households' rooftop solar)
- RDSS for distribution reforms and smart meters (INR 3.03 Lakh Cr outlay)

Achievements in last decade:

- Surged non-fossil capacity and hit NDC milestone early: Non fossil capacity ~259.4 GW (solar ~129.9 GW; wind ~53.6 GW) by October 2025; crossed 50% non-fossil share of installed capacity in 2025
- National grid plan readied for 500 GW RE by 2030: CEA's transmission blueprint for integrating ~537 GW RE by 2030 (including HVDC corridors), with indicative ISTS cost ~INR 2.44 Lakh Cr
- Industry momentum in rooftop and state storage: Rooftop roll out under Surya Ghar and state BESS programs (e.g., TN, Rajasthan) have begun to scale, supported by a national BESS VGF program

Challenges:

- Supply chain dependence in critical grid materials: CRGO electrical steel—core for transformers—shows domestic shortfall; only ~10-12% of demand met at home with recurring shortages reported
- HVDC and large transformer bottlenecks: Long global lead times and supplier concentration expose India's transmission build out to delays and cost escalations
- Upstream solar dependence: Despite PLIs, ingot/wafer/polysilicon capacity is still nascent; China controls >80% of PV manufacturing across the chain
- Storage deployment gap: Even as auctions grow, operational BESS remains small relative to the 2030s requirement; execution and tariffs are being refined

Global success stories

China: Integrated solar and battery scale up:

- What they achieved: Built an end-to-end PV chain with >80% share across polysilicon/ingot/wafer/cell/module; accelerated clean tech manufacturing investment.
- How they got there: Aggressive scale, low-cost capital, sustained industrial policy; record module exports on price leadership
- Key learnings for India: Prioritize full backward integration for solar (incl. polysilicon); pursue niches (LFP & Naion for stationary) where domestic materials and logistics can yield durable advantage

United States: Grid manufacturing resurgence under IRA/BIL:

What they achieved: Put grid modernization at the center (IRA/BIL ~USD 97 Bn at DOE across infrastructure programs) and moved to reshore transformer capacity as >80% of U.S. large power transformers are imported; demand from data centers fuels urgency.

Sources: PIB, Government Data, Secondary Research

How they got there: Targeted funding/loans, rebates, and R&D to relieve transformer bottlenecks; longterm procurement and standards alignment.

Key learnings for India: Purchase guarantee models + R&D support for HVDC/transformers and standardsled scaleup can catalyze local capex

Germany and EU: Multi year HVDC/cable contracting:

- What they achieved: Locked in multi billioneuro HVDC converter and cable contracts for corridor projects to move wind/solar to load centers, easing curtailment
- How they got there: Programmatic, multiyear frameworks that prebook vendor capacity and derisk delivery
- Key learnings for India: Replicate long horizon, corridor wise contracting for HVDC & cable to secure slots and stabilize pricing

Emerging opportunities for India going forward

HVDC equipment and ultra high voltage transformers: Global shortages and multi year grid plans (India and abroad) create a durable export and domestic play—converter valves, controls, converter transformers, DC yard gear

Battery storage build out (stationary + EV): BESS need of ~236 GWh by 2031-32 plus rising EV demand (several estimates place India Li-ion demand ~115 GWh by 2030). Localization of cells and packs is a sizable manufacturing wedge

Smart grid software and digital optimization: Forecasting, DERMS, lossreduction analytics and demand flexibility solutions to accelerate RDSS outcomes

Circularity and recycling: As gigawatt hours accumulate, battery recycling and, secondlife become economically attractive; EPR (Extended Producer Responsibility) norms can anchor early economics

Renewable Energy linked manufacturing corridors: Cluster testing/standards labs, logistics, and export financing for transformers/switchgear/BESS assemblies to serve U.S./EU/Gulf demand

Potential Pathways

HVDC “full stack” build

Encourage consortia (OEMs + EPCs + design houses) to localize converter stations, converter transformers, valve halls and controls, backed by typetesting labs and lifetime service centers

Solar—full backward integration to polysilicon

Leverage PLI Tranche II to drive fully integrated (polysilicon → wafers → cells → modules) lines and address upstream dependency

Wind—100% indigenization including gearboxes

Policymakers and industry participants may evaluate opportunities to localize manufacturing of gearboxes, main bearings, and converters. Aligning offshore and onshore procurement visibility may further support steady order flows for domestic suppliers

Battery manufacturing at scale

Beyond the 50 GWh Advanced Chemistry Cell (ACC) PLI, one pathway is to enable brownfield expansions for cells, modules, packs, and BMS units, alongside investments in recycling. (Multiple projections indicate India may need ~115 GWh Li-ion by 2030 and ~236 GWh BESS by 2031-32; industry should prudently plan for 50 GWh+ annual additions in peak years)

Quality research and technology

Fund application-driven R&D (materials for high-MVA transformers; HVDC control algorithms; grid-forming inverters; Na-ion LFP alternatives), and link grant tranches to field pilots with utilities

Sources: PIB, Government Data, Expert Discussions, Secondary Research

5. Potential Pathways for policymakers and industry participants and start-ups

India's next phase of manufacturing growth should focus on deepening mid-stack capabilities, scaling technical talent, accelerating design and R&D intensity, and enhancing export readiness—with startups acting as co-developers alongside large OEMs and DPSUs.

The following themes outline potential pathways that policymakers, industry participants, and startups can consider to strengthen India's manufacturing ecosystem and drive sustainable competitiveness:

Fostering innovation

Deepen R&D and Design Intensity

India's next phase of growth will be shaped by a transition from assembly to innovation-led manufacturing.

Progress Underway

Government is scaling national R&D funding and research—industry collaboration

- The Anusandhan National Research Foundation (ANRF) Act, establishes a unified fund to drive multi-year, mission-led research and promote collaboration
- Programs such as the Design Linked Incentive (DLI) and Chips-to-Startup (C2S) support sector-specific R&D by funding chip design, EDA tool access, and prototyping—critical for electronics and semiconductor innovation

Potential unlocks going forward

Consider ring-fence multi-year R&D budgets with industry co-funding for priority areas (India's current R&D spend as % of GDP is at <1%—trailing other peers like USA's 3.5% and China's 2.4%)

- Priority areas can be extended to semiconductor packaging, propulsion systems, advanced materials, and green manufacturing technologies

Another path is to establish public–private research consortia that link universities, national labs, and industry players for applied research with commercialization targets

Sources: PIB

Attract and embed top research talent in industry

Building a globally competitive innovation ecosystem will require stronger integration between research institutions and industry.

Progress Underway

India's research base is expanding through initiatives such as the NRF, Atal Innovation Mission, and PM Research Fellowships

Potential unlocks going forward

Policymakers could evaluate options to increase the concentration of PhD-level talent within companies by offering competitive re-entry fellowships and diaspora incentives.

One potential model is a structured "Return to India" program (drawing on examples like China's Thousand Talents and South Korea's KIAT initiatives) to include:

- Fast-track research and startup grants
- Adjunct and dual appointments between global universities and Indian R&D institutions
- Set up Seed funding and ready lab infrastructure

Continue easing start-up participation

Start-ups play a critical role in driving innovation and diffusing new technologies across manufacturing value chains.

Progress Underway

Policy reforms are opening government procurement to startups and MSMEs

- The Defence Procurement Manual (DPM 2025) has eased entry barriers

- The Public Procurement (Preference to Make in India) policy mandates that all government departments prioritize domestically manufactured goods

Dedicated platforms are also broadening market access

- The Government e-Marketplace (GeM) Startup Runway lets startups list their products and sell directly to ministries, PSUs, and defence buyers

Several states—including Telangana, Karnataka, and Maharashtra—have established innovation hubs and T-Hubs that co-locate start-ups with research institutes and manufacturing parks

Potential unlocks going forward

Consider dedicated "Startup Tracks" in government tenders

- One option is to introduce lighter eligibility criteria-covering turnover, years of operation, and experience—while maintaining delivery assurance.

- Creating a unified, fast-track vendor registration system for recognized start-ups could further simplify market entry and collaboration with public-sector buyers

Improve strategic dominance

Build manufacturing intensity at 'mid-stack' and deepen indigenization across value chains

India's manufacturing ecosystem has achieved significant scale in final assembly; the next opportunity lies in strengthening mid-stack manufacturing and increasing self-reliance in critical components and materials.

Progress Underway

Several initiatives have been introduced to expand India's manufacturing base

- Electronics Component Manufacturing Scheme (ECMS 2025), Design Linked Incentive (DLI) and Chips-To-Startup (C2S) program, OSAT and advance packaging facilities

Similarly, complementary initiatives are promoting local sourcing and co-development

- SRIJAN Portal: Lists over 19,000 defence items for indigenization

- iDEX, ADITI, and TDF schemes: Provide grants and pilot contracts for startups and MSMEs to co-develop technologies such as drones, sensors, and autonomous systems

Potential unlocks going forward

Policymakers could consider incentivizing the localization of high-value materials and components by expanding existing schemes to focus on upstream segments.

Encourage standard design frameworks to allow for scale in productions

Build for global markets from day one (export readiness and niche dominance)

India's manufacturing competitiveness will be strengthened by aligning design and production standards with global benchmarks and targeting specific value-chain niches.

Progress Underway

Several global OEMs have deepened their partnerships in India

- Electronics majors like Apple, Samsung, and Dell have deepened manufacturing in India

- Foxconn, Pegatron, and Tata Electronics building export-grade products for global markets

Infrastructure readiness (new airports, ports, and logistics corridors under Gati Shakti) are reducing lead time and improving India's export competitiveness

Potential unlocks going forward

Consider intorducing National export-readiness checklists by sector to help companies validate and certify products

- Example benchmarks include IPC/IEC/UL (electronics), EN9100/EASA/NSN (defence), and ISO 26262 (EV/auto)

Create co-certification and partnership frameworks with global OEMs could enable joint testing, standardization, and faster market access

Strengthening global supply corridors will help deepen India's participation in international manufacturing networks

Improve competitiveness by lowering factor costs

Building on cluster led growth

Doubling down on clusters will reduce cost and time by co-locating suppliers, shared labs, logistics, and talent.

Progress Underway

Multiple industrial corridors and manufacturing hubs are developing to anchor emerging sectors such as defence, semiconductors, and electronics

- Defence Industrial Corridors in Uttar Pradesh and Tamil Nadu are co-locating suppliers, testing facilities, and training institutes
- Dholera, Gujarat is emerging as a semiconductor and electronics cluster with the Tata-PSMC fab and Micron ATMP facility driving a full upstream ecosystem
- Electronics Manufacturing Corridor in Tamil Nadu (Chennai–Sriperumbudur–Hosur) has become a base for major global OEMs like Foxconn, Pegatron, and Tata Electronics

Government programs are adding shared infrastructure and testing capacity

- The Defence Testing Infrastructure Scheme (DTIS) is envisaging world-class testing and certification facilities within these corridors to support MSMEs and exporters

Potential unlocks going forward

Consider measures to enhance the effectiveness of clusters through additional infrastructure and targeted benefits:

- Expand shared infrastructure inside clusters to include tool rooms, calibration labs, logistics hubs, and component testing facilities
- Fast-track testing and certification centres within existing corridors to provide MSMEs easy access to quality validation

Encourage multi-sector co-location, example:

- Enable defence, EV, and semiconductor suppliers to share logistics, warehousing, utilities, and skilled manpower within the same zones to enhance efficiency and lower costs

Making talent a national advantage through skilling

India's manufacturing competitiveness depends on a skilled workforce—especially process engineers, technicians, and operators trained in advanced manufacturing technologies.

Progress Underway

National skilling and design programs are building early momentum

- The Chips-to-Startup (C2S) program is training around 85,000 VLSI and embedded engineers across accredited institutes
- The Design Linked Incentive (DLI) scheme gives 70+ domestic firms access to EDA design tools and training resources

Potential unlocks going forward

Consider launching process-engineering academies focused on key manufacturing domains such as PCB fabrication, chip packaging (OSAT), power electronics, and precision machining

- International models such as Singapore's SkillsFuture and South Korea's Meister schools illustrate how skilling can be embedded directly into cluster ecosystems

Align national skilling frameworks (NSDC, AICTE, UGC) with sectoral needs by introducing modular, industry-certified programs

Develop risk capital on a scale

Expanding access to risk capital across the manufacturing value chain can enable suppliers and innovators to scale faster and invest in capacity.

Progress Underway

India's financing architecture for innovation is expanding

- FFS expands the VC pool → SISFS supports very early-stage startups → CGSS ensures access to debt without collateral – together building a complete funding ladder

India is also growing its "green finance" ecosystem with multiple tranches raised and active bodies like IREDA bonds and GGEF – Green Growth Equity Fund

Potential unlocks going forward

Consider a “Finance & Scale the Middle” program: Dedicated growth-stage funds focused on mid-stack priorities such as components, OSAT, PCBs, and EV power systems with localization-linked milestones

- Global precedents include Japan’s JIC and China’s National IC Fund, which catalyzed industrial scale-ups through patient, mission-oriented capital

Supplier-financing programs could be established to provide low-interest working-capital lines and invoice-discounting facilities tailored for suppliers in high-value manufacturing clusters

DRIVE EFFICIENCIES THROUGH AI

AI adoption and Industry 4.0 (build deep tech capability in factories and design flows)

The application of artificial intelligence (AI) and Industry 4.0 technologies could enhance productivity, quality, and speed across manufacturing and design processes, helping India’s industrial base become more globally competitive.

Progress Underway

Multiple initiatives are underway to promote AI-driven manufacturing and digital transformation

- IndiaAI Mission is developing a national compute marketplace (10,000+ GPUs) available on demand for researchers, startup financing and skills – important for AI-first factories & design

- SAMARTH Udyog 4.0 centres demonstrate I4.0 tech and practices for industry adoption

Potential unlocks going forward

Policymakers can consider incentives to accelerate AI and smart-manufacturing adoption across industrial sectors

- One pathway is to link a portion of PLI disbursements or scheme incentives to measurable adoption of Industry 4.0 technologies

- Another option is to introduce testing reimbursements or pilot funding for MSMEs deploying AI-assisted inspection and reliability validation tools.

- Global examples such as China’s Smart Factory 2025 program (reported to have achieved productivity gains of up to 20 percent through AI–MES integration) illustrate the potential benefits of structured adoption at scale

Sources: PIB, Secondary Research

Appendix

Manufacturing Focus Areas

Sector	GVA (INR Mn) 2022-23	Growth % 2022-23	FDI (USD Mn) 2023	Import (USD Mn) 2023-24	Budget allocation (INR Mn) 2025-26	Funding to Start-ups (USD Mn) since 2021
Electronics & Semiconductors	5,76,163	9%	7,820	1,78,306	2,60,263	1,418
Auto & EV	22,15,567	10%	1,741	7,610	29,50,134	16,898
Pharmaceuticals	16,12,260	8%	1,235	2,585	52,687	16,470
Defence Manufacturing	5,77,288	9%	1	12,842	99,29,426	2,088
Energy	19,10,368	5%	4,747	2,19,054	9,17,724	18,900
Wearing Apparel	5,44,595	8%	60	1,540	-	760
Textiles	9,05,165	4%	359	4,850	52,720	44
Basic Metals	25,42,439	6%	241	38,963	-	1,039
Other Non-metallic Mineral Products	9,72,548	7%	675	4,255	30,380	-
Machinery and Equipment n.e.c.	13,87,640	10%	507	-	-	550
Chemicals and Chemical Products	21,59,433	9%	1,193	3,639	16,19,652	7,178
Rubber and Plastics Products	9,35,259	8%	133	25,745	-	-

Sources: Secondary Research

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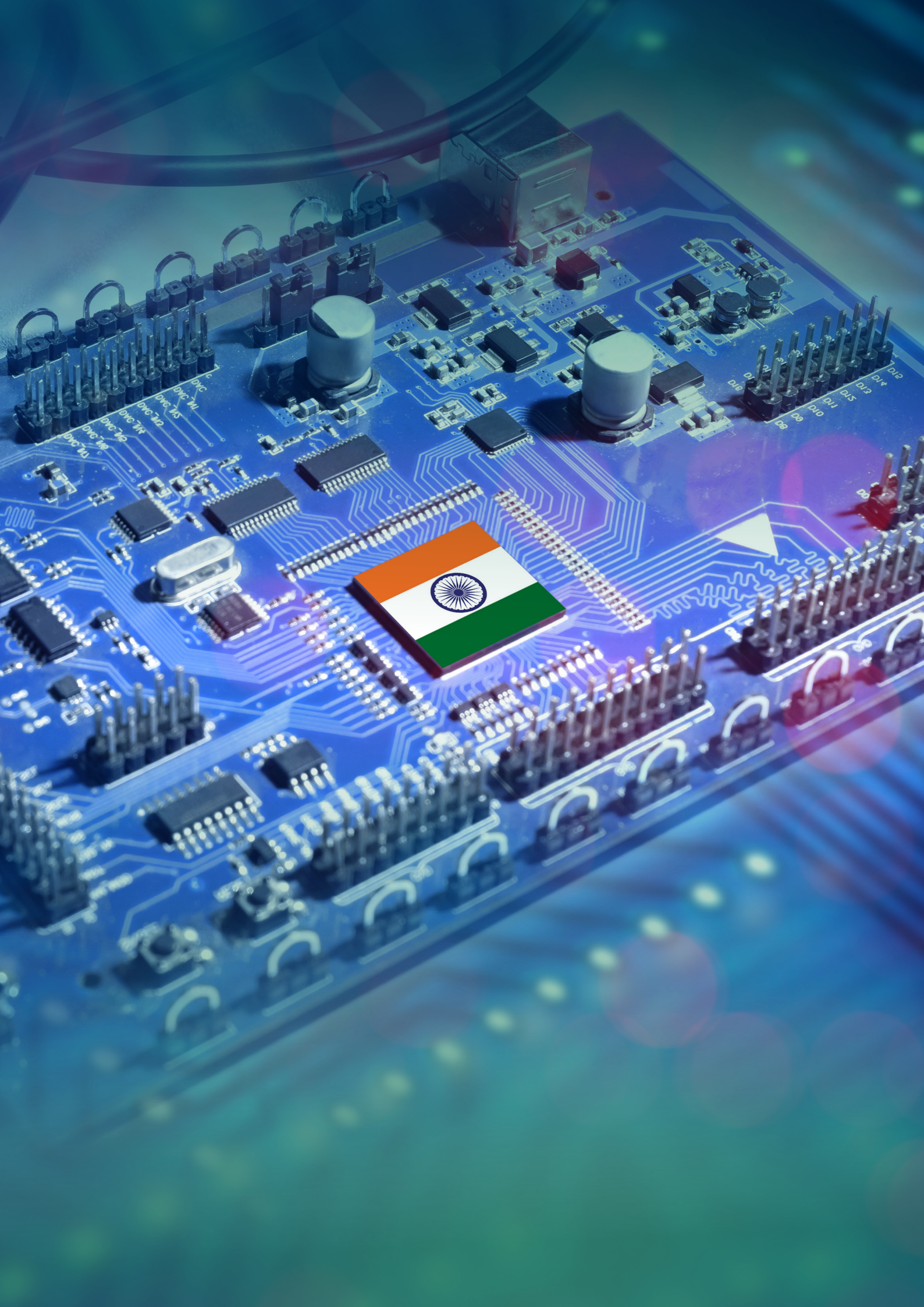


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