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Securing, Automating, and Scaling: Manufacturing's Next Chapter

As manufacturing systems become more intelligent, interconnected, and digitally driven, the definition of resilience is undergoing a fundamental shift. Today, safeguarding operations is no longer limited to physical robustness alone—it increasingly hinges on digital security, smart automation, and future-ready infrastructure. The January 2026 edition of Machine Edge Global brings together these critical themes, offering readers a comprehensive view of how technology, talent, and strategy are reshaping the manufacturing landscape in India and beyond.

Gracing our cover this month is an insightful interview with Harshad Mehta, Founder, RIR Power, who makes a compelling case for why cybersecurity resilience has become as vital as electrical and thermal robustness in critical power systems. As power infrastructure grows smarter and more connected, his perspectives underline the urgent need for manufacturers to treat cybersecurity as a core pillar of system reliability rather than an afterthought.

This edition also dives deep into the transformation of welding, where the convergence of AI, skilled manpower, and sustainable practices is redefining the process. The feature highlights how technology-enabled welding is improving efficiency and quality while making manufacturing more environmentally responsible—strengthening India's position as a competitive global manufacturing hub.

Another key article examines the rising prominence of India's Tier-2 cities as engines of industrial growth. With advantages such as cost efficiency, access to skilled talent, and improving infrastructure, these emerging centres—supported by smart factory adoption, progressive policies, and local supply chains—are fast becoming integral to India's global manufacturing ambitions.

We also explore the growing importance of robot integration with PLC and SCADA systems, a development that is enabling smarter, more connected, and highly efficient factories. By improving control, visibility, and productivity, unified automation platforms are paving the way for Industry 4.0-ready operations, even as the article candidly addresses integration challenges and best practices.

Adding another dimension to this issue is our feature on drones as critical enablers of industrial growth. From enhancing safety and productivity to enabling data-driven decision-making, drones are proving their value across sectors. The article also highlights their role in driving sustainability, generating skilled employment, and positioning India as a global leader in next-generation drone technologies.

Along with several other thought-provoking articles, this January 2026 edition reaffirms Machine Edge Global's commitment to delivering in-depth stories from the heart of manufacturing, automation, and robotics. As we step into a new year, we remain focused on bringing our readers not just the trends shaping the industry, but also the behind-the-scenes insights that define its future.

Sanjay Jadhav

Sanjay Jadhav

Founder & Editor
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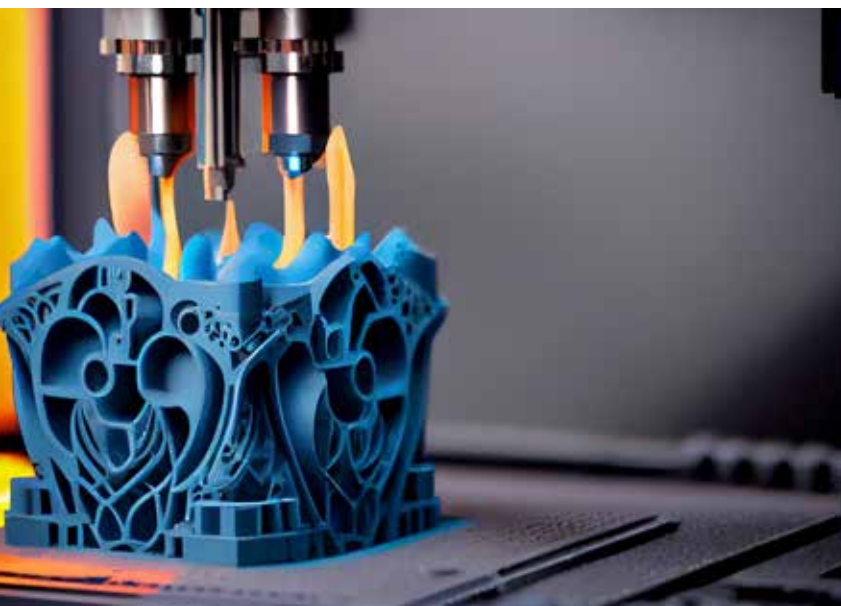
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“As power electronic systems become increasingly connected, cybersecurity has emerged as a critical design consideration”

“Ensuring cybersecurity resilience is now as important as electrical and thermal robustness in critical power systems,” says **Harshad Mehta - Founder, RIR Power** in an interview with **Machine Edge Global**.



Q. What are the most significant advancements in power semiconductor technologies, such as SiC and GaN devices, that you foresee impacting energy efficiency and high-voltage applications in the global industrial sector over the next decade?

► Over the next decade, wide-bandgap semiconductors—particularly Silicon Carbide (SiC)—will fundamentally redefine high-voltage and high-power applications. Advancements in high-voltage SiC devices beyond 10 kV, including next-generation SiC IGBTs, MOSFETs, and diodes, will enable higher switching frequencies, lower conduction losses, and dramatically improved system efficiency. This will directly impact grid infrastructure, rail traction, renewable integration, and hydrogen electrolyzers. While GaN will dominate lower-voltage, high-frequency applications, SiC will be the technology of choice for medium- and high-voltage industrial systems where efficiency, power density, and reliability are critical.

Q. How do you anticipate the integration of wide-bandgap semiconductors will transform traditional power conversion systems in emerging markets, and what technical challenges must be addressed to ensure reliable deployment?

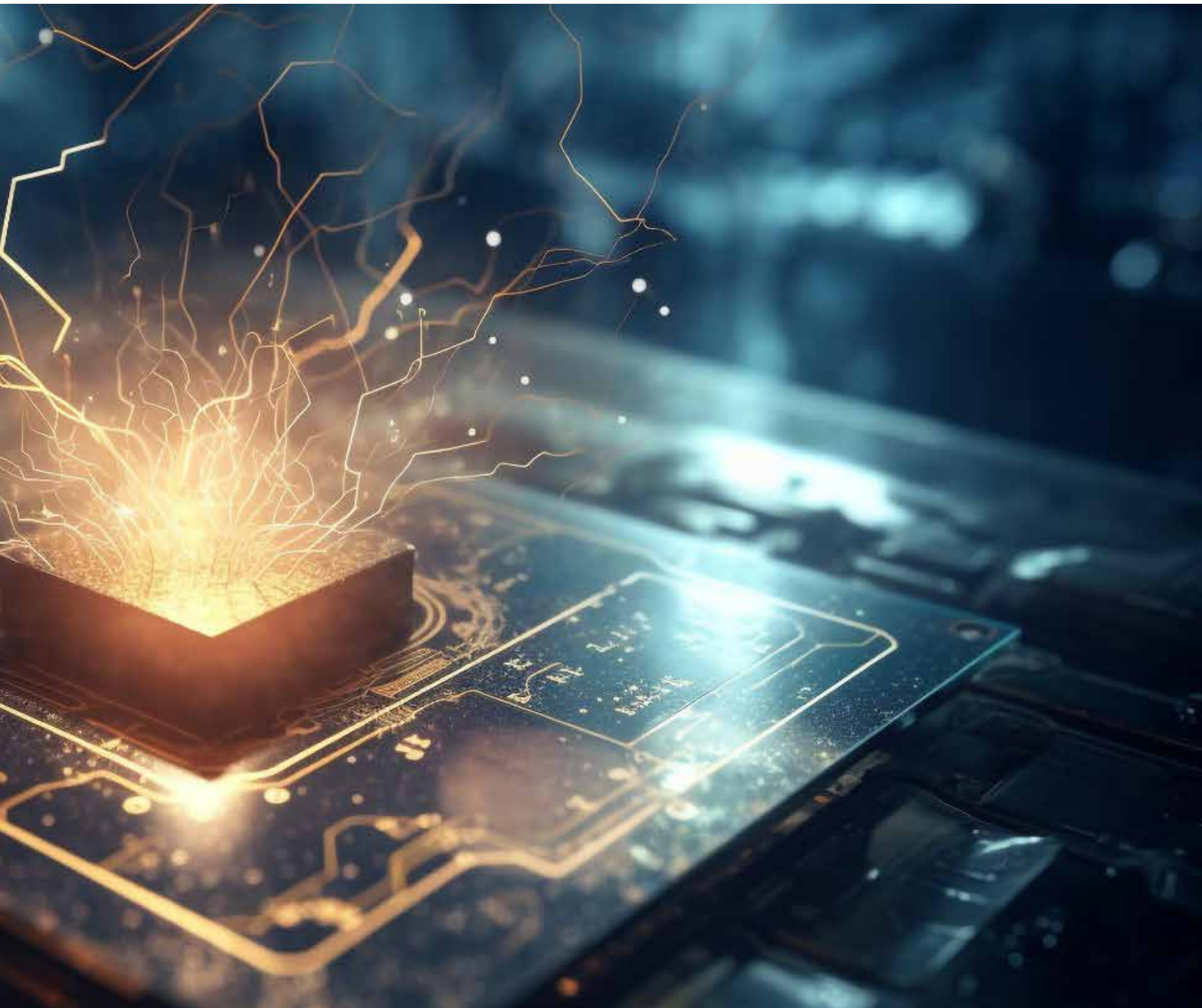
► Wide-bandgap semiconductors will allow emerging markets to leapfrog legacy power conversion architectures. SiC-based systems enable smaller, lighter, and more efficient converters, reducing balance-of-system costs and improving reliability in challenging grid environments. However, reliable deployment requires

addressing key technical challenges such as high-voltage gate drive design, electromagnetic interference (EMI), insulation coordination, and long-term device reliability under harsh operating conditions. Developing robust packaging, thermal management, and qualification standards will be essential for large-scale adoption.

In the realm of electrification, what key obstacles do you see in developing robust power electronics for electric vehicle charging infrastructure, and how might innovations in thermal management and switching efficiency



As power electronic systems become increasingly connected, cybersecurity has emerged as a critical design consideration particularly for grid, transportation, and industrial infrastructure. Vulnerabilities can arise at control interfaces, firmware layers, and communication protocols.



mitigate these?

▶▶ The primary obstacles in EV charging infrastructure are efficiency losses, thermal stress, grid compatibility, and reliability under continuous high-power operation. Ultra-fast chargers operating at hundreds of kilowatts demand power devices that can handle high voltages

and currents with minimal losses. Innovations in high-efficiency SiC switching devices, advanced module packaging, and double-sided cooling technologies significantly reduce thermal bottlenecks. These advances enable higher power density, longer operating life, and lower total cost of ownership for charging networks.

Q. How has the adoption of digital technologies, including AI and IoT, influenced the design and reliability of power modules and IGBTs in industrial applications, and what technical best practices are crucial for optimization?

▶▶ Digital technologies such as AI and IoT have transformed power electronics from passive components into intelligent systems. Embedded sensing, real-time monitoring, and predictive analytics now enable condition-based maintenance and early fault detection in power modules and IGBTs. Best practices include integrating temperature, voltage, and current sensing at the module level, using digital twins for design validation, and leveraging AI-driven models to optimize switching behavior and lifetime performance. This convergence significantly enhances reliability, uptime, and system efficiency.

Q. What role does cybersecurity play in safeguarding power electronic systems within critical infrastructure, and what emerging vulnerabilities should the industry prioritize in its technical development strategies?

▶▶ As power electronic systems become increasingly connected, cybersecurity has emerged as a critical design consideration—particularly for grid, transportation, and industrial infrastructure. Vulnerabilities can arise at control interfaces, firmware layers, and communication protocols. Secure-by-design architectures, hardware-based authentication, encrypted communications, and robust firmware update mechanisms are essential to prevent vulnerabilities that could impact system availability and safety. Ensuring cybersecurity resilience is now as important as electrical and thermal robustness in critical power systems.

Q. From a technical perspective, how can advancements in thyristors and diodes contribute to achieving

sustainability targets in sectors like renewable energy and industrial automation?

▶▶ Despite the rise of wide-bandgap devices, advanced thyristors and high-efficiency diodes remain indispensable for high-power, high-current applications such as HVDC transmission, industrial drives, and renewable energy systems. Improvements in wafer design, lifetime control, and thermal performance reduce losses and improve system efficiency at scale. These devices enable efficient bulk power transfer and conversion, directly supporting sustainability targets by minimizing energy losses across large industrial and grid installations.

Q. What are the main supply chain challenges facing the power electronics industry globally, and how could localized manufacturing strategies in regions like Asia enhance technical resilience and innovation?

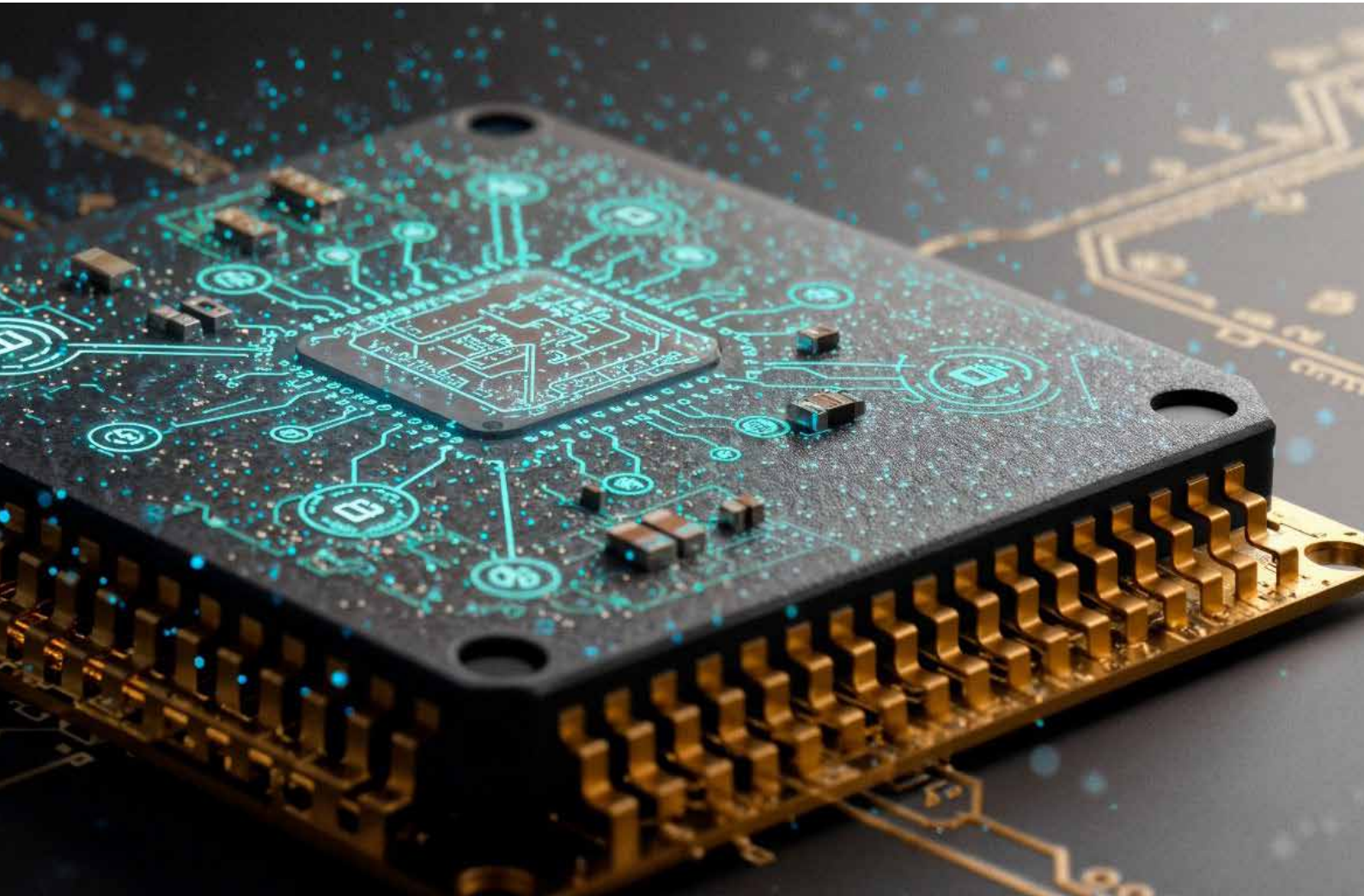
▶▶ The power electronics industry faces significant supply chain challenges, including geopolitical risk, long qualification cycles, and dependence on a limited number of fabrication hubs. Localized manufacturing strategies can enhance technical resilience by shortening supply chains, improving process control, and enabling faster innovation cycles. Establishing domestic capabilities for design, fabrication, packaging, and testing is critical not only for supply security but also for developing region-specific solutions optimized for local applications.

Q. How will evolving international standards and regulations on energy



efficiency affect the adoption of advanced power semiconductors, and what technical interoperability considerations should be emphasized?

▶▶ Stricter global energy efficiency standards and carbon reduction regulations will accelerate the adoption of advanced power semiconductors. These regulations increasingly favor high-efficiency, low-loss solutions such as SiC-based systems. From a technical standpoint, interoperability, standardization of module footprints, qualification protocols, and compliance



with international safety and reliability standards will be essential to ensure seamless global deployment and scalability.


Q. What opportunities exist for collaboration between power electronics manufacturers and sectors like automotive and renewable energy to advance innovations in integrated power management systems?

▶▶ There are significant opportunities for deep collaboration between power semiconductor manufacturers and

sectors such as automotive and renewable energy. Co-development of integrated power modules, optimized for specific system architectures, can dramatically improve performance and reduce system costs. Joint innovation in areas like traction inverters, onboard chargers, wind and solar inverters, and energy storage interfaces will be key to advancing integrated power management solutions.

Q. Looking forward, what technical breakthroughs in high-power semiconductor devices do you predict will drive the acceleration towards net-zero

goals in energy-intensive industries?

▶▶ Looking ahead, breakthroughs in ultra-high-voltage SiC devices, advanced power module packaging, and integrated power systems will be decisive in accelerating net-zero goals. Devices operating at 10 kV and beyond will enable more efficient electrification of power grids, heavy industry, rail, mining, and hydrogen production. Combined with digital control, advanced thermal management, and system-level optimization, these innovations will significantly reduce energy losses and carbon intensity across energy-intensive sectors. 

Sustainable Manufacturing Excellence:

Panasonic's Journey to Carbon Neutrality with ELGI's Oil-Free Compressed Air Solutions

The case study highlights how Panasonic Life Solutions India is advancing its carbon neutrality goal through the adoption of ELGI's oil-free compressed air technology, ensuring contamination-free, energy-efficient manufacturing. It showcases the critical role of reliable, high-quality compressed air in electronics production and how this partnership enhances sustainability, efficiency, and operational resilience.



Panasonic Life Solutions India Ltd. partnered with ELGi to implement the AB 30 Oil-Free Screw Compressor, ensuring contamination-free compressed air for its advanced manufacturing operations. This collaboration supports Panasonic's commitment to carbon neutrality by 2027, enhancing energy efficiency, operational reliability, and sustainability. With ELGi's innovative technology and responsive service, Panasonic has optimized its production processes, reducing downtime and improving

overall efficiency.

Industry Landscape Electronics Manufacturing in India – Projected Growth of \$400 Billion by 2025

The consumer electronics manufacturing sector in India represents a crucial component of the country's industrial growth strategy.

With the government's push for domestic manufacturing through initiatives like "Make in India" and

the Production Linked Incentive (PLI) scheme, the sector has seen remarkable expansion. The industry is projected to reach \$400 billion by 2025, establishing India as one of the world's major electronics manufacturing hubs.

However, this growth presents unique challenges. Electronics manufacturing demands pristine production environments, with stringent quality control measures and zero tolerance for contamination.

The industry also faces increasing pressure to reduce its environmental

impact, making energy efficiency and sustainable manufacturing practices essential priorities.

Panasonic: Leading Through Innovation and Sustainability

Since establishing its Indian manufacturing operations in 2012, Panasonic has emerged as a significant player in India's consumer electronics sector. Their state-of-the-art facility produces air conditioners (comprising 70% of production), refrigerators, and washing machines, and they maintain specialized divisions for automotive sensors and audio systems, serving major clients like Honda and Maruti.

What sets Panasonic apart is its commitment to quality and innovation. The company maintains an in-house R&D facility within its factory, enabling rapid product development and manufacturing process optimization.

Their approach to manufacturing excellence is built on several key principles:

- Lean Manufacturing Implementation:** Panasonic's manufacturing philosophy centers on single-piece flow from input to output, comprehensive value stream mapping, and continuous identification and elimination of waste. Their production methodology ensures consistent quality throughout the production process.
- Quality-First Philosophy:** The company maintains rigorous quality control processes, regular market benchmarking, and continuous improvement initiatives. Their customer-centric approach drives product development and manufacturing excellence.

- Sustainability Focus:** With an ambitious target of achieving carbon neutrality by 2027, Panasonic has implemented various sustainability initiatives, including rooftop solar panels, energy-efficient manufacturing processes, and advanced energy-efficient drives throughout their facility.

The air supply must be 100% oil-free to prevent contamination, maintain a low dew point to avoid moisture-related issues and deliver consistent pressure for precise operations.

The Critical Role of Compressed Air in Electronics Manufacturing

Compressed air serves as a vital utility in electronics manufacturing, powering numerous critical operations throughout the production process.

The technology powers essential cleaning applications, removing microscopic dust and debris from circuit boards while controlling static electricity through ionizing air guns. In testing and quality control, compressed air operates leak detection systems and environmental testing chambers.

Additionally, compressed air powers packaging operations and material handling systems. Given these critical applications, the air supply must meet stringent requirements: it must be 100% oil-free to prevent contamination, maintain a low dew point to avoid moisture-related issues and deliver consistent pressure for precise operations.

In Panasonic's sophisticated manufacturing processes, compressed air serves as an indispensable utility that powers multiple critical operations throughout the facility. The assembly line operations form the backbone of production, where compressed air

powers a range of precision tools, including pneumatic screwdrivers and fastening systems that require exact torque control.

These systems work in conjunction with automated pick-and-place mechanisms that handle delicate electronic components with precision. The compressed air network also drives sophisticated quality testing equipment that ensures each finished product meets Panasonic's exacting standards.

The facility's pneumatic tool





operations rely heavily on compressed air for various specialized applications. Precision assembly tools handle delicate electronic components with the necessary care, while impact wrenches facilitate housing assembly with controlled force. The system also powers air guns used in cleaning and maintenance procedures and pneumatic grippers that ensure precise handling of components throughout the manufacturing process.

The extrusion operations represent a particularly demanding application of compressed air. The system carefully

controls material feed rates in plastic extrusion processes while simultaneously powering cooling systems for extruded components. Automated cutting systems work in tandem with material handling equipment, all powered by the same reliable compressed air network.

Industry Landscape: Electronics Manufacturing in India

- **Pressure Stability Demands:** Maintaining consistent pressure levels is fundamental to precise manufacturing operations. The

compressed air system must deliver stable pressure to control assembly tools and automated systems accurately.

Any pressure fluctuations can lead to a chain of quality issues, from inconsistent tool performance to irregular component placement, directly impacting the final product quality.

- **Moisture Control and Dew Point Management:** In electronics manufacturing, maintaining precise moisture control is critical to product quality and reliability. To prevent moisture-related complications, the compressed air system must maintain a dew point below 3 degrees Celsius. Even minimal moisture content can trigger a cascade of problems, from electronic component oxidation to compromised solder joints, potentially leading to catastrophic product failures.

- **Energy Efficiency Requirements:**

In alignment with Panasonic's ambitious 2027 carbon neutrality goal, the compressed air system must achieve optimal performance while minimizing power consumption.

This balance between performance and energy efficiency is crucial, as compressed air systems typically account for a significant portion of a facility's energy usage. The challenge lies in maintaining high-performance standards while reducing the overall carbon footprint.

- **100% Oil-Free Air Requirements:**

The demand for absolutely oil-free air is non-negotiable in electronics production. Even microscopic levels of oil contamination can interfere with electronic component functionality and compromise surface adhesion during assembly.

This stringent requirement must be maintained throughout the entire compressed air system, from generation to point of use, as any contamination can result in costly product failures and production delays.

- **Maintenance Considerations:**

The design of the compressed air system must prioritize minimal maintenance requirements while ensuring continuous operation. Any downtime can significantly impact production schedules and costs.

When maintenance is necessary, it must be quick and straightforward to minimize disruption to manufacturing operations. This requires a system design that facilitates

easy access to components and rapid service resolution.

ELGi's Solution: The AB Series Advantage

The implementation of ELGi's AB 30 Oil-Free Screw Compressor has been a gamechanger for Panasonic, addressing its compressed air challenges with precision.

Delivering 100% oil-free air that meets the stringent ISO 8573-1 Class 0 and ISO 8573-7 standards, the AB Series ensures superior air quality with zero contamination and stable dew point performance, crucial for Panasonic's high-stakes manufacturing environment.

Designed for maximum energy efficiency, the AB Series optimizes power consumption through intelligent control systems, directly supporting Panasonic's sustainability initiatives while reducing operational costs. This efficiency plays a pivotal role in their journey toward carbon neutrality.

Operationally, the AB Series stands out for its exceptional reliability and minimal downtime. Its maintenance-friendly design and ELGi's responsive service and readily available spare parts ensure seamless production with minimal disruptions.

Looking ahead, the AB Series equips Panasonic with advanced capabilities for Industry 4.0 integration. Its SCADA and DCS compatibility, combined with real-time monitoring through ELGi's air~alert, provides deep insights into system performance, enabling proactive maintenance and operational optimization.

This is one of the key elements that helps Panasonic with its sustained growth and continued technological leadership in the electronics manufacturing industry.

Measurable Impact and Customer Satisfaction

The implementation of ELGi's compressed air solution has delivered significant, measurable benefits to Panasonic's manufacturing operations. The system consistently meets the stringent air quality requirements while maintaining optimal energy efficiency levels.


Maintenance requirements have been notably reduced, supported by ELGi's responsive service team and comprehensive parts availability. These improvements have contributed to enhanced operational efficiency and reduced downtime, directly impacting the facility's productivity and cost-effectiveness.

"ELGi compressors require minimal maintenance and come with exceptional aftersales support." - Senior Maintenance Engineer, Panasonic

"Switching to ELGi compressors instantly enhanced our maintenance efficiency. The reliability and energy efficiency of the oil-free AB Series perfectly aligns with our sustainability goals. Moreover, the prompt service response and readily available parts have been invaluable for maintaining our continuous operations." - Operations Manager, Panasonic

Looking Ahead: A Future-Ready Partnership

The partnership between Panasonic and ELGi is poised for continued growth as both companies explore new avenues for advancement.

As Panasonic moves closer to its 2027 carbon neutrality target and accelerates its Industry 4.0 initiatives, this collaboration represents sustainable manufacturing excellence in the electronics sector. By leveraging ELGi's innovative compressed air solutions, Panasonic drives operational efficiency and reinforces its commitment to environmental stewardship, setting a new standard for the future of electronics manufacturing in India. 

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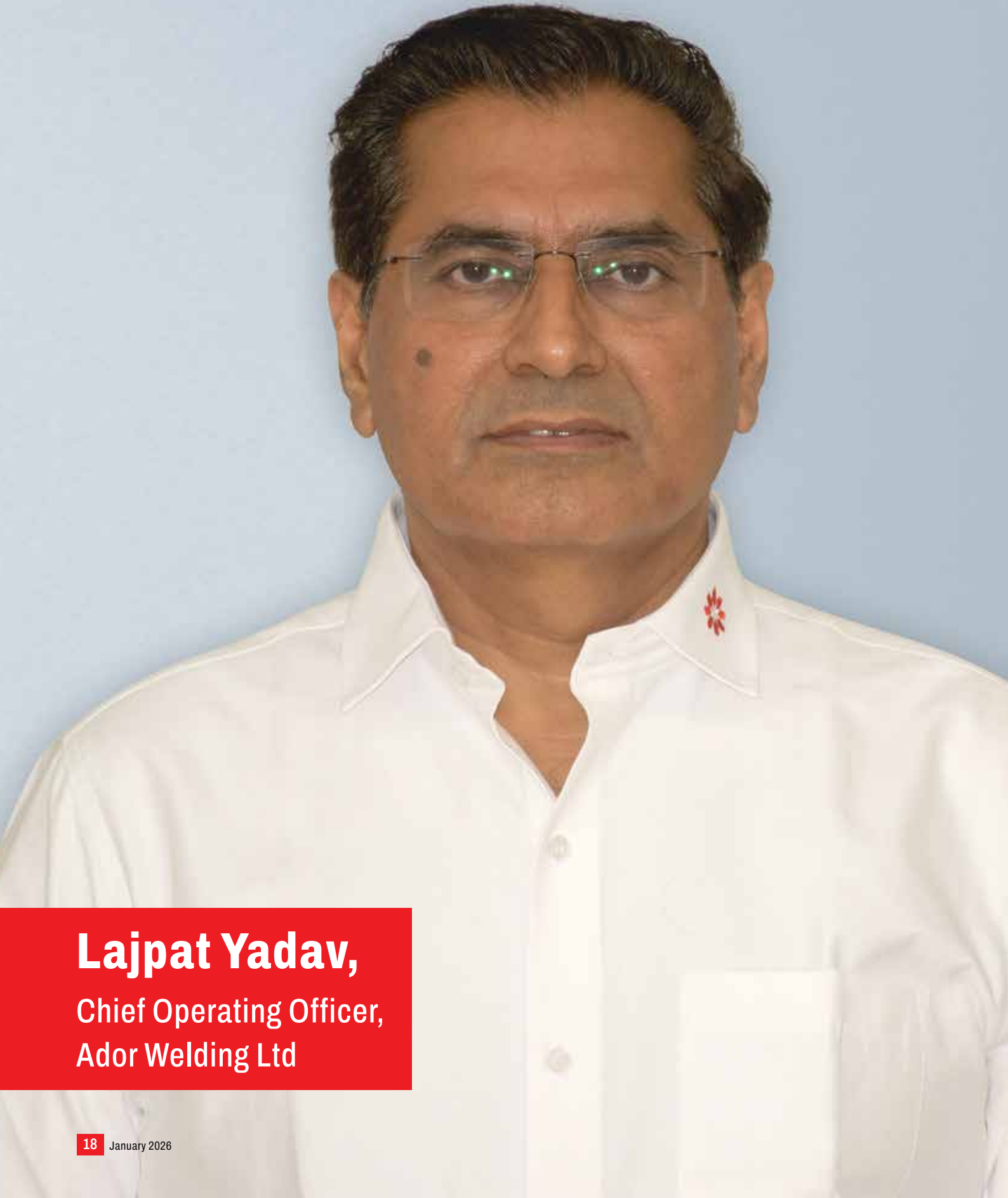


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AI, Skills & Sustainability: Shaping the Future of Welding in India

The article explores how AI, skilled labor, and sustainable practices are transforming welding into a smarter, more reliable, and environmentally responsible process. It highlights the role of technology-enabled welding in boosting efficiency, quality, and India's manufacturing competitiveness.

Manufacturing is about to reach a critical phase that will affect how industries operate for many years to come. The development of advanced robotics, digital automation, and artificial intelligence is radically changing the nature of industries. Production scheduling, quality control, and general efficiency are all being impacted by this change. Welding is going through a significant revolution of its own. It was once thought of as a manual and skill-intensive career, but it is gradually changing into a more accurate, intelligent, and sustainable process. The importance of welding is being increased by the combination of technology, skilled labour, and ethical production. This change is crucial for India, which wants to dominate the world in manufacturing.

AI is Reinventing Welding from the Ground Up

For a very long time, the person holding the torch was mostly responsible for the quality of the weld. The key to getting it right was instinct, experience, and judgment. Now, that reality is shifting. Data is increasingly being used to direct welding, and sophisticated systems are keeping an eye on the process. Real-time tracking of variables like heat, wire movement, travel speed, and weld penetration using AI-enabled equipment enables problems to be found before they become expensive errors. Additionally, these systems can identify early indicators of wear or imbalance, assisting maintenance personnel in taking action before malfunctions cause output to be disrupted.

The use of automated and AI-supported welding systems is expanding throughout India, particularly in sectors like heavy engineering, railroads, automobile manufacture, and defence manufacturing. To increase output quality and operational efficiency, manufacturers are investing more in robotic and smart welding technologies.



The domestic welding equipment market is estimated to be worth between ₹9,000 and

₹10,500 crores. Early adopters of automated welding lines have observed definite benefits, such as throughput increase of 20 to 30 percent and discernible decrease in labour-intensive inefficiencies and rework, especially in high-volume fabrication settings. This change highlights India's larger goal of achieving precision, dependability, and

scalability levels in its manufacturing ecosystems that are competitive on a global scale.

Faster manufacturing is only one aspect of these technologies' true impact. AI-enabled welding increases process consistency by lowering rework and guaranteeing that each joint satisfies the same quality standard regardless of operator variability. In industries like automotive, railroads, shipbuilding, and heavy engineering,



where even little deviations can have major repercussions, this dependability is extremely crucial. For manufacturers competing at scale, data-led welding is now a necessary capability rather than a nice-to-have improvement.

Automation, intelligent systems, and real-time analytics reinforce strong metallurgical expertise in what was long thought to be a mostly manual art that is now developing into a disciplined, technologically advanced process.

Why Skilled People Still Matter in a High-Tech Welding World

Many people believe that professional welders will eventually become obsolete due to automation. In reality, the opposite is turning out to be true. In fact, the importance of qualified workers is rising as welding becomes more technologically advanced. The role's nature is changing, going beyond manual execution to encompass duties like system

development, supervising automated operations, and optimizing processes.

Manufacturers in the sector are realizing that artificial intelligence will influence welding in the future. Whether it's operating robotic welding cells, receiving training via augmented reality platforms, deciphering AI-driven controls, or employing digital inspection systems to guarantee quality, realizing that promise requires individuals who are at ease using sophisticated tools.

With strong support from government-led initiatives like Skill India, PMKVY, and the MSME Technology Centre network, which collectively channel more than ₹1,500 crore annually into technical skill development, training centers and technical institutes throughout India are gradually modernizing the way welding skills are taught. In order to increase safety and shorten learning times, these programs are increasingly utilizing simulation-led and digitally supported training, which enables welders to practice difficult skills in controlled, virtual environments.

Institutions affiliated with SAMARTH Udyog Bharat 4.0 are implementing robotics- and VR-enabled welding curriculum as Industry 4.0 gains traction, guaranteeing that trainees acquire both practical experience and digital confidence. This combination of technology and experience is creating what the industry now calls "Welding 2.0," where intelligent equipment and human ability combine to produce stronger, more reliable manufacturing results.

Fundamentally, welding is still a human talent based on ability, judgment, and safety consciousness. Instead of replacing that basis, technology strengthens it by providing competent workers with improved tools to apply their knowledge more confidently and precisely.

Sustainability is Redefining Welding Practices

Welding techniques are also being re-examined from a more environmentally friendly perspective as sustainability shifts from desire to expectation throughout global supply chains. Manufacturers are paying more attention to how much material is ultimately lost on the shop floor, how energy is consumed, and how processes are optimized.

This change is being significantly

influenced by advanced welding technologies, especially those backed by AI. Smarter systems reduce errors, apply heat more precisely, and manage consumables more effectively, which results in observable decreases in energy use and material waste. These advancements eventually result in significantly less rework and fewer rejected components.

Just as significant as the environmental impact is the commercial one. Cleaner, more reliable welds use raw materials more efficiently, cut pollutants, and reduce scrap, all of which directly affect operational costs. Sustainable welding is no longer seen as a compliance requirement by many manufacturers. It is becoming more widely acknowledged as a workable strategy to boost margins, resilience, and long-term competitiveness.

India's Manufacturing Ambitions Depend on Advanced Welding

With the help of national initiatives and strong momentum in industries like defence, infrastructure, shipbuilding, automotive, power, oil, and gas, India's industrial environment is growing at a rate never seen before. Large-scale industrial expansion and investment have been made possible by initiatives like PM Gati Shakti, the National Infrastructure Pipeline, and Make in India.

However, capacity alone is insufficient to achieve global competitiveness. It calls for advanced fabrication capabilities, consistently high precision, and quality that is benchmarked globally. Welding, a procedure that subtly affects the durability, strength, and dependability of manufactured goods, is at the core of all of these.

Indian manufacturers can produce tighter tolerances, lower variability, and increase consumer confidence in "Made in India" products when they integrate AI-enabled welding technologies with targeted skill development and



sustainable practices. India's move into higher-value manufacturing sectors, such as heavy engineering, clean energy systems, aerospace components, and large-scale infrastructure production, will also depend heavily on advanced welding.

Welding is no longer merely a shop floor activity in this setting. It becomes a strategic pillar that helps India achieve its larger industrial and economic goals.

Challenges That Must Be Addressed

Although there are many opportunities, the transition to sustainable and AI-enabled welding is not without difficulties. The initial cost



of contemporary technology continues to be a major obstacle for many small and medium-sized firms. In other situations, the lack of standardized training and certification results in skill gaps that hinder the efficient application of new technology and inhibit their acceptance.

Strong foundations are also necessary for digital integration. Cyber-secure infrastructure, dependable data systems, consistent power supplies, and dedicated leadership are crucial, but they are not equally developed throughout India's manufacturing environment.

It will need teamwork to close these disparities. Improved access to capital for SMEs, the development of structured skill routes, and the alignment of certificates


with international standards can all be achieved through closer cooperation between industry, educational institutions, and governmental organizations. To ensure that new welding technologies can be confidently and widely used, investments in collaborative research and practical innovation will be equally crucial.

The Road Ahead

Intelligence, capability, and accountability will shape the factories of the future. Welding, the process that powers almost all industrial systems and designed structures, is at the center of this evolution. Welding will continue to be

essential to the development of products' strength, dependability, and performance as manufacturing progresses.

Manufacturing becomes safer, more effective, and more resilient when AI-driven accuracy is combined with a highly skilled workforce and sustainable practices. This intersection offers India more than just increased productivity. It offers an opportunity to establish new standards for creativity, quality, and dependability on a worldwide scale.

The goal of welding has always been to join materials. It will also integrate human expertise, technology, and environmental responsibility in the next years. The future of manufacturing is being shaped there, and it is already taking shape. 



NIRMAL M. VASANI,
Chief Operating Officer (COO)
& Promoter, Aimtron Group



Can Tier- 2 become India's Manufacturing Backbone?

The article explores how India's Tier-2 cities are becoming key drivers of manufacturing growth, offering cost efficiency, skilled talent, and modern infrastructure. By integrating smart factories, policy support, and local supply chains, these emerging hubs are poised to strengthen India's global manufacturing competitiveness.

For decades, the narrative of India's economic growth was written in the skyscrapers of its Tier-1 metropolises. Mumbai, Bengaluru, and the National Capital Region served as the primary magnets for investment, talent, and industrial expansion. However, as these urban centers grapple with the inevitable challenges of saturation spiraling real estate costs, infrastructure bottlenecks, and high operational overheads a silent but powerful shift is occurring.

The next chapter of India's manufacturing story is being written in its Tier-2 cities. From Vadodara and Coimbatore to Indore and Nagpur, these emerging manufacturing hubs are no longer just peripheral support systems; they are evolving into the foundational backbone of a self-reliant, globally competitive manufacturing ecosystem. For an India aiming to increase manufacturing's share of the GDP to 25%, the decentralization of industry is not just an option, it is a strategic imperative.

The Strategic Shift: Why Tier-2, Why Now?

The migration toward Tier 2 is driven by a convergence of economic logic and visionary policy. At the core lies the "Plug and Play" infrastructure model. Unlike the organic, often chaotic growth of older metros, offer the luxury of planned industrial clusters. These hubs provide ready-to-use land parcels, dedicated power grids, and specialized logistics corridors that significantly reduce the "time-to-market" for new enterprises.

Cost remains a dominant factor. The operational expenditure (OPEX) in a city like Vadodara or Aurangabad can be 20% to 30% lower than in a Tier-1 city. This includes everything from lower lease rentals to more stable labor costs. However, the modern manufacturer is looking beyond mere cost-cutting. The real draw is the "Value-to-Cost" ratio—the ability to access high-quality infrastructure and a skilled workforce without the friction of a hyper-congested urban environment.

Vadodara: A Blueprint for the Tier-2 Ecosystem

Consider the trajectory of Vadodara. Historically known as a center for chemicals and pharmaceuticals, it has evolved into a sophisticated hub for power equipment, heavy engineering, and increasingly, high-end electronics and defense manufacturing. Its strategic location on the Delhi-Mumbai Industrial Corridor (DMIC) makes it a logistical goldmine.

What makes Vadodara a blueprint for others is its holistic ecosystem. It doesn't just house factories; it houses an entire value chain from raw material suppliers and specialized component manufacturers to testing laboratories and technical universities.

The Policy Tailwinds: Connecting Regions to National Objectives



The rise of next- generational industrial cities is inextricably linked to the government's flagship initiatives. The PM Gati Shakti National Master Plan is perhaps the most significant catalyst, integrating multimodal connectivity across the country. By linking remote industrial zones via high-speed rail, modernized ports, and expressways, the government is effectively shrinking the distance between a factory in a Tier-2 city and a global consumer in Europe or America.

Furthermore, the Production Linked Incentive (PLI) schemes across sectors like electronics, semiconductors, and specialty steel are incentivizing

companies to look for large-scale land parcels that are only available and viable in next- generational industrial cities. These policies are not just encouraging production; they are mandating a standard of quality and precision that aligns with global benchmarks.

Talent Democratization and the Reverse Migration

One of the most profound shifts in recent years has been the democratization of talent. For years, the "brain drain" from smaller towns to metros was considered a given. Today, we are witnessing a "reverse migration." As high-tech manufacturing



units set up factories in emerging manufacturing hubs, they are bringing with them high-value jobs that require specialized engineering skills.

Young professionals are increasingly choosing the quality of life offered by next- generational industrial cities characterized by shorter commutes, lower cost of living, and better environmental conditions—provided they have access to "Tier-1 work." For the manufacturing sector, this means a more stable, loyal, and focused workforce. To sustain this, the industry must continue to collaborate with local Industrial Training Institutes (ITIs) and engineering colleges to bridge the gap between academic theory and the

practical demands of Industry 4.0.

The Innovation Edge: Precision and Quality

As India positions itself as a global alternative in the "China Plus One" strategy, the focus must shift from "low-cost" to "high-value." This is where the leadership vision for the next decade comes into play. The manufacturing of the future is not about mass-producing generic goods; it is about precision engineering, advanced electronics, and sustainable practices.

Tier-2 hubs are uniquely positioned to adopt these "Smart Factory" concepts.

With the ability to build facilities from the ground up, manufacturers can integrate IoT, AI-driven quality control, and green energy solutions into the very blueprint of their operations. The vision is to establish "Centers of Excellence" in these cities that rival the best in the world. By focusing on zero-defect manufacturing and global quality standards, these hubs can ensure that "Made in India" is synonymous with "World Class."

Building a Resilient Supply Chain

Global supply chain disruptions in recent years have highlighted the danger



of over-concentration. By spreading the manufacturing base across Tier-2 cities, India is building a more resilient and distributed industrial network. If one region faces a localized challenge, the national output remains steady.

Moreover, these cities serve as the perfect staging ground for MSMEs (Micro, Small, and Medium Enterprises). A large anchor manufacturing unit naturally spawns a galaxy of smaller vendors and service providers around it. This creates a robust local supply chain that reduces dependence on imports for components and sub-assemblies, truly embodying the spirit of Atmanirbhar Bharat.

The Road Ahead: Challenges and Imperatives

While the potential is immense, the

transition is not without challenges. Last-mile connectivity, consistent power quality, and the availability of specialized social infrastructure (like international schools and healthcare) are critical to attracting top-tier global management talent to these cities.


Furthermore, digital transformation must be the bedrock of this growth. For a Tier-2 city to function as a global manufacturing hub, it must be digitally integrated. High-speed data connectivity is as important as road connectivity in the age of remote monitoring and digital twins.

The Future is Decentralized

The rise of emerging manufacturing hubs marks a decisive evolution in India's economic development. It reflects

a move away from concentration-led growth toward a distributed, resilient, and capability-driven industrial model.

The future points toward a network of high-efficiency manufacturing clusters embedded across India's heartland—each contributing scale, specialization, and innovation to a shared national ambition. By strengthening these ecosystems, India is not merely expanding capacity; it is redefining how and where value is created.

The shift from Tier-1 to Tier-2 is ultimately a shift in mindset. It recognizes that global manufacturing leadership will be built not through a few saturated metros, but through many well-integrated, future-ready industrial cities. In these emerging hubs, the foundation of India's next manufacturing chapter is already taking shape. 



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Robot controller integration with existing PLC and SCADA systems

This article explains how integrating robots with PLC and SCADA systems is enabling smarter, more connected, and efficient manufacturing in India by improving control, visibility, and productivity. It also highlights integration challenges, best practices, and how unified automation platforms are shaping the future of Industry 4.0-ready factories.

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India's manufacturing landscape is entering a new phase of transformation—and this shift is being powered not just by AI, but by the rising adoption of robotics across industries. As factories increasingly combine automation systems with advanced robotic technologies, India is steadily positioning itself as a serious global manufacturing hub.

Robotics today is more than just a symbol of progress. Robots bring accuracy, consistency, safety, and the ability to perform repetitive tasks tirelessly. With fewer manual errors, productivity naturally increases, and human workers can shift their focus to higher-value, strategic roles. This is made possible by the seamless integration of robots with PLCs (Programmable Logic Controllers) and SCADA (Supervisory Control and Data Acquisition) systems, helping machines communicate intelligently and operate efficiently in real time.

What are PLCs and SCADA systems?

PLCs act as the dependable “control brains” of industrial equipment. They gather data, manage machines, and efficiently handle both simple and complex tasks. Unlike older relay-based systems, PLCs offer far greater precision, flexibility, and scalability.

SCADA, meanwhile, serves as the plant-wide supervisory system. Through a Human-Machine Interface (HMI), operators can monitor equipment, issue commands, and optimize processes from a centralized environment. Together, PLCs and SCADA keep operations synchronized, predictable, and reliable.

How do they work together?

The workflow is simple yet powerful:

Sensors capture real-time conditions
→ The PLC takes immediate action →
SCADA supervises, analyzes, and guides the broader response.



For example, if a turbine vibrates above safe limits, sensors alert the PLC, which triggers immediate corrective action. The SCADA system then displays this event, helping operators anticipate issues and initiate timely maintenance. This PLC–SCADA interplay forms the foundation of predictive maintenance.

Why these systems matter in industrial automation

Together, PLCs and SCADA systems orchestrate plant operations, ensuring smooth flow across production lines, robotics, and machine processes. They help minimize downtime, eliminate bottlenecks, improve diagnostics, and drive enterprise-wide visibility. This synergy supports Industry 4.0 goals of smart, connected, and scalable manufacturing.

Delta's Unified Industrial Automation Ecosystem

Delta uniquely provides robotics, PLCs, SCADA, motion control, drives, sensors, and software within a single integrated ecosystem. This unified architecture ensures that every component—from robot arms to inspection sensors—works smoothly without integration conflicts.

For manufacturers, this reduces engineering complexity, accelerates

commissioning, and improves long-term maintainability across the entire production line.

Key challenges in integration

While integration is powerful, it comes with challenges. Synchronizing robot cycles with PLC scan times requires precision. Ensuring reliable low-latency communication in large industrial networks is not always straightforward. Cybersecurity threats continue to grow, making secure design and monitoring essential. And as robotics and automation expand, setup and maintenance require careful planning and skilled oversight.

Understanding and addressing these challenges early helps maintain stable, high-performance operations.

Best practices for successful integration

The foundation of seamless integration begins with selecting open, standardized communication protocols. Delta's support for Modbus TCP/IP, EtherCAT, and OPC UA is a major industry advantage.

These open standards make it easier for customers to integrate Delta equipment with existing third-party systems, legacy assets, and future upgrades.

By avoiding vendor lock-in, manufacturers gain flexibility and

scalability as their automation needs grow. Engineering tools also play a critical role. Delta's DIASudio platform simplifies robotics, PLC, and SCADA engineering with unified configuration, simulation, and deployment tools. This reduces engineering effort, ensures system-wide synchronization, and shortens time-to-production.

Engineers can design, test, troubleshoot, and fine-tune automation sequences in one place, reducing handoff delays between teams. This also helps standardize engineering practices across plants, ensuring consistent workflows and reducing project turnaround time.

Cybersecurity must be prioritized with layered controls. Modular programming and structured logic help minimize debugging efforts and ensure faster upgrades. With digital twins and simulation tools, engineers can test systems before deployment, limiting risk and ensuring smoother implementation.


Emerging technologies—edge computing, IIoT, and Industry 5.0—will further enhance real-time data processing. They will also support human-robot collaboration, helping robots and humans work together efficiently and safely.

Unified control platforms will improve flexibility and responsiveness, enabling

industries to adapt quicker and optimize resources across their operations.

What lies ahead

The seamless integration of robots, PLCs, and SCADA systems is no longer optional—it is becoming fundamental for future-ready manufacturing. Companies that invest today will build stronger digital infrastructure, improve process efficiency, and stay competitive in a rapidly evolving industry.

Those who embrace this shift will shape the next decade of smart manufacturing. 





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How Drones are Powering the Next Wave of Industrial Growth

This article highlights how drones are emerging as critical enablers of industrial growth by enhancing productivity, safety, and data-driven decision-making across sectors. It also emphasizes their role in driving sustainability, creating skilled jobs, and positioning India as a global leader in next-generation drone technologies.



**AGNISHWAR
JAYAPRAKASH,**
Founder and CEO,
Garuda Aerospace

We are witnessing an extraordinary transformation in the global industrial landscape — one that is being accelerated by drones. Once seen as futuristic gadgets, drones today stand at the heart of the world's next industrial revolution. They embody the fusion of intelligence, autonomy, and agility that industries need to thrive in an era of sustainability, resilience, and rapid innovation. The drone revolution is not coming — it is already here, and it is powering the next wave of industrial growth.

Drones: The new engines of industrial productivity

Drones have become indispensable to modern industry because they combine the best of mobility, precision, and data intelligence. They can go where humans cannot, capture what machines on the ground cannot see, and deliver insights faster than traditional methods ever could. Equipped with AI, high-resolution sensors, and advanced flight systems, drones act as the eyes, ears, and extended hands of industries — performing inspections, mapping assets, transporting materials, and even aiding decision-making in real time.

In sectors such as infrastructure, energy, logistics, agriculture, and public safety, drones have shifted from being support tools to becoming core operational assets. Every flight saves hours of labour, reduces risk, and contributes to measurable economic gains. What truly makes drones transformative is that they not only cut costs but also enhance performance — delivering better data, faster turnaround, and smarter outcomes.

Revolutionising industries through aerial intelligence

Infrastructure and Construction. Drones have completely redefined the



way we build and maintain physical assets. From surveying sites to monitoring progress and ensuring safety compliance, drones deliver unparalleled accuracy and efficiency. They create 3D maps, digital twins, and automated reports that empower engineers to make real-time, data-driven decisions. Construction companies using drones report time savings of up to 70% and significant reductions in project delays.

Agriculture and Rural Transformation. Precision agriculture powered by drones is enabling farmers to optimise inputs and increase yields sustainably. Drones can analyse crop health, detect pest infestations early, and ensure precise spraying — minimising chemical use and maximising productivity. For India and other agrarian economies, this technology holds the key to transforming rural livelihoods, conserving resources, and building climate resilience.

Energy and Utilities. Drones are now vital for inspecting wind turbines, solar farms, and transmission lines. They detect faults, monitor wear and tear, and provide detailed visual analytics that prevent costly downtime. The

renewable energy sector, in particular, benefits immensely from drone-enabled predictive maintenance — a cornerstone for achieving net-zero targets.

Logistics and Industrial Delivery. Drones are streamlining last-mile logistics and site-to-site deliveries within large industrial campuses. They are also being deployed for medical supplies, spare parts, and emergency equipment, cutting lead times drastically. Drone logistics not only enhance operational continuity but also reduce carbon emissions, aligning with global sustainability goals.

Disaster Response and Public Safety. In emergencies, drones are often the first responders. They assess damage, locate survivors, and deliver aid in record time. These life-saving capabilities highlight the social value of drones beyond their industrial utility.

The economic and social dividends

The economic case for drones is compelling. Studies show that drone integration can increase industrial productivity by 20–40%, reduce inspection costs by up to 60%, and create

thousands of new skilled jobs. But beyond numbers, drones democratise technology — empowering even small businesses and local governments with aerial data that was once prohibitively expensive.

Drones also foster inclusive growth. They open career paths for young professionals in drone operations, data analytics, and maintenance. Governments and educational institutions are now incorporating drone training into skill development programs, ensuring the next generation is ready to lead this airborne revolution.

Technology driving transformation is innovation. The backbone of this growth is innovation. Modern drones are equipped with AI-driven navigation, obstacle avoidance, real-time analytics, and cloud-based reporting systems. Autonomy enables multiple drones to operate simultaneously, executing missions with precision and reliability. With improved battery endurance and seamless data connectivity, drones are becoming smarter, safer, and more capable every year.

Integration with IoT, GIS, and enterprise software systems is another

major leap. Drone data now feeds directly into industrial dashboards and decision-making platforms, enabling predictive analytics and preventive maintenance — key pillars of Industry 5.0. In this new paradigm, drones don't replace humans; they amplify human intelligence, allowing teams to focus on strategy rather than repetitive tasks.

Building trust and scaling responsibly

The journey toward widespread drone adoption depends on robust



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The government's Production-Linked Incentive (PLI) scheme, coupled with liberalised drone rules, has catalysed the growth of domestic manufacturing and R&D. Indian drone startups are now exporting to global markets, providing agricultural, mapping, and inspection solutions tailored to diverse geographies. This momentum aligns perfectly with the vision of Atmanirbhar Bharat and Viksit Bharat 2047 — where indigenous technology drives inclusive and sustainable growth.

The road ahead

The next phase of drone evolution will see them integrated deeply into smart cities, automated logistics, and AI-powered industrial ecosystems. Imagine drone fleets conducting daily infrastructure audits, monitoring environmental compliance, and even assisting in urban planning through live spatial data. These are not distant possibilities — they are already being piloted in several regions.

The focus must now shift to scaling operations responsibly, investing in infrastructure such as drone ports, and enabling continuous innovation through research and collaboration. The public and private sectors must work hand-in-hand to build an ecosystem where drones become as common and trusted as any industrial tool.

Conclusion: The sky is the new industrial frontier

Drones are no longer auxiliary tools; they are central to the way modern industry operates and evolves. They embody the very essence of progress — innovation that is efficient, inclusive, and sustainable. As we enter a new age of industrial growth, drones will continue to elevate productivity, unlock economic value, and empower nations to achieve their development goals faster. 

regulation, safety protocols, and public confidence. Governments around the world, including India, are making remarkable progress with progressive drone policies that promote indigenous manufacturing, local innovation, and ease of operation. Industry players must continue to prioritise transparency, safety, and ethical use of data to ensure that drones remain a trusted part of our skies.

As manufacturers, we are deeply

committed to responsible innovation — building drones that are reliable, secure, and environmentally conscious. Public awareness, pilot training, and adherence to operational standards are key to creating a sustainable ecosystem.

A made-in-India opportunity

For India, drones represent a once-in-a-generation opportunity to lead the world in next-gen industrial technologies.

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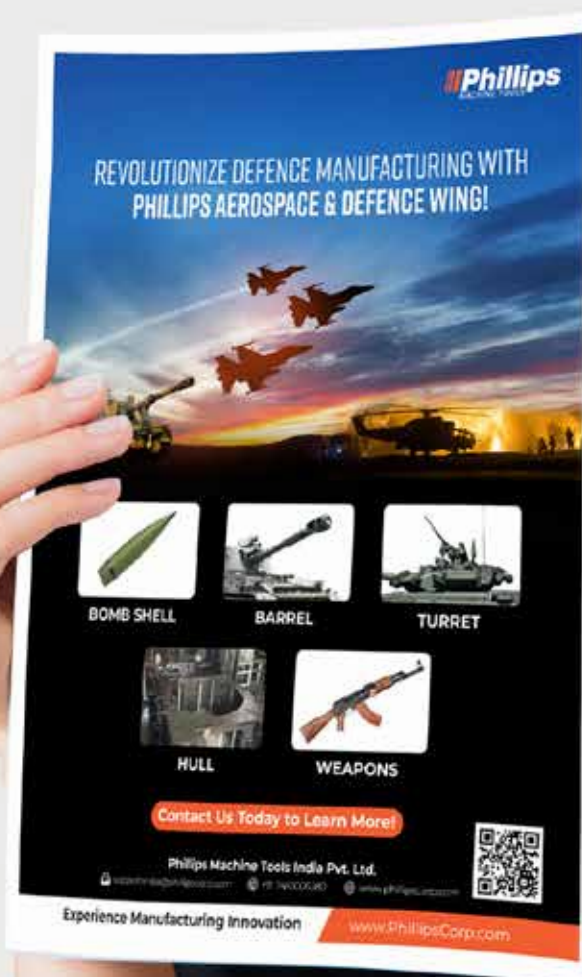
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Factory 2030: The Convergence of CNC, Additive, and Precision Manufacturing

The article explores how CNC machining, additive manufacturing, and precision engineering are converging into intelligent, hybrid production systems by 2030. It highlights the role of digitalization, sustainability, and advanced materials in shaping flexible, high-precision, and future-ready factories.

As we approach 2030, the landscape of manufacturing stands on the cusp of a dramatic transformation. The traditional boundaries between subtractive machining, additive manufacturing (AM), and precision engineering are dissolving. What once were distinct domains; CNC machining, 3D printing, and precision finishing; are converging into unified, intelligent, hybrid production systems. This convergence is driven by rapid advances in computing, materials science, digitalization and sustainability, fundamentally reshaping how components and products are designed, produced, and refined.

In this article, we explore how innovations in Computer Numerical Control (CNC), additive manufacturing, and precision engineering machines are coming together; and what that means for industry, design freedom, and global competitiveness by 2030.

The Surge of Smart CNC: Intelligence Meets Machining

CNC machining has long been the backbone of precision manufacturing. But its next evolution is not about faster spindles alone; it's about smarter machines.

AI, IoT, and Real-Time Optimization Modern CNC systems are increasingly embedded in connected networks via IoT. Sensors monitor critical parameters; vibration, temperature, spindle load, tool wear; in real time, feeding data into analytics engines that dynamically adjust machining parameters.

Meanwhile, AI and machine-learning algorithms are optimizing tool paths, predicting maintenance needs, and detecting anomalies before parts are scrapped. This not only improves quality and precision but significantly reduces downtime and waste; a major competitive advantage for high-volume and high-precision manufacturing.

Multi-Axis & Micromachining: Complex Geometries, Tight Tolerances

CNC machining is also evolving quickly in capabilities. Multi-axis machines; especially 5-axis and beyond; are now common, enabling the machining of complex geometries and curved, organic shapes in a single setup.

At the same time, demand is rising for micromachining and ultra-precision work; manufacturing components with submicron tolerances, ultra-fine surface finishes, or micro-scale features. This is especially relevant for sectors like semiconductors, optics, medical devices, and high-precision instruments.

Sustainability & Efficiency as Core Drivers

Manufacturers are increasingly mindful of resource usage, energy consumption, and waste. CNC processes are being optimized for material efficiency, energy savings, and minimal scrap. Machining centers now adopt high-speed machining (HSM), energy-efficient drives, minimum-quantity lubrication or coolant recycling, and other eco-conscious practices.

In parallel, real-time monitoring helps extend tool life, reduce rejects, and avoid unnecessary energy usage, aligning with broader environmental and sustainability goals.

The result: smarter, leaner, cleaner CNC; not just for precision, but for future-ready sustainable manufacturing.

The Rise of Additive Manufacturing — From Prototyping to Production

Additive manufacturing (3D printing) has matured past its early days of rapid prototyping. Entering the 2020s, it is steadily becoming a mainstream method for producing real, usable parts — not just prototypes.



Growing Market & Broadening Applications

Global growth trends suggest that precision machining and AM markets will swell significantly by 2030. One recent market forecast estimates that the global precision-machining market — including CNC operations could grow to approx. US\$193.7 billion by 2030.

In parallel, as additive manufacturing technologies advance and costs fall, AM is increasingly viable for production of complex parts; especially where traditional machining struggles or is wasteful.



Materials, Complexity, Customization — The Additive Edge

One of the real strengths of AM lies in geometry and design freedom. Low-waste, near-net-shape fabrication allows for parts with internal lattices, variable wall thicknesses, conformal cooling channels, organic shapes, and other geometries that would be extremely difficult or costly with subtractive methods.

Moreover, as materials science advances, AM increasingly handles high-performance materials such as titanium alloys, composites, ceramics, previously hard to shape by conventional machining.

AM also enables customization, small-batch production, and rapid iteration. AM allows multiple components to be combined into a single, optimized part, reducing assembly time, minimizing failure points, and improving overall system efficiency.

Hybrid Manufacturing: The Best of Both Worlds

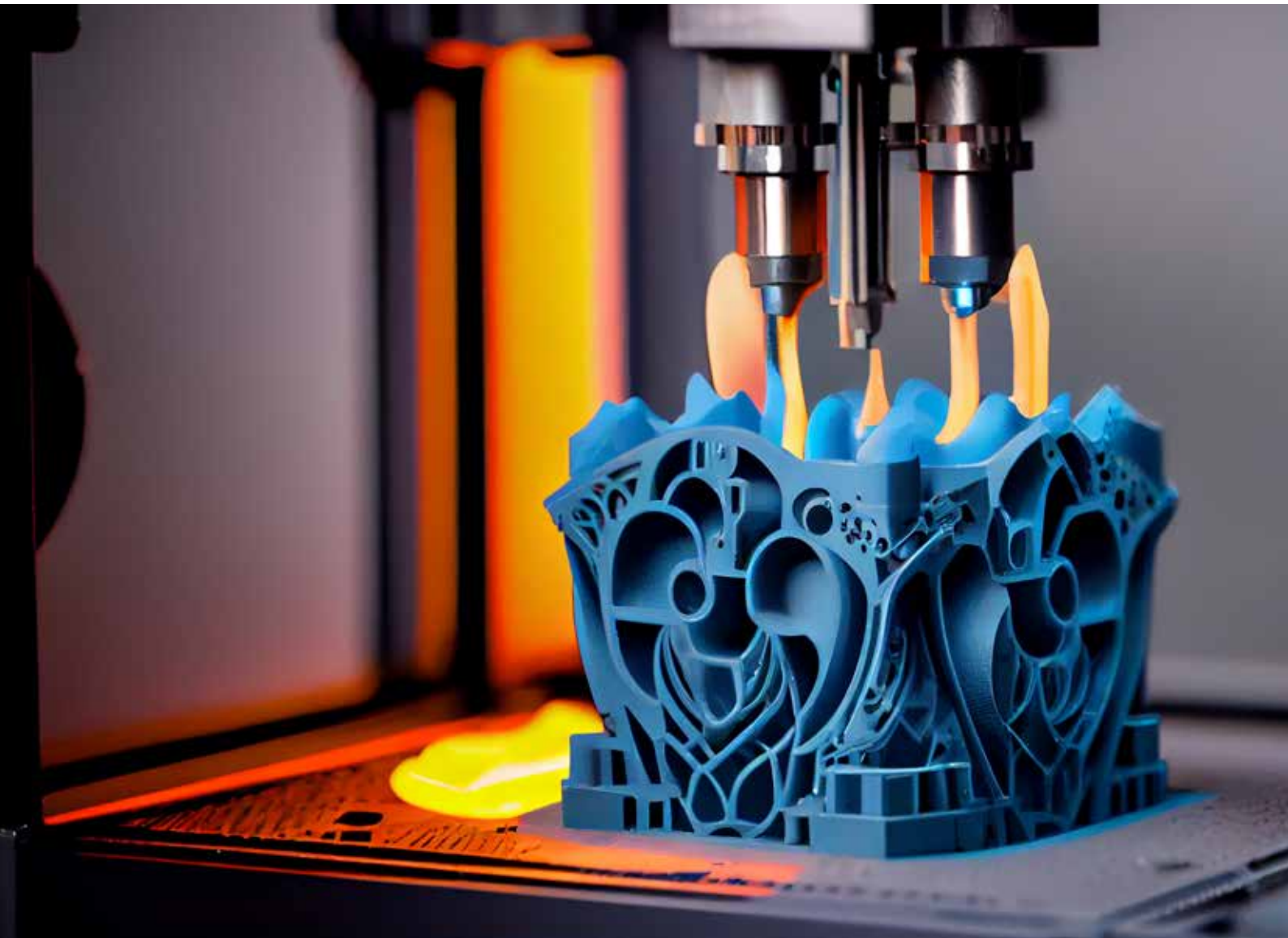
The real revolution, however, comes when subtractive and additive converge. Hybrid manufacturing, combining CNC (subtractive) and AM (additive) in integrated platforms, is becoming the gold standard.

Hybrid Machines & Integrated Workflows

By 2030, hybrid machines that can both 3D-print and machine on the same platform will be increasingly common. These machines allow rapid formation of complex shapes via additive methods, followed by precision finishing; all in a single work cycle.

This synergy offers several benefits:

- **Complex geometries + tight tolerances:** Internal lattices, complex fluid channels, and organic shapes built by AM; finished to high-precision dimensions via CNC.
- **Material efficiency:** Less wastage



than subtractive-only processes; near-net building reduces scrap.

- **Reduced lead times & cost:** Prototyping, tooling, and final part manufacturing can be streamlined, often dramatically cutting time from concept to part.
- **Repair, rework, customization:** Damaged or worn parts (e.g. aerospace turbine blades) can be rebuilt via AM deposition and then machined to tolerance; extending lifecycles and saving costs.

In essence, hybrid manufacturing

blurs the line between “prototyping” and “production.” By 2030, it could become standard in high-value, high-complexity industries.

Digital Transformation & Precision Engineering Ecosystems

Beyond the machines themselves, the broader manufacturing ecosystem is evolving; powered by digital technology, simulation, analytics, and lifecycle thinking.

Digital Twins, Simulation, and

Closed-Loop Manufacturing

One of the most powerful enablers is the concept of a digital twin: a virtual replica of a machine, production line, or even entire factory that reflects real-world performance in real time. With such digital twins, engineers can simulate machining or AM processes, predict tool wear, optimize parameters, and catch errors before they occur.

Combined with AI analytics, these digital twins; and the data they feed; form the backbone of closed-loop manufacturing: design ↔ simulation ↔ production ↔ quality control ↔



feedback. This approach significantly increases reliability, repeatability, and speed of innovation.

Precision Engineering & High-Performance Materials

Demand for high-performance components; lighter, stronger, more durable; continues to grow. That means more usage of exotic materials: titanium, Inconel, composites, ceramics, carbon-fiber reinforced polymers, advanced alloys.

But with such materials come

challenges: higher tool wear, tougher machining conditions, and stringent quality requirements. Advances in tooling; nanocomposite cutting tools, advanced coatings, diamond-like coatings, adaptive tooling with real-time vibration or wear sensing; are helping meet those demands.

Likewise, precision engineering machines (ultraprecision spindles, air-bearing spindles, micromachining setups) are being brought into mainstream manufacturing; enabling submicron tolerances, mirror-grade surface finish, and micro/nano-scale features.

Flexible, On-Demand, and Customized Production

Instead, flexible manufacturing lines; reconfigurable CNC + AM + inspection + robotic material handling; will emerge as key enablers of “make-what-you-need, when-you-need” business models.

This flexibility will increase responsiveness to customer demand, reduce inventory, and minimize lead times; a competitive advantage in a world where design cycles and customer preferences evolve rapidly.

Vision 2030: What the Future Factory Looks Like

Imagine a factory in 2030 built around these converging trends:

- **A hybrid machining cell:** a machine that 3D-prints a complex titanium component layer-by-layer, then immediately machines finishing surfaces, holes, and features to micron-level tolerances.
- **Fully connected via IoT:** sensors track every spindle vibration, temperature, and tool wear; analytics dashboards monitor throughput, quality, and predictive maintenance.
- **Digital twin systems:** before launching any new component, engineers simulate the build; check


for stresses, thermal distortion, optimal tool paths; reducing trial-and-error and ensuring right-first-time production.

- **Flexible workflows:** from a 3D-printed medical implant batch of 10 pieces, to aerospace spare-part runs, to custom tooling for automotive prototypes; the same shopfloor, reconfigured in hours, not weeks.
- **Sustainability:** minimal material waste, energy-efficient drives, coolant recycling, optimized tool life, and supply-chain transparency throughout.
- **A skilled workforce:** machinists and production engineers who understand metallurgy, digital manufacturing, quality analytics; working hand in hand with AI-driven machines, defining the future of precision manufacturing.

Such a factory defines what we might call the “Factory of 2030”; where CNC, additive manufacturing, and precision engineering don’t just coexist, but converge into a seamless, intelligent, and adaptive production ecosystem.

Conclusion

As we head toward 2030, the boundaries in manufacturing are blurring. CNC machining is no longer isolated from additive manufacturing; precision engineering is no longer limited to hand-finishing or traditional practices. Instead, we are witnessing the emergence of a unified, intelligent, and hybrid manufacturing paradigm; where CNC, AM, and precision engineering converge.

This convergence promises greater design freedom, faster innovation, flexible production, sustainability, and competitiveness. For companies, engineers, and nations looking to lead in the future of manufacturing, the time to act is now. The Factory of 2030 is not a distant dream; it’s being designed, coded, and built today. 

How reverse Logistics can unlock value in India's circular economy journey

This article explains how reverse logistics can transform returns and end-of-life products into economic, environmental, and social value, making it a cornerstone of India's circular economy. It highlights how structured reverse flows, supported by technology and policy, can improve sustainability, regulatory compliance, and supply-chain resilience.

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Country General Manager, YCH India





India's ambition to build a circular economy is steadily gaining momentum. With rising consumption, rapid urbanisation, and growing environmental pressures, the country is rethinking how products move not just forward from factory to consumer, but also backward after use. This is where reverse logistics is emerging as a critical enabler. Once viewed as a cost-heavy and operationally complex necessity, reverse logistics is now being recognised as a strategic lever that can unlock economic value, improve sustainability outcomes, and strengthen supply chain resilience.

At its core, reverse logistics covers the movement of goods from the point of consumption back to manufacturers, distributors, or designated facilities for reuse, repair, refurbishment, recycling, or responsible disposal. In a linear economy, products end their life at the consumer. In a circular economy, they re-enter the value chain. Reverse logistics provides the connective tissue

that makes this loop viable at scale.

India's case for reverse logistics is particularly compelling. According to government estimates, the country generates over 3.5 million tonnes of e waste annually, making it one of the largest e waste producers globally. Add to this the surge in packaging waste driven by ecommerce, growing returns in fashion and consumer electronics, and the increasing volume of end of life industrial equipment. Without efficient reverse flows, much of this material either leaks into informal channels or ends up in landfills, resulting in lost value and environmental harm.

The circular economy framework aims to change this outcome. By designing systems that recover products and materials, India can reduce its dependence on virgin resources, cut emissions, and create new economic opportunities. Reverse logistics sits at the centre of this transformation because it determines whether returned goods become assets or liabilities.

One of the most immediate value unlocks comes from improved asset recovery. In sectors such as electronics, automotive components, and industrial equipment, returned products often retain significant residual value. With structured collection, inspection, and refurbishment processes, companies can resell or redeploy these assets at lower cost. This is particularly relevant in India, where demand for affordable and reliable products remains high. Refurbished goods can bridge the gap between sustainability goals and price sensitive markets.

Ecommerce provides another powerful illustration. Returns are a defining feature of online retail, with return rates in certain categories reaching double digit percentages. When reverse logistics is inefficient, returns erode margins through delays, damage, and write offs. When managed well, they become an opportunity to recover inventory quickly, reduce waste, and improve customer trust.

Faster return cycles also free up working capital, which is critical in a competitive retail environment.

Reverse logistics also plays a growing role in meeting regulatory and policy expectations. India has introduced extended producer responsibility norms across categories such as plastics, electronics, and batteries. These regulations require producers to take responsibility for post consumer waste. Compliance is not possible without robust reverse logistics networks that can track, collect, and process materials across geographies. Companies that invest early in these capabilities are better positioned to manage compliance costs and avoid operational disruptions.

Technology is reshaping how reverse logistics operates in practice. Digital tracking systems enable real time visibility into returned goods, improving forecasting and reducing losses. Data analytics helps identify patterns in returns, allowing businesses to address root causes such as product quality issues or packaging failures. Automation in sorting and handling improves speed and accuracy, especially in high volume environments. These tools are turning reverse logistics from a reactive function into a data driven strategic capability.

Warehousing infrastructure also needs to evolve to support circular flows. Traditional warehouses are designed for forward movement and high throughput. Reverse logistics requires flexible spaces that can handle inspection, grading, light repair, and consolidation. Purpose built facilities that integrate these functions reduce handling costs and shorten turnaround times. Green warehouses that optimise energy use and waste management further strengthen the sustainability impact of reverse operations.

Beyond economics and compliance, reverse logistics has a strong human and social dimension in India. The

informal sector has long played a role in waste collection and recycling, especially in urban centres. As organised reverse logistics networks expand, there is an opportunity to integrate informal workers into safer, more productive value chains. Training, formal employment, and better working conditions can improve livelihoods while increasing material recovery rates. This alignment of social and environmental outcomes is central to a truly inclusive circular economy.

The industrial sector stands to gain significantly from reverse logistics as well. Heavy industries, infrastructure projects, and manufacturing plants generate large volumes of scrap, surplus materials, and end of life equipment. Structured reverse flows allow these materials to be recovered and reintegrated into production cycles, reducing procurement costs and exposure to commodity price volatility. In a global environment marked by supply chain disruptions, such resilience is becoming a strategic priority.

India's logistics ecosystem is gradually adapting to these needs. Integrated supply chain providers are expanding capabilities across warehousing, transportation, technology, and sustainability services. Multi city networks make it possible to aggregate returns efficiently, even in a geographically diverse market. Investments in green infrastructure signal a broader shift towards long term value creation rather than short term cost optimisation.

Looking ahead, reverse logistics will be a defining pillar of India's circular economy journey. As consumption grows and resources become more constrained, the ability to recover value from what was once considered waste will separate resilient supply chains from fragile ones. The transition will require collaboration across manufacturers, retailers,




logistics providers, policymakers, and consumers. It will also require a mindset shift, from viewing returns as friction to recognising them



as flows of opportunity.

India has the scale, entrepreneurial energy, and policy momentum to lead in this space. By strengthening

reverse logistics capabilities today, the country can unlock economic value, reduce environmental impact, and build supply chains that are fit for a

circular future. The path forward is not without complexity, but the rewards, for businesses, society, and the planet, are well worth the effort. 

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