The background of the entire page is a photograph of a modern industrial factory. In the foreground, a large orange robotic arm is positioned on the left, its joints and gripper visible. In the middle ground, a worker wearing a blue uniform and a yellow hard hat is seen from the side, looking towards the right. Further back, another worker is visible, and several other robotic arms are in operation, creating a sense of a busy, automated manufacturing environment. The lighting is a mix of cool blue tones from the overhead lights and warm orange/yellow tones from the sparks and the robots.

Manufacturing 5.0: Accelerating Telangana's industrial transition from Industry 4.0 to 5.0

March 2025

■ ■ ■
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Confederation of Indian Industry



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Executive summary

The transition from Industry 4.0 to Industry 5.0 represents a pivotal moment in the evolution of global manufacturing—a shift from automation-centric processes to a human-centric paradigm, where advanced technologies collaborate with human ingenuity to achieve sustainable, resilient and personalized production systems. This whitepaper, Manufacturing 5.0: Accelerating Telangana's industrial transition from Industry 4.0 to 5.0, explores how Telangana can lead this transformation, leveraging its industrial strengths, forward-thinking policies and commitment to innovation.



Industry 5.0: The next frontier in manufacturing

Industry 5.0 builds on the digital foundations of Industry 4.0, introducing collaborative robotics (cobots), generative AI, and sustainable manufacturing principles. This paradigm prioritizes:

- **Mass personalization:** Moving from mass production to consumer-driven customization.
- **Human-machine collaboration:** Augmenting human creativity and decision-making with advanced AI and automation.
- **Sustainability:** Embedding environmental stewardship into core industrial practices.

The global manufacturing market, forecasted to grow to US\$691 billion by 2032, underscores the urgency of embracing this transformative approach.

Telangana: Positioned to lead India's transition to Industry 5.0

Telangana's strategic vision aligns seamlessly with Industry 5.0. The state's pharmaceutical, automotive and electronics sectors have already begun deploying cutting-edge technologies to create human-centric, smart factories. Initiatives like Schneider Electric's IoT-enabled sustainability lighthouse and Dr. Reddy's Laboratories' AI-driven drug discovery are emblematic of this shift.

Moreover, Telangana's government is playing a catalytic role. Policies such as TG-iPASS streamline industrial clearances, while infrastructure projects like Hyderabad Pharma City create ecosystems tailored for innovation and scalability. The establishment of skill development programs through TASK ensures that the workforce is prepared to engage with advanced technologies like AI, generative AI and robotics.

Sustainability and resilience: Core pillars of Industry 5.0

Telangana's commitment to sustainability is evident in its transition to green manufacturing. AI-powered energy optimization, circular economy practices and renewable energy adoption are being integrated into industrial processes. These efforts are complemented by a strong focus on cybersecurity to ensure the resilience of interconnected systems in an increasingly digital landscape.

A comprehensive roadmap for transformation

This whitepaper outlines a clear roadmap for Telangana to position itself as a global leader in Industry 5.0:

1. **Human-machine collaboration:** Scaling the use of cobots and intelligent systems to drive personalization and flexibility in manufacturing.
2. **Advanced technology integration:** Expanding AI and generative AI adoption for predictive maintenance, product design and real-time analytics.
3. **Sustainability integration:** Implementing AI-driven energy management and circular economy practices to reduce waste and emissions.
4. **Skill development:** Establishing comprehensive training programs to upskill the workforce for human-AI collaboration.
5. **Policy and governance:** Creating a robust regulatory framework to govern ethical AI deployment, data security and sustainable practices.

A vision for the future

As manufacturing evolves, the competitive edge will belong to those who can seamlessly integrate advanced technology with human creativity. Telangana, with its proactive policies, robust industrial base, and skilled workforce, is uniquely positioned to lead this global shift, setting a benchmark for human-centric and sustainable industrial excellence.

CII's continued engagement in Telangana's industrial growth—through fostering partnerships, advocating for forward-looking policies, and building capacity across sectors—ensures that this transformation is both scalable and inclusive. Together, Telangana and CII are setting a benchmark for India's leadership in the global Industry 5.0 revolution, enabling a future where technology and human ingenuity drive sustainable and resilient manufacturing excellence.

This whitepaper serves as a clarion call for policymakers, industry leaders, and innovators to collaborate and capitalize on the opportunities of Industry 5.0, ensuring that Telangana not only participates in this revolution but leads it decisively.

Foreword EY

In the heart of India's vibrant economic landscape, Telangana stands out for its stupendous GDP growth of 196.7% over the last ten years. As one of India's newest states, Telangana has quickly become a leader in industrial innovation and the adoption of new technologies. As a hub for industries like pharmaceuticals, automotive, and electronics manufacturing, the state has shown a strong commitment to sustainable and advanced practices, attracting significant global investment.

The state's success in Industry 4.0 can be seen in its proactive policies and the collaborative ecosystem it has nurtured. Telangana has embraced digital transformation in manufacturing, empowered small and medium-sized enterprises (MSMEs) with new technologies, and developed a skilled workforce in areas like AI, robotics, and data analytics through partnerships with industry. The creation of Centers of Excellence for smart manufacturing and initiatives such as TG-iPASS and Hyderabad Pharma City have created an environment that encourages innovation, automation, and sustainable growth.

At the World Economic Forum in Davos in 2025, Telangana's Hon'ble Chief Minister, A. Revanth Reddy shared a vision to expand the state's economic base, focusing on new industries such as electric vehicles, semiconductors, and renewable energy. The 'Telangana Rising' delegation was instrumental in showcasing the state as a key player in the global supply chain. Through international partnerships and a commitment to industrial innovation, Telangana is making strides toward a high-value, future-oriented economy.

Telangana is poised to lead the way into Industry 5.0, which will bring a new level of collaboration between humans and machines, leverage generative AI, and integrate sustainable manufacturing practices. This transition aims to enhance productivity and establish Telangana as a center for next-generation manufacturing. This white paper, developed jointly by EY India and the Confederation of Indian Industry (CII), offers a strategic roadmap to support this shift. It explores the technologies that will drive change, the importance of sustainability, the skills needed for a technology-driven workforce, and the regulatory support required for a smooth transition.

We hope this white paper will be a useful tool for policymakers and industry leaders, helping them to build a strong, innovative, and competitive manufacturing sector in Telangana.

Rohan Sachdev

Consulting Services Leader,
EY India



With recent advancements in AI and human machine integration technology, the manufacturing sector is set to leapfrog into its next stage, transitioning from Industry 4.0 to 5.0. This shift is expected to improve efficiency by an average of 25% and increase the adoption of connected manufacturing solutions rate by 30%. With 90% of India connected by a 5G network and the availability of local and low-band 5G networks, this transformation will further gain momentum. As the data capital of the world, India offers the most affordable data usage rates, further supplementing this transition.

In a recent EY India C-Suite survey, 50% of pharmaceutical executives said they have prioritized AI and Generative AI capabilities in operations and manufacturing. Additionally, 50 % of the C-suite executives reported revenue growth due to AI adoption, while 75% saw improvement in customer satisfaction and cost reduction. Adoption of industry 5.0 will enhance the quality of this data, leading to better insights and decision making. An EY-led GenAI transformation program for a global pharmaceutical company demonstrated the potential for a 14% incremental growth in EBITDA.

Telangana has been at the forefront of pharmaceutical and life sciences manufacturing. With special pharma city projects acting as a vehicle for growth and investments, the state is poised to lead the country in transitioning from Industry 4.0 to 5.0. This transition requires focused attention to detailed mapping of transformation journey, addressing potential challenges and risks. Appropriate sponsorship from the state government will play a pivotal role in unlocking the sector's tremendous potential.

CII plays a crucial role in enabling this transformation. EY and CII have joined hands on preparing this forward-looking paper to outline the broader contours of this journey and accelerate the transition.

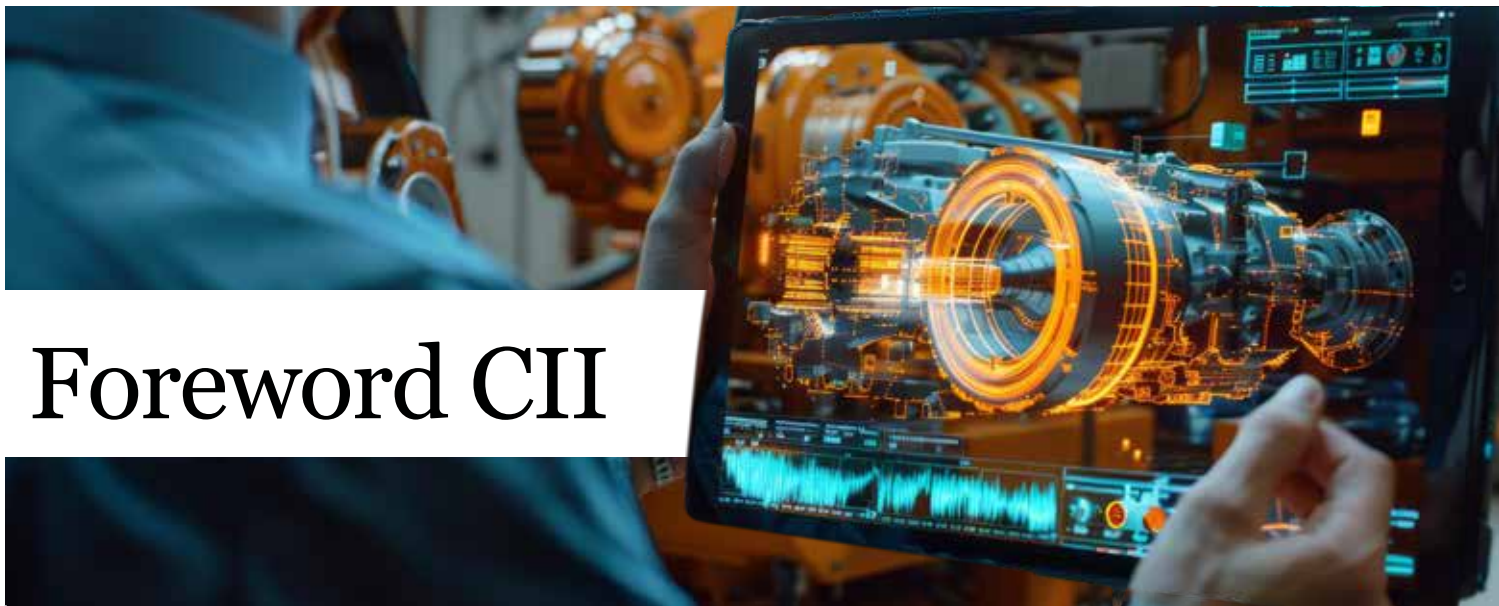
Hyderabad is poised to grow to a US\$100 billion business generator by 2030, up from US\$13 billion (2020) as per projections made in the life sciences report of the Telangana government. Pharmaceutical product exports from Telangana, totaling INR36,893 crore in 2023-24, accounted for 32% of the state's total merchandise exports of INR1,16,182 crore during the fiscal year. This sector's significant share underscores its pivotal role in Telangana's export landscape.

Industry 5.0 addresses key manufacturing challenges by enhancing human-machine collaboration, customization and sustainability:

1. Labor shortages and skill gaps: Collaborative robots (cobots) handle repetitive tasks, allowing humans to focus on complex work
2. Supply chain disruptions: AI and data analytics improve resilience, predict disruptions and optimize inventory
3. Customization at scale: Flexible systems enable mass customization
4. Sustainability: Eco-friendly materials and energy-efficiency reduces carbon footprint
5. Data utilization: Advanced analytics optimize production, improve quality and uptime
6. Cybersecurity: Robust measures protect against data breaches and cyber threats
7. Worker safety: Automation of hazardous tasks and AI-driven safety reduce accidents

Ram Deshpande
Technology Consulting Partner,
EY India





Foreword CII

CII Telangana is pleased to present this White Paper, “Manufacturing 5.0: Accelerating Telangana’s industrial transition from industry 4.0 to 5.0”, developed in collaboration with EY. This whitepaper reflects our shared commitment to guiding Telangana and India into the next era of manufacturing excellence, where human ingenuity and advanced technologies converge to redefine industrial practices.

The transition to Industry 5.0 represents a transformative shift in manufacturing. While Industry 4.0 laid the foundation for digitalization, automation, and smart factories, Industry 5.0 introduces a human-centric approach. It emphasizes collaboration between humans and advanced technologies such as Artificial Intelligence (AI), collaborative robots (cobots), and generative AI to achieve sustainable, resilient, and personalized production systems. This vision aligns seamlessly with Telangana’s ambitious roadmap for manufacturing and its efforts to position itself as a global hub for innovation.

Telangana has already demonstrated remarkable leadership in adopting Industry 4.0 technologies. Initiatives such as TG-iPASS, Hyderabad Pharma City, and strategic industrial corridors have created a conducive environment for technological adoption and economic growth. The state’s focus on skill development through TASK, its investment in digital infrastructure, and its emphasis on sustainability further strengthen its readiness for Industry 5.0.

This whitepaper offers a comprehensive roadmap for Telangana’s journey from automation to collaboration. It identifies actionable strategies in areas such as human-machine collaboration, technology integration, sustainability, and workforce development. Additionally, it provides key recommendations for policymakers, industry leaders, and academia to collectively drive the adoption of Industry 5.0 and establish Telangana as a leader in global manufacturing.

I take this opportunity to thank the CII Telangana Manufacturing & Industry 4.0 Panel, led by Mr. VS Ram, Vice President-Mfg. Operations-Farm Division and Location Head, Zaheerabad, Mahindra & Mahindra Ltd; Mr. Rajesh Khosla, CEO, AGI Greenpac Ltd; Mr. A Dayanand Reddy, Founder & Managing Director, Vasantha Tool Crafts Pvt Ltd., and other members of the panel, for their invaluable insights and guidance. My gratitude also extends to the CII Secretariat for their coordination and support throughout this endeavor.

Finally, I sincerely thank the Ernst & Young team for their expertise and contribution in developing this whitepaper. Together, we aim to inspire innovation, foster collaboration, and accelerate the adoption of Industry 5.0 in Telangana, paving the way for a sustainable, human-centric, and globally competitive manufacturing ecosystem.

Sai Devarajulu Prasad

Executive Director, Bharat Biotech

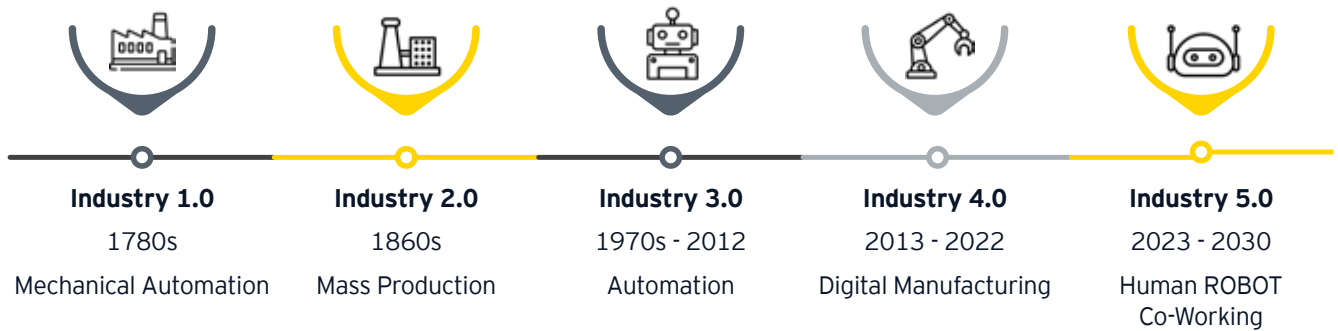




1

Introduction

The evolution of manufacturing



Evolution of the digital manufacturing industry

	Industry 1.0	Industry 2.0	Industry 3.0	Industry 4.0	Industry 5.0
	Mechanical Production	Mechanical Production	Automation	Digital Manufacturing	Human Robot Co-Working
Production features	Mechanical Assemblies	Initial Electrification & Assembly Lines	Automated Production using Memory Programmable Controls & Computer	Network Connection & Production Automation	Mass Customization through analytics & intelligence, Cyber-Physical Production System
Technologies	Steam Powered Engines & Machinery	Electrically Powered Mechanical Assemblies	Digital Logic, MOS Transistors, Integrated Circuit Chips, Microprocessors	Cloud, AI/ML, IoT, RPA, Edge Computing, 2G-3G, Digital Twin, Additive Manufacturing, COBOTS, Edge AI	Metaverse, Quantum Computing, Web 3.0, Distributed & Decentralized System, Fog Computing, 6G, Cyber Physical Cognitive System
Timeline	1780s	1860s	1970-2012	2013-2022	2023-2030
Human machine involvement					

AI/ML	COBOTS	IoET	Blockchain	Digital Twin	Metaverse	Quantum Computing	6G & Beyond
<ul style="list-style-type: none"> Intelligent Automation Greater Efficiency Quality Control Quick decision making 	<ul style="list-style-type: none"> Increases productivity Robustness Higher Consistency & Accuracy Advanced dexterity 	<ul style="list-style-type: none"> Asset/Equipment productivity Cost Efficiency Supply chain & Logistics visibility Reflects intelligence in network 	<ul style="list-style-type: none"> Decentralized Management Operational Transparency Create digital identities Compartmentalized approach 	<ul style="list-style-type: none"> Cost efficiency Predicting future errors Design customization Predictive Maintenance 	<ul style="list-style-type: none"> Virtual product designs Asset management & maintenance simulation Digital human for human behaviour simulation 	<ul style="list-style-type: none"> Lower latency Increased cybersecurity Expanded interoperability Reduced storage cost 	<ul style="list-style-type: none"> Knowledge discovery Smart resource management Lower Latency Higher reliability

Legend: Evolved Infrastructure
 Involvement in repetitive and manual tasks: Low High



The world has experienced four major industrial revolutions, each significantly reshaping the manufacturing landscape. The first, also known as Industry 1.0, laid the groundwork for modern production by introducing machine tools and assembly lines, prioritizing quality and speed in manufacturing processes.

Industry 2.0 marked the second wave of industrial development, driven by technological advancements and scientific discoveries that accelerated industrial growth. The third, also called the Digital Revolution or Industry 3.0, ushered in the transition from mechanical and analog systems to digital technologies. The widespread use of computers revolutionized industries and daily life. This era also introduced the internet and digital communication, including cellular phones, which paved the way for digital transformation in manufacturing.

Today, we are in the midst of Industry 4.0, or the Fourth Industrial Revolution, characterized by the rapid integration of digital technologies into manufacturing and industrial processes. Key technologies such as cloud computing, artificial intelligence, the Internet of Things (IoT), and the Industrial Internet of Things (IIoT) are now central to modern industrial operations.

Micro, Small, and Medium Enterprises (MSMEs) in Telangana have significant opportunities to enhance their productivity, efficiency and occupational safety by adopting advanced technological tools in their production processes. As per survey results published by the Telangana government, 25% of MSMEs in Telangana were aware of options for automation of industrial processes, and 10% were aware of the Internet of Things. Of all relevant technology, MSMEs were least aware of Robotics and Blockchains. Furthermore, only 38% of respondents were familiar with the Credit Linked Capital Subsidy and Technology Upgradation Scheme initiated by the Government of India.

As per the report released by the Telangana Government, in stakeholder consultations, MSMEs identified several substantial barriers to technology adoption, including:

- **High costs:** The financial burden associated with acquiring technological tools and equipment poses a significant challenge for many MSMEs
- **Integration challenges:** There exists a steep learning curve in effectively integrating new technologies into existing production processes
- **Skill gaps:** A notable shortage of skilled manpower capable of efficiently utilizing these technological tools further hampers adoption efforts

Looking ahead, the manufacturing industry is evolving towards the fifth industrial revolution, or Industry 5.0. This next revolution is built on three core principles: sustainability, human-centeredness, and resilience. Industry 5.0 focuses on the collaboration between humans and technology, often described as a “human-tech” revolution, emphasizing the harmonious synergy between human ingenuity and advanced technological innovation.

The market value of Industry 5.0 was estimated at US\$154.73 billion in 2023 and is anticipated to surge to US\$691.02 billion by 2032. This growth trajectory represents a Compound Annual Growth Rate (CAGR) of 18.09% from 2024 to 2032¹.

Industry 5.0 signifies a progressive manufacturing approach that emphasizes the synergy between humans and machines. It follows the digital evolution of Industry 4.0, which introduced groundbreaking technologies such as the Industrial Internet of Things and the integration of Artificial Intelligence with Big Data, providing businesses with insights driven by data.

As per the European Union's definition, “Industry 5.0 provides a vision of an industry that aims beyond efficiency and productivity as the sole goals and reinforces the role and the contribution of industry to society. It places the wellbeing of the worker at the center of the production process and uses new technologies to provide prosperity beyond jobs and growth while respecting the production limits of the planet.”

¹Industry 5.0 Market - Comprehensive Study Report & Recent Trends | IMR (introspectivemarketresearch.com)

From Industry 4.0 to 5.0: A paradigm shift in manufacturing strategy²

We are standing at the precipice of the fourth industrial revolution, characterized by Smart Manufacturing, where manufacturing processes are seamlessly integrated with computing systems. This revolution has seen the introduction and application of groundbreaking technologies like Artificial Intelligence (AI) for intelligent decision-making, Machine Learning (ML) for analyzing data patterns, Robotic Process Automation (RPA) to handle repetitive back-office tasks, Digital Twins providing insights into equipment and facilities over their entire lifecycle, Collaborative Robots (Cobots) facilitating assembly line automation and handling heavy lifting, as well as the evolution of connectivity from 2G to 5G for faster and more efficient communication.

Looking ahead, Industry 5.0 is expected to bring about a collaborative dynamic between humans and robots, where automation is maximized, and human interaction is minimized. This co-working relationship will be essential for the transition of current smart factories into “lights-out” factories, designed to operate with minimal human intervention. The benefits will include significant reductions in energy consumption and lower electricity usage. Another pivotal theme driving Industry 5.0 over the next five years will be mass customization. A prime example is Nike, a global apparel giant that allows customers to personalize their footwear and clothing, from design and color to the material used in the product.

The European Commission (EC) introduced the concept of Industry 5.0 to promote industrial standards that foster innovation. The EC’s definition, now widely used, reflects the growing necessity for a new industrial paradigm.

Over the past decade, the complexity of societal and economic challenges has escalated. Climate change, resource depletion, and unforeseen events like global pandemics and wars are forcing manufacturers to experiment with both established and emerging technologies, materials, and processes. For instance, 3M has allocated fresh budgets to explore new materials and expand production capabilities for personal safety products in response to the COVID-19 pandemic.

Industry 5.0's reform of key Industry 4.0 aspects

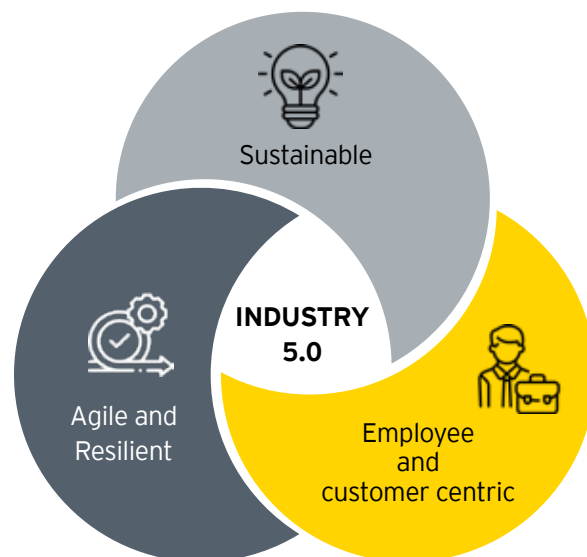
Industry 5.0 will focus on reforming three essential aspects of Industry 4.0:

1. AI-Driven customization and automation: Manufacturing is transitioning from mass production to mass customization, enabled by AI and generative technologies. This shift allows for greater personalization of products while maintaining operational efficiency.
2. Sustainable manufacturing: There is a growing emphasis on minimizing environmental impact through AI-powered resource optimization, energy

management systems, and circular economy principles.

3. Cybersecurity in smart factories: As digital integration becomes more widespread, protecting sensitive manufacturing data and infrastructure from cyber threats is paramount.

Areas of transformation leading the path to industry 5.0



AI, IoT: The backbone of Industry 5.0

Industry 5.0 will further develop existing technologies, driven by ongoing research and technical innovations. Figure 1 illustrates how AI-ML, Cobots, IoT (Internet of Everything), Blockchain, and Digital Twins have established a strong foothold in the manufacturing sector over the past five years. These technologies are expected to evolve further, with new applications emerging that will be instrumental in shaping the future of Industry 5.0.

AI is being applied across the entire manufacturing value chain. One major advancement in Industry 5.0 will be the collaboration between humans and robots, with AI augmenting this interaction. From data-driven development of autonomous vehicles to smart warehouse-picking robots capable of identifying products based on orders, human-robot collaboration has advanced from handling routine tasks to performing high-priority roles. The collaborative robot (cobots) market is one of the fastest-growing segments in Industry 5.0, with the hardware segment capturing a significant market share of around 49% in 2024. To support this collaboration, factories and production facilities have become highly connected virtual environments, a dramatic shift from what existed two decades ago.

²Industry 5.0: The Next Paradigm Shift In Manufacturing | Zinnov

IoT, when combined with big data analytics and AI, has enabled the rise of Smart Factories. The integration of IT and OT (Operational Technology), which began in Industry 4.0, continues to expand and intensify, gradually evolving into the Internet of Everything (IoET). IoET encompasses a complex network of inter-connected devices across various industrial settings. Digital twin technology is playing an increasingly vital role in Industry 5.0, allowing for more precise simulations, predictive maintenance, and optimization of production processes.

The software segment is expected to witness the highest CAGR of around 30.8% from 2025 to 2030, driven by advancements in AI and ML technologies. The Artificial Intelligence (AI) & Machine Learning (ML) segment is expected to witness the highest CAGR from 2025 to 2030, as Industry 5.0 focuses on mass customization powered by AI and ML. These technologies are not only enhancing efficiency but also enabling manufacturers to offer personalized products at scale, marking a significant shift in how goods are produced and delivered to consumers.

Key technology advancements for the next decade

1. Industrial Co-workers or Cobots

The use of “cobots” or collaborative robots in industrial environments, such as in automotive and manufacturing can augment human-machine interactions and offload tasks that are repetitive in nature, non-value adding, or has the potential to harm the industrial workers, such as heavy lifting. Polyfunctional robots are another emerging industry trend that can enhance human-machine interactions that Industry 5.0 envisions. Polyfunctional robots sport flexible designs and can perform multiple tasks, promising cost-efficiency. Gartner predicts that by 2030, 80% of humans will be engaged with smart robots daily. That’s a significant uptick from less than 10% today. Rising labor competition and demand to drive up ROI in industries like warehousing and manufacturing will likely fuel the adoption of polyfunctional robots.

Benefits

- Offloads repetitive and dangerous tasks such as product quality inspection and handling poisonous substances ensuring workers focus on more critical activities.
- Raises the potential to personalize and customize goods that can help in mass customization.

Case in Point

- Sanofi leverages cobots at the end of its line to assist with product packaging, and to reduce ergonomic risk to workers by relieving them from strenuous tasks. This was done by implementing a palletizing solution capable of palletizing 150,000kg of products per month with robotics to boost production efficiency and relieve workers from repetitive tasks.

2. Industrial Metaverse

Industrial Metaverse, which can be defined as a blend of physical and digital environments within industrial setups is enabled through the convergence of digital technologies, like IIoT, AI/ ML, and AR/VR, and leads to advanced digitalization in the form of applications like digital twin. Some of the key use cases of Industrial Metaverse include 3D modeling and simulation using product and process digital twins, optimizing assembly/ packaging lines using process digital twins, and plant digital twins for virtual commissioning.

Benefits

- Enables real-time collaboration and connectivity amongst industrial workers/ remote technicians, and between critical data, development processes, and applications.
- Reduces efforts around testing, commissioning, and maintenance to lay the groundwork for customization.

Case in Point

- BMW is set to open its Debrecen, Hungary plant in 2025 capable of producing 150,000 vehicles annually. For this, it is collaborating with NVIDIA to create a digital twin of the entire factory, that will enable global design teams to work together across multiple software suites in a shared virtual space. With this initiative, BMW envisions to be the world’s largest custom-manufacturing company.
- With the progression towards Industry 5.0, the industrial sector is seeing widespread adoption of advanced technologies. Technologies like Metaverse, 5G/6G, and Quantum Computing are poised to supercharge the next phase of the industrial revolution.
 - Amidst the current challenges around legacy data, and computing environments, what does it take to realize the vision of Industry 5.0?
 - How can companies take advantage of existing industrial big data?
 - What is the missing link between Industry 5.0, industrial connectivity, and industrial big data?

The next wave of innovation: Metaverse, Quantum Computing, and 6G

Industry 5.0 is already on the horizon, and its growth will be fueled by new technologies like the Metaverse, Quantum Computing, and 6G Communications.

Metaverse – The Metaverse will accelerate the remote co-development of products and solutions through Digital Twins in the manufacturing sector. Companies like Airbus and Boeing are already leveraging the Metaverse to run R&D for their new aircraft and jet variants. Boeing, for instance, intends to create Digital Twins in the Metaverse and run simulations to test different customization options. Outside of manufacturing, enterprises are experimenting with using the Metaverse for immersive employee training, providing a faster and safer learning environment. Schneider, for example, has launched an Innovation Center in the Metaverse focused on product development and innovation.

Quantum Computing – Though still in its infancy, manufacturers are keen to explore Quantum Computing's potential to optimize investment strategies, improve encryption and discover new products. Honeywell's Quantum Solutions division, in partnership with Cambridge Quantum, has formed Quantinuum, a joint venture building the world's first quantum operating system, along with quantum software and hardware. BASF, a major player in the chemical industry, is working with Pasqal to develop quantum neural networks for computational fluid dynamics applications.

6G Connectivity – 6G trials are showing promise in supporting Industrial IoT. Enterprises are currently collaborating with ISVs and solution providers at the R&D stage to advance IoT over the coming years. For example, Samsung has partnered with UCSB to prototype 6G THz wireless communication, and European nations have collectively launched the Hexa-X Project to explore the future of wireless technology. Industrial leaders like Intel and Siemens have joined the project, aiming to develop AI-driven interfaces, improve frequency resolution and enhance sensing technologies.

The ongoing advancement of technologies like AI, IoT and Blockchain will define the future of industrial progress. There is substantial room for solution providers to collaborate with manufacturers, understand their needs and offer innovative solutions that will drive industrial growth over the next decade.

Benefits of Industry 5.0

01

Customization with a human creative element:

While robots excel at producing standardized products in high volumes, they often struggle with customization and personalization, requiring human guidance to adapt. Maintaining a human presence in production processes is essential to ensure flexibility and creativity. Automation reaches its full potential when human ingenuity is integrated into the process. Traditional industrial robots, though efficient, only perform pre-programmed tasks, which often require time-consuming programming. In contrast, collaborative robots, or cobots, work alongside human operators. In this partnership, humans handle customization while robots focus on product preparation or repetitive tasks. Cobots act as versatile tools, assisting with tasks like screwing, packaging, or palletizing, allowing employees to enhance their roles and productivity.

02

Job creation

Robots, particularly cobots, are well-suited to assist in filling this gap by taking on repetitive, mundane, and hazardous tasks, allowing human workers to transition into higher-value roles. Contrary to fears of job displacement, automation provides businesses with a competitive edge through improved product quality, increased output, and reduced costs. In the food industry alone, it is estimated that robots created 70,000 to 90,000 jobs globally between 2017 and 2020.

Cobots, unlike traditional robots, can increase employment opportunities by boosting productivity and encouraging the development of new skill sets. Instead of replacing workers, cobots complement them, allowing manufacturers to scale their operations while moving employees into more satisfying and higher-paying positions.

Job creation

Cobots are designed to support, not replace, the human workforce, taking over physically demanding or dangerous tasks so that employees can focus on more complex, creative projects. For example, when robots handle routine assembly work, employees can shift to more specialized tasks requiring human expertise.

A notable example is Boeing's Airpower Teaming System, also known as the "Loyal Wingman." These AI-powered drones can operate independently or support manned aircraft, expanding the capabilities of military missions. This illustrates how human-machine collaboration can extend the reach and impact of human efforts.

With tasks like labelling handled by robots, employees can operate more machines and engage in a wider range of tasks, leading to increased job satisfaction. Learning to operate cobots also provides workers with a sense of pride and accomplishment. This connected and collaborative workforce fosters greater manufacturing productivity, innovation, and job growth, while improving safety and creating more fulfilling roles for human workers.



Key value creation in transitioning from Industry 4.0 and to Industry 5.0

S.No	Key Aspect	Industry 4.0	Industry 5.0	Indian Manufacturing Perspective
1	Primary Focus	Automation, digital transformation, smart factories, IoT, and autonomous systems	Human-machine collaboration, mass personalization, and sustainability	Technological Gap: Indian manufacturing, especially SMEs, is still catching up with full automation and IoT adoption, which Industry 4.0 requires. Moving to Industry 5.0 will demand even greater integration of human skills with technology.
2	Human Role	Workforce reduction through automation and autonomous systems	Humans work alongside machines, combining creativity with advanced technologies	Workforce Dynamics: In India, with a large labor pool, the transition to human-machine collaboration will be critical. Industries need to upskill workers to interact with smart systems while maintaining human ingenuity.
3	Customization	Focus on efficient, high-volume, and smart production processes	General Mass production to Mass personalization, customized solutions based on individual consumer needs	Personalization Challenges: Indian manufacturers, accustomed to mass production for cost-efficiency, will need to shift towards more flexible, personalized manufacturing, especially in sectors like consumer goods and automobiles.
4	Sustainability	Focus on operational efficiency and productivity with some attention to energy efficiency	Strong emphasis on sustainability, resilience, and aligning with global climate goals	Sustainability Pressure: While Indian manufacturers are beginning to adopt energy efficient technologies, Industry 5.0's demand for comprehensive sustainability practices will push them to integrate green energy and circular economy principles into their production lines.
5	Technology Use	IoT, AI, cloud computing, autonomous systems, smart sensors for real time data processing	Advanced AI, human centric systems, digital twins, robotics working collaboratively with humans	Digital Transformation Roadblock: Many Indian factories are just beginning their journey toward integrating AI and smart sensors. Industry 5.0 will further increase the need for sophisticated technologies like digital twins, which require significant investment.

6	Consumer expectations	Product traceability and quality through connected systems and data-driven insights	Products co-created with consumers, emphasizing ethics, environmental responsibility, and personalized experiences	Consumer Evolution: Indian consumers, especially millennials, are becoming more conscious of sustainability and personalized products. Indian companies will need to rethink their business models to align with these evolving consumer expectations.
7	Company Focus	Maximizing productivity, profit, and operational efficiency	Balancing growth with ethical considerations, sustainability, and resilience	Profit vs. Sustainability: For Indian manufacturers, especially those with a profit driven focus, Industry 5.0 represents a challenge. Balancing profitability with ethical, sustainable practices will be a crucial shift for the sector.

In-depth analysis of Industry 4.0 vs. Industry 5.0 in Indian manufacturing

1. Technological transition:

- **Industry 4.0:** In India, adoption of Industry 4.0 technologies, such as IoT, cloud computing, and machine learning, is still in its nascent stage, particularly for small and medium-sized enterprises. While larger firms in sectors like automotive and electronics have embraced smart factories and automation, full-scale implementation is uneven due to infrastructural limitations and the high cost of technology.
- **Industry 5.0:** Moving to Industry 5.0 will demand a shift toward human-machine collaboration, where humans work in tandem with intelligent machines. For Indian manufacturing, this could mean upskilling the workforce to integrate human creativity with automation. Given India's large labor force, the shift may also create more jobs that focus on human-machine interaction rather than automation-led job displacement.

2. Sustainability challenges:

- **Industry 4.0:** This industrial revolution primarily focuses on efficiency, with sustainability as a secondary concern. However, as global environmental regulations tighten, the Indian manufacturing sector has had to reconsider energy use and waste management.
- **Industry 5.0:** Industry 5.0 places sustainability at the forefront, aligning closely with the UN's Sustainable Development Goals (SDGs). For India, where pollution and resource management are pressing concerns, this will push industries to innovate around cleaner technologies, circular economies, and sustainable manufacturing practices. For example, the push toward electric vehicles in India aligns with Industry 5.0's sustainability focus.

• 3. Human-centric approach: •

- **Industry 4.0:** Automation has been reducing human labor in factories, leading to fewer human-centric operations and more focus on autonomous systems. While this boosts efficiency, it often sidelines human creativity.
- **Industry 5.0:** This model brings humans back into the equation, encouraging human-centric innovation where people co-create with machines. In India, this could be particularly transformative in sectors like textiles and handicrafts, where human skill and creativity play a key role. Industry 5.0 can enhance these traditional industries by combining human ingenuity with modern technology, increasing both productivity and uniqueness.

• 4. Mass personalization and consumer-centric manufacturing: •

- **Industry 4.0:** Indian industries have primarily focused on mass production for cost-effectiveness and high output, often leaving personalization at the fringes.
- **Industry 5.0:** Industry 5.0 shifts the focus toward mass personalization, where products are tailored to individual consumer needs. In India, this trend is gaining momentum with the rise of e-commerce and the demand for personalized consumer goods. Manufacturers will need to invest in flexible production systems to cater to this growing demand for customization, especially in sectors like fashion, electronics, and automotive.

• 5. Economic resilience: •

- **Industry 4.0:** Focused on digital transformation to enhance operational efficiency, productivity, and competitive advantage. The emphasis is primarily on cost savings and streamlined operations.
- **Industry 5.0:** Industry 5.0 introduces the concept of economic resilience, ensuring that manufacturers are not just productive, but also adaptable to crises like pandemics, supply chain disruptions, or environmental challenges. For Indian manufacturing, building resilience will be crucial in a post-COVID era, where global supply chains have been disrupted, and localized production with strong supply chain visibility is becoming more important.

SWOT analysis of Industry 5.0

SWOT	Description
Strength	<ol style="list-style-type: none">1. Human and machine collaboration: Emphasizes the interaction between humans and machines, promoting a collaborative environment. Combines human creativity with machine efficiency to enhance productivity and improve workplace safety.2. Human-centric approach: Puts human needs and interests at the center of the production process. Industry 5.0 prioritizes the well-being of industrial workers, emphasizing their importance in the production process.3. Customized production: Enables tailoring of manufacturing processes to individual needs.4. Organizational resilience: Industry 5.0 focuses on resilience, allowing industries to adapt and thrive in changing conditions.5. Environmentally conscious: Places a strong emphasis on sustainability and environmental protection.6. Digital twins and augmented reality: Introduces digital twin and augmented reality technologies into manufacturing processes.7. Technological advancements: The integration of advanced technologies such as IoT, AI, and robotics to create flexible and efficient production systems.8. Sustainable manufacturing: Manufacturing must respect planetary boundaries and be sustainable. The industry meets societal demands while respecting planetary boundaries

Weakness	<ol style="list-style-type: none"> 1. Complex technologies: Introduction and integration of new technologies can pose complex challenges for companies. 2. Training Requirement: Workers need to acquire new skills for the effective use of new technologies. 3. Social heterogeneity: There can be societal differences in values and acceptance. 4. Transition challenges: Moving from Industry 4.0 to 5.0 might pose challenges, especially for industries heavily invested in the former. 5. Data security and interoperability: Concerns related to ensuring data security and interoperability between systems. 6. Potential resistance: Traditional industries might resist the change due to the costs and complexities involved in the transition. 7. Lack of clear definition: Being a topic in development, there's no precise consensus on its definition, which can lead to confusion and misinterpretation
Opportunities	<ol style="list-style-type: none"> 1. Competitive advantage: Companies that successfully implement Industry 5.0 technologies can gain a competitive edge in the market. 2. Sustainable growth: Environmentally conscious manufacturing processes allow companies to achieve sustainable growth in the long run. 3. Resilience: Manufacturing must be capable of defending against disruptions and ensuring critical infrastructure during crises. 4. Meeting societal demands: Industry 5.0 offers the chance to realign industries with societal needs, potentially opening new markets and avenues for growth. 5. Innovation and entrepreneurship: The emphasis on creating an environment conducive to innovation can lead to the birth of new ideas, products, and services 6. Strengthening partnerships: There is an opportunity to strengthen collaborations between the public and private sectors, leading to shared growth and development. 7. Addressing global challenges: The ability to address significant global challenges such as climate change, rapid consumption of non-renewable resources, environmental pollution, and social injustice.
Threats	<ol style="list-style-type: none"> 1. Cybersecurity risks: As systems become more complex and interconnected, security risks increase. 2. High initial investment: Introduction of Industry 5.0 technologies may require significant initial investment. 3. Productivity challenges: Significant investments are needed while also expecting an increase in productivity. 4. Rapid technological changes: The pace of technological advancement might outstrip the industry's ability to adapt, leading to potential inefficiencies. 5. Environmental and social challenges: Issues like climate change, environmental pollution, and social injustice can pose significant challenges to the successful implementation of Industry 5.0 6. Potential overshadowing by industry 4.0: The existing prominence and momentum of Industry 4.0 might overshadow the newer paradigm, slowing down its adoption. 7. Global conflicts: Events like the Russia-Ukraine conflict can elevate complexities in the global industrial context.



Voices from policy makers, industry leaders, workers

Policy makers: Telangana government plans to spend INR4,000 crore over the next five years towards various initiatives to develop Micro Small, Medium and Enterprises in the state.

The new policy sought to link Telangana's MSME sector with industry 4.0 advancements for its integrated development, faster generation of jobs and improved output.

The policy is aiming to see that over 25,000 new MSMEs are established in the state in the next five years.

The Telangana government has implemented policies like TG-iPASS to simplify industrial approvals and foster a business-friendly environment.

As per the September 2024 release of Telangana MSME Policy 2024, the Government of Telangana is committed to being a pioneer in the implementation of Industry 4.0. The government aims to accelerate the technological and digital transformation of MSMEs in the state.

The government proposes to support MSMEs in increasing awareness, building adoption capability, and augmenting purchasing power to develop next-gen production lines and digital capacity.

- Identifying technology needs of MSMEs: Within three months of the release of this policy, the government will commission a comprehensive study to review existing technology adoption practices across MSMEs in the state. This study will publish a catalogue of processes and machinery that MSMEs can adopt to upgrade their production lines.
- Dedicated fund for technology transformation of MSMEs: The government will constitute the Yantram Fund—a special fund for technology transfer and modernization in the MSME Sector to encourage the adoption of innovative and effective processes and machinery that will accelerate the productivity of MSMEs in the state. The government will allocate INR100 crore over the next four years to the Yantram Fund. Cognizant of the fact that the payback from technology upgrades manifests after a significant time lag, the government will provide monetary assistance through the Yantram Fund. The Fund will be operationalized within a period of six months from the publication of this policy.
- Enhancing Digitalization of MSMEs: In addition to upgradation of manufacturing processes, the government will also provide support in the digital transformation of MSMEs. The government will facilitate bulk purchase of digital technologies and software at discounted rates for MSME clusters and industrial parks.

- Support for IPR registration: Under T-PRIDE, the government currently offers a 100% subsidy on the expenses incurred for patent registration limited to INR3 lakh for SC/ST-owned MSMEs. The government will continue to do so. Under TIDEA, the government will now offer a 100% subsidy on the expenses incurred for patent registration limited to INR2 lakh for all other MSMEs.
- Support for Research and Development: The Research and Innovation Circle of Hyderabad (RICH)—set as a part of the Hyderabad Science & Technology (S&T) Cluster, an initiative of the Office of Principal Scientific Advisor (PSA) to the Government of India—will support research and development activities within the MSME sector.
- Facilitating engagement between MSMEs and technology providers: The Government of Telangana will organize workshops and technology fairs that will facilitate interaction and knowledge sharing between MSMEs and suitable technology providers or larger enterprises.
- To promote the adoption of green technologies, the government will provide incentives like an additional 15 per cent floor area if the MSME has a solar photovoltaic plant installed or a solid waste management plant for treatment of total generated waste or if the building has three to five star rating on green building for integrated habitat assessment.

Industry 5.0 represents a shift from connected devices in Industry 4.0 to seamless collaboration between humans and machines, enhancing each other's capabilities. Telangana's strong AI ecosystem, including T-Hub, We Hub, and the Research and Innovation Circle of Hyderabad (RICH), supports this transition. With a focus on developing skilled manpower, the state is positioning Hyderabad as a leading AI hub. Industry 5.0 fosters a symbiotic relationship between human intelligence and advanced technologies like robotics, transforming factories into spaces that enhance creativity, personalization, and human-centric experiences

- India's leading coal-producing state Telangana is aiming to become Net Zero by 2047 – nearly two decades before the national goal of 2070. The southern state, which accounts for 7.3% of the country's coal production, is in the process of preparing a roadmap to gradually transition away from coal usage in its new industrial parks.
 - As a leading manufacturing hub, the state has also planned that all its new industrial parks in Hyderabad will not depend on coal as the primary source of energy. Telangana, specifically Hyderabad, is an important center for the life sciences industry with industrial parks for

pharmaceutical manufacturing, including vaccines as well as medical devices. While most of the old industrial units are coal-fired, the new industrial parks will not have coal as the source of energy. We are very clear that we now have better alternatives,

- **Industry leaders in Telangana:** Telangana's pharmaceutical industry is also a major driver of this transition. Dr. Reddy's Laboratories, noted, "AI has improved production efficiency in pharmaceuticals, allowing us to meet global demand while maintaining the highest safety and quality standards".
- **Workforce Adaptation:** The workforce in Telangana is adapting to advanced manufacturing technologies through skill development programs, industry collaborations, and government initiatives. Programs like TASK train workers in AI, robotics, and IoT, while partnerships with industries and educational institutions enhance hands-on learning and innovation-driven upskilling.



2

Global perspective: Industry 5.0 through the SIRI and WEF Lighthouse frameworks

To provide a robust framework for understanding the shift from Industry 4.0 to Industry 5.0, this section integrates global insights from recognized frameworks such as the Smart Industry Readiness Index (SIRI) and the World Economic Forum (WEF) Lighthouse Network with a tailored EY framework. This structured approach allows for an analysis that is globally relevant while being regionally applicable to Telangana's specific industrial needs and growth trajectory.

The transition to Industry 5.0, marked by a focus on human-centric innovation, collaborative human-machine systems, and sustainability, can be analyzed through two established global frameworks: SIRI and the WEF Lighthouse Network. Both frameworks offer insights into the digital maturity of industries and provide a roadmap for aligning operations with the key objectives of Industry 5.0

SIRI Framework: Process, technology and organization

The Smart Industry Readiness Index (SIRI), developed by Singapore's Economic Development Board (EDB), is a globally adopted framework for assessing Industry 4.0 readiness. By evaluating industries across three core building blocks—Process, technology and organization—SIRI sets the stage for understanding how these pillars evolve in Industry 5.0:

- **Process innovation:** Industry 4.0 prioritized automation and efficiency. Industry 5.0, however, emphasizes collaborative human-machine systems. In Telangana's electronics and automotive sectors, cobots can enable human workers to perform creative and adaptive tasks while machines handle repetitive processes. For instance, Hyundai Motors' plant has already integrated augmented reality (AR) and cobots for vehicle production, paving the way for more human-machine collaboration.
- **Technology integration:** Industry 4.0 emphasized connectivity, data analytics, and digital infrastructure, while Industry 5.0 layers AI-driven collaboration and real-time decision-making on top of this foundation. In Schneider Electric's Hyderabad factory, recognized as a WEF Lighthouse, digital twins and AI-powered systems, advanced, cloud-based manufacturing system powered by IoT-enabled devices, leveraging real-time data and predictive analytics for smart decision-making processes. Over four years, the plant reduced its energy consumption by 59%, improved waste optimization by 64%, decreased CO2 emissions by 61%, and reduced water consumption by 57%. Moving forward, Telangana's pharmaceutical and electronics sectors could integrate AI-based predictive maintenance and cobots to increase productivity and allow for greater customization. Additionally, according to Salesforce report, India's manufacturing sector has seen a 20%





increase in AI and machine learning (ML) adoption over 2020-2023, with 54% of Indian manufacturing companies using AI and analytics. Almost 64% of the organizations surveyed in the Industrial Products and Manufacturing sector say they are currently at an early stage of their AI-based transformation journey reflecting the opportunities for further investments and growth led by AI/ML solutions in this sector.³

- Organizational resilience and talent readiness: The SIRI framework highlights the importance of talent development, which is central to Industry 5.0. Telangana's TASK initiative and collaboration with Tata Technologies to transform 65 Industrial Training Institutes (ITIs) position the region to upskill its workforce in AI, robotics, and advanced analytics. Excitement – along with concern – is swirling around AI, as generative AI applications have entered the workplace, seizing imaginations and garnering hundreds of millions of users around the world.

Analyzing the promise of Industry 5.0 for India: A pathway to human-centric innovation

As the world moves toward the next industrial paradigm, Industry 5.0, India is uniquely positioned to lead this transformation. The convergence of digital infrastructure, technological advancements, a dynamic workforce, and supportive government policies sets the stage for the country's shift from automation-driven Industry 4.0 to human-centric Industry 5.0. Several factors stand out as key enablers:

A. Digital infrastructure and technological advancements

India's digital landscape is evolving rapidly, with significant strides in internet access, mobile penetration, and digital literacy. Initiatives like 'Digital India' and the proliferation of tech start-ups working on AI and automation solutions lay a strong foundation for Industry 5.0. The country's technological backbone is well-prepared to support the integration of human-centric automation and personalized production systems.

B. Young, dynamic, and skilled workforce

India's demographic advantage, with a median age of 29 years, presents a robust pool of adaptable, tech-savvy talent. The surge in skilled professionals across engineering, data science, and advanced manufacturing equips the country to embrace Industry 5.0 technologies. This youthful workforce is ready to drive innovation and contribute to the integration of human-machine collaboration across industries.

C. Cost-effective labor market

Compared to developed economies, India benefits from an efficient and cost-effective labor force. This allows Indian companies to experiment with Industry 5.0 innovations at a lower financial burden, enabling SMEs and start-ups to adopt cutting-edge technologies like AI, IoT, and robotics without the capital constraints faced by their counterparts in high-wage countries.

D. Strategic geopolitical position

India's active membership in global organizations such as BRICS and the G20, along with growing relationships with technologically advanced nations like the US, Japan, and the EU, provides access to resources and expertise necessary for Industry 5.0. Through these partnerships, India can leverage global knowledge sharing and collaborate on innovations that align with the country's industrial aspirations.

E. Supportive government policies

The government's continued focus on policies like 'Make in India,' 'Skill India,' and 'National Quantum Mission' underscores its commitment to fostering an environment conducive to Industry 5.0. These initiatives encourage the development of cutting-edge technologies and support the growth of a skilled, innovation-driven economy. Government support for R&D and start-ups further accelerates the country's readiness for the next industrial wave.

³https://www.salesforce.com/content/dam/web/en_in/www/documents/pdf/unleashing_the_power_of_ai_in_manufacturing.pdf

WEF Lighthouse Network: Best practices for human-centric and sustainable manufacturing

The World Economic Forum (WEF) Lighthouse Network showcases global leaders in adopting Industry 4.0 technologies, focusing on IoT-enabled systems, AI-driven optimization, and sustainable production models. As factories transition to Industry 5.0, they serve as examples of how human-machine collaboration and environmental stewardship can coexist.

- Sustainability and digital twins: WEF's focus on digital twins as a tool for real-time monitoring and optimization offers a pathway for Telangana's Pharma City and Hyderabad's industrial zones to reduce their environmental impact while boosting operational efficiency. For example, Schneider Electric's Hyderabad factory manufactures mission-critical electrical equipment and operates with an advanced, cloud-based manufacturing system powered by IoT-enabled devices, leveraging real-time data and predictive analytics for smart decision-making processes. Over four years, the plant reduced its energy consumption by 59%, improved waste optimization by 64%, decreased CO2 emissions by 61%, and reduced water consumption by 57%.
- Human-centric manufacturing: The WEF's focus on human-centered design aligns well with Industry 5.0's core principle of augmenting human creativity with technology. In Telangana, industries such as electronics and automotive can apply this approach to improve worker safety and foster innovation.





3

EY Industry 5.0 framework

A comprehensive framework for Industry 5.0 in manufacturing

As manufacturing enters the Industry 5.0 era, the focus shifts from purely automating processes to creating synergies between human capabilities and advanced technologies. This transformation enhances personalization, flexibility, and sustainability in production systems. Industry 5.0 empowers workers by integrating Artificial Intelligence (AI) and Generative AI (GenAI) into manufacturing processes, promotes green manufacturing to minimize environmental impact, and fortifies the digital ecosystem through enhanced cybersecurity.

EY's Industry 5.0 framework for manufacturing to accelerate the path to transformation and realize value

EY's Industry 5.0 framework for manufacturing helps organizations leverage these technologies to optimize production, improve efficiency, and create resilient, sustainable, and human-centric manufacturing environments.

The key questions to ask to establish business value entry points

Key questions

for Selecting
The Right
AMR Periodic
Table Elements

	Cx	Ns	
Cl	Gs	Dd	Ut
Cp	Ec	Sc	Ht
Dv	Dm	Lv	Bc
Om	Dt	Xs	Tt



Product Innovation

- How can we leverage innovation to capture new customers?
- How do we create dynamic products and services that serve a rapidly changing market?
- What opportunities do we have with x-as-a-service business models?



Customer Experience

- How can manufacturers create a seamless customer experience?
- How can technology enable operational efficiencies and provide hands-on services?
- How does the shift from b2b to b2c impact how we operate today?



Intelligent & Sustainable Supply Chain

- How can we leverage emerging technologies to future-proof our supply chain?
- How can we minimize touches along the supply chain to reduce the number of potential failure points?



Workforce Reimagined

- How do we engage our workforce & empower them to innovate?
- How do we selectively release old practices and beliefs to make space for renewal?
- How can we advance innovation as a core capability through hiring, developing, training, and incentivizing our employees?

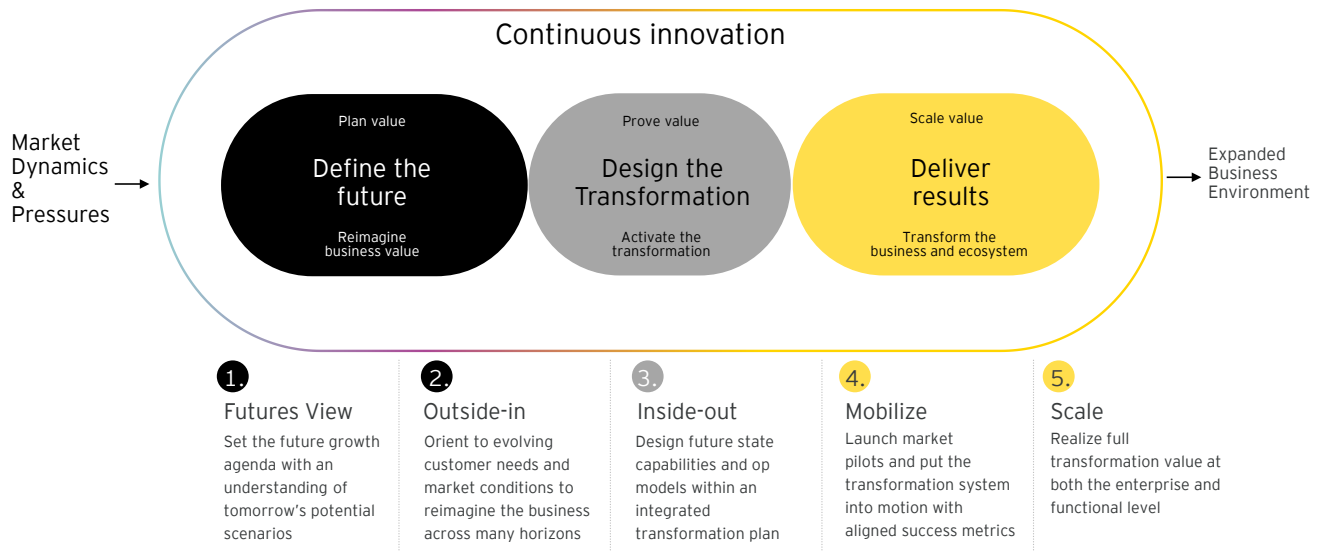


Business Model Innovation

- What new opportunities in adjacent markets am I well positioned to realize in the future?
- How do we innovate to drive the core business to peak profitability while simultaneously incubating new growth engines?
- How do I design a value-driven transformation to ensure ROI-led decision making?



Our approach to transformation



1 Strategic vision: Balancing automation with human creativity

In the manufacturing industry, **Industry 5.0** is not just about further automation but creating a seamless collaboration between humans and machines. The aim is to harness AI for routine tasks while enabling humans to focus on high-value, creative, and complex decision-making processes. This balance is especially crucial in manufacturing environments where human intuition, skill, and flexibility remain vital, particularly in precision-driven sectors like automotive and aerospace.

AI and GenAI can elevate manufacturing from mass production to **mass personalization**, allowing businesses to create products that cater to individual customer needs without compromising efficiency or quality.

Key considerations:

- **AI and GenAI** can drive mass customization, from product design to assembly lines, enabling manufacturers to efficiently meet unique customer specifications.
- Align Industry 5.0 initiatives with manufacturing-specific goals, such as increased **Overall Equipment Effectiveness (OEE)**, improved **first-time quality**, and reduced production downtime.

Deliverables:

- **AI-powered customization** platforms that integrate real-time customer feedback into production.
- An Industry 5.0 vision that connects human-machine collaboration with key manufacturing performance indicators, like capacity utilization and waste reduction.

People-centric manufacturing: Enhancing workforce capabilities

As manufacturing environments become smarter, the workforce must evolve from traditional operators to **digital collaborators**. The integration of **AI and GenAI** tools will automate routine tasks such as predictive maintenance, quality checks and supply chain optimization, allowing workers to focus on managing exceptions, designing improvements and driving innovation. This requires a clear focus on **upskilling** and creating a new kind of workforce that is equipped to oversee and collaborate with intelligent machines.

Key considerations:

- **Human-in-the-loop AI systems** should empower workers to make real-time decisions using insights generated by AI and data analytics.
- Upskilling programs should focus on data interpretation, AI interface management and GenAI capabilities to ensure human workers are leading the decision-making process, even in highly automated environments.

Deliverables:

- Cross-functional training programs that integrate AI technologies into shop floor activities.
- **Co-bots (Collaborative Robots)** that work alongside human operators, increasing flexibility and efficiency on the production floor.
- A framework for human-AI collaboration, allowing operators to adjust AI-driven production parameters dynamically.

Advanced technology integration: AI, GenAI, and IoT for Agile Manufacturing

Manufacturing companies that adopt **Industry 5.0** principles will leverage the potential of **AI, GenAI, and IoT** to not only automate but also **enhance production agility**. In a modern factory, AI can predict machine failures, optimize assembly lines, and fine-tune production processes. Meanwhile, **Generative AI** can be employed to design better products, simulate manufacturing processes, and offer real-time solutions to complex production issues.

AI and IoT will transform manufacturing plants into **smart factories**, where machinery, people, and systems are interconnected, enabling **data-driven insights** that can predict demand shifts, minimize inventory, and increase throughput.

Key Technologies:

- **AI for predictive maintenance:** Using sensors and AI algorithms, manufacturers can anticipate equipment failures and reduce downtime, leading to enhanced **Overall Equipment Effectiveness (OEE)**.

- **GenAI for product design:** Generative AI can assist in creating product prototypes, optimizing materials usage, and offering real-time feedback on design feasibility.
- **IoT for real-time monitoring:** IoT sensors will capture critical data across the production line, feeding it into AI systems for real-time analysis and decision-making.

Key considerations:

- Build **digital twins** of manufacturing operations that simulate real-time performance and allow manufacturers to experiment with different scenarios without halting production.
- Use **AI and GenAI** to analyze and optimize energy consumption, resource use, and overall efficiency in manufacturing operations.

Deliverables:

- **AI-driven predictive maintenance** systems integrated with IoT sensors to reduce equipment downtime and improve OEE.
- **GenAI tools** for real-time product design and production process simulations, optimizing material usage and efficiency.
- A fully integrated **smart factory**, leveraging AI, IoT, and digital twins for real-time production adjustments and optimization.

Green manufacturing: Sustainable, circular and efficient

The shift to green manufacturing is one of the most significant changes in Industry 5.0. Manufacturers are increasingly expected to reduce their environmental impact while maintaining profitability and efficiency. AI and IoT technologies play a crucial role in enabling resource optimization, energy efficiency and waste reduction. Generative AI can help manufacturers adopt circular economy principles by designing products that can be recycled, reused or disassembled more easily.

Key considerations:

- **AI for energy management:** AI can optimize energy consumption across the manufacturing plant by automatically adjusting equipment settings, reducing energy wastage and maximizing the use of renewable energy sources.
- **IoT for resource monitoring:** IoT sensors can monitor water usage, material consumption, and emissions, feeding data into AI models that offer real-time recommendations for reducing waste and improving sustainability.

- **GenAI for sustainable design:** Generative AI can help manufacturers design products that are easier to recycle, reducing material waste, and creating more sustainable supply chains.

Deliverables:

- **AI-driven energy management** systems that monitor and optimize energy use, reducing carbon footprints in manufacturing plants.
- **IoT-enabled monitoring** systems to track material consumption, emissions, and resource utilization in real time.
- **GenAI-powered product design** systems that focus on **circular economy principles**, ensuring products are designed with minimal waste and maximum reuse potential.

5 Cybersecurity: Protecting Smart Manufacturing from digital threats

As manufacturing plants become more interconnected and reliant on **AI, GenAI, and IoT**, they become more vulnerable to cyber-attacks. **Cybersecurity in Industry 5.0** must go beyond traditional IT security and include **Operational Technology (OT) security** to safeguard critical manufacturing systems. The adoption of AI for threat detection and response allows manufacturing companies to identify vulnerabilities and respond to security incidents in real time, ensuring the integrity of production systems.

Key considerations:

- Implement **AI-based cybersecurity systems** that autonomously detect and mitigate threats in real-time across both IT and OT environments.
- Ensure **IoT devices** are equipped with **end-to-end encryption** and secure communication protocols, minimizing the risk of data breaches or system disruptions.
- Use **AI for anomaly detection**, which can analyze vast amounts of sensor data to detect unusual patterns in machine behavior that may indicate cyber threats.

Deliverables:

- **AI-driven threat detection systems** that monitor IT and OT networks for cybersecurity risks in real time.
- **Zero-trust security architectures** that limit access to critical manufacturing data and systems, ensuring only authorized personnel can interact with AI-driven production systems.
- Regular **cyber-resilience assessments** for IoT-enabled production environments to ensure ongoing protection against cyber-attacks.

6 Data-driven manufacturing: Optimizing decisions through analytics

In Industry 5.0, data is not just a resource—it is a competitive advantage. The integration of AI and GenAI in manufacturing processes allows for real-time data analysis, predictive analytics, and dynamic decision-making. This empowers manufacturers to anticipate market shifts, optimize production processes, and reduce waste, resulting in improved Overall Equipment Effectiveness (OEE) and first-time quality.

AI enables data-driven decision-making by continuously monitoring production lines and making adjustments in real-time, while GenAI can simulate future scenarios and suggest new ways to optimize production. These technologies transform manufacturing into a proactive, intelligent operation, where decisions are made based on predictive insights rather than reactive responses.

Key considerations:

- Use AI-driven analytics to monitor and optimize performance metrics like OEE, capacity utilization, and resource efficiency.
- Employ GenAI for process simulation and scenario planning, enabling manufacturers to anticipate and mitigate potential bottlenecks or disruptions.
- Develop predictive analytics models for supply chain management, enabling manufacturers to respond dynamically to demand fluctuations and minimize lead times.

Deliverables:

- **Real-time AI-driven analytics dashboards** for monitoring production efficiency, energy consumption, and quality metrics.
- **GenAI tools for predictive modeling and scenario testing** to optimize production schedules and reduce downtime.
- **Data governance frameworks** that ensure data integrity, security, and compliance with global standards while empowering data-driven decision-making across the enterprise.

Case study: Transforming the car customization process through data transparency

In its journey towards Industry 5.0, a leading European car manufacturer was focused on enhancing customer experiences by offering personalized vehicle customization. However, a lack of transparency across its global supply chain resulted in inefficiencies, delays, and dissatisfied customers.

Strategic vision: Balancing automation with human creativity

EY's solution enabled the car manufacturer to balance automation with human creativity by developing a data analytics platform that integrated real-time data across the supply chain. The solution allowed customers to track the customization status of their vehicles at every stage, providing full transparency from design to delivery.

This human-machine collaboration empowered decision-makers with AI-driven insights to optimize production, increase overall equipment effectiveness (OEE), and deliver mass customization – key objectives of our EY Industry 5.0 framework.

People-centric manufacturing: Enhancing workforce capabilities

The new system reduced routine tasks such as manual tracking and status updates, allowing employees to focus on higher-value tasks like innovation and customer engagement. As part of this transformation, EY helped the manufacturer upskill its workforce, enabling them to collaborate with AI technologies, handle data insights, and manage customization requests more efficiently.

Advanced technology integration: AI, IoT, and real-time monitoring

The platform leveraged IoT and AI-driven predictive analytics to monitor the manufacturing process in real time.

By integrating these technologies, the company achieved:

- Reduced production delays through predictive maintenance and real-time problem-solving.
- Optimized supply chain management, improving inventory accuracy and production schedules.
- Enhanced customer satisfaction, as real-time updates on vehicle customization improved transparency.

Data-driven manufacturing: Insights for agile decision-making

With the EY data analytics platform, the manufacturer gained deep insights into production and customer preferences. These insights allowed the company to make informed, agile decisions that improved first-time quality and reduced downtime. Real-time data dashboards helped predict demand fluctuations and adjust production processes to minimize lead times and waste, aligning with the data-driven focus of Industry 5.0.

Outcome: Through this partnership, the manufacturer transformed its car customization process by achieving a perfect blend of human oversight and advanced digital technologies.

This case demonstrates how the EY Industry 5.0 framework can enable manufacturers to provide personalized customer experiences, improve operational efficiency, and integrate sustainability, paving the way for a human-centric, agile, and resilient future.

Other compelling use-cases of Indian companies leveraging the EY Industry 5.0 framework for Industry 5.0 initiatives include, Chennai-based petrochemical manufacturing company Tamil Nadu Petroproducts Limited (TPL) that aims at developing an integrated carbon-neutral roadmap aligned with its long-term sustainability goals. TPL aims at establishing internal reduction targets consistent with the science-based targets initiative (SBTi) and devising an emission reduction plan primarily for Scope 1 and 2 emissions. By implementing interventions such as clean energy substitution, process efficiency improvement, circularity and digital automation, the company wants to move towards its goal of carbon-neutral manufacturing.



4

A deep dive into Telangana's manufacturing sector

Policy and regulatory landscape of Telangana

1. Telangana Industrial Project Approval and Self-Certification System (TG-iPASS)

TG-iPASS is a flagship initiative by the Telangana government aimed at providing a streamlined, single-window clearance system for entrepreneurs. Here are the key features:

Single-window clearance: TG-iPASS ensures that all necessary approvals for setting up industries are processed through a single point of contact.

Time-bound approvals: The system guarantees clearances within a specified timeframe, with mega projects (over INR200 crore) receiving approvals within 15 days.

Self-certification: Industries can commence operations based on self-certification, without waiting for statutory clearances.

Accountability: The system holds officials accountable for delays, with provisions for penalizing responsible officers

2. Telangana Industrial Policy 2014

The Telangana Industrial Policy 2014 aims to create a business-friendly environment and attract investments. Key aspects include:

Infrastructure development: Focus on developing industrial parks, improving connectivity, and providing essential utilities like water and power

Skill enhancement: Initiatives to enhance the skills of the local workforce to meet industry requirements

Incentives: Various incentives for industries, including tax benefits, subsidies, and financial assistance

Priority sectors: The policy identifies key sectors such as life sciences, IT hardware, precision engineering, food processing, and textiles for focused development

3. Telangana Industrial Infrastructure Corporation (TGIIC)

TGIIC is responsible for developing industrial infrastructure in Telangana. Key functions include:

Industrial Parks: Development of industrial parks with ready-to-use infrastructure

Land Acquisition: Facilitating land acquisition for industrial projects

Infrastructure Provision: Ensuring the availability of essential utilities like water, power and gas

4. Special Economic Zones (SEZs)

Telangana has several Special Economic Zones (SEZs) designed to boost manufacturing, exports and employment. Key features include:

Tax Benefits: SEZs offer various tax incentives to export-oriented units

Infrastructure: SEZs are equipped with world-class infrastructure to support industrial activities

Employment generation: These zones aim to create job opportunities and contribute to economic growth

5. Empowering MSMEs: Telangana's vision for growth and innovation

In a bid to bail out the ailing MSME (micro, small, and medium enterprises) sector in the State, the Telangana Government has announced a six-pronged strategy to put



them on the path to growth. The MSME Policy 2024 says the government will focus on the development of infrastructure, access to finance and human resources, availability of raw materials; promotion of technology adoption; and enhancing access to markets. A high-level steering committee will supervise the policy's execution, monitor progress, and set the strategic direction. The government will spend INR600 crore over the next five years to support these initiatives.

- The policy envisions the creation of an Industrial Park in each of the 33 districts in the State, with each park setting aside 20% of the space for MSMEs. We are going to set up 10 Industrial parks in the area between the Outer Ring Road and the upcoming Regional Ring Road.
- Realizing the fact that most of the MSMEs are using outdated technologies, the policy introduced a INR100-crore fund to help MSMEs modernize their technologies and help them to graduate to the Industry 4.0 era.
- Recognizing the unique needs of women entrepreneurs, the government will also establish flatted factories equipped with essential facilities

in all 119 constituencies, further promoting women's participation in the MSME sector.

- As a prominent manufacturing hub, Telangana has strategically planned for its new industrial parks in Hyderabad to transition away from coal as the primary source of energy. Hyderabad, in particular, serves as a vital center for the life sciences sector, featuring industrial parks dedicated to pharmaceutical manufacturing, including vaccine production and medical devices.

While many of the older industrial units continue to rely on coal-fired energy, the new industrial parks will be designed to utilize alternative energy sources.

In line with these objectives, the government has proposed the establishment of a Net Zero City – a satellite township situated near Hyderabad – where all industrial activities will utilize gas as their energy source. This initiative underscores the state's commitment to moving away from coal dependency. However, the government also acknowledges the pressing challenge of ensuring a just transition for the numerous workers currently employed in the mining industry.



5

Paving the path: Strategic imperatives for Telangana's Industry 5.0 future

What will drive the manufacturing evolution in Telangana?

As Telangana moves towards Industry 5.0, will be driven by a combination of technological advancements, policy initiatives, and strategic collaborations.

1. **Government initiatives and policy support:** The Telangana government has been at the forefront of creating a conducive environment for industrial growth. The state's policies are designed to attract investment, foster innovation and streamline the process of setting up and running businesses. Key initiatives include:
 - **TG-iPASS:** The Telangana State Industrial Project Approval and Self-Certification System provides a single-window clearance for industrial projects, reducing the time and effort required to obtain various approvals.
 - **Industrial corridors and parks:** The development of dedicated industrial corridors and parks, such as the Hyderabad Pharma City and the National Investment and Manufacturing Zone (NIMZ), offers state-of-the-art facilities and infrastructure tailored for modern manufacturing.
 - **Innovation and R&D Support:** Programs like T-Hub and the Research and Innovation Circle of Hyderabad (RICH) aim to bridge the gap between academia, research institutions, and industry, fostering an ecosystem conducive to innovation.
2. **Skilled workforce and education:** Telangana's focus on education, particularly in engineering and technology, has resulted in a skilled workforce that can adapt to the demands of Industry 5.0. The presence of premier institutions like the Indian Institute of

Technology (IIT) Hyderabad, and numerous other engineering colleges, ensures a steady supply of trained professionals who can work alongside advanced technologies.

3. **Technological infrastructure:** The state's commitment to building robust technological infrastructure, including high-speed internet connectivity, reliable power supply, and smart city projects, lays the foundation for the integration of Industry 5.0 technologies in manufacturing.
4. **Collaboration with tech companies:** Telangana's capital, Hyderabad, is known as a tech hub, with a strong presence of multinational corporations and a vibrant startup ecosystem. Collaborations between these tech companies and manufacturing firms can lead to the development of cutting-edge solutions, such as AI-driven predictive maintenance, IoT-enabled supply chains, and robotics for automation.
5. **Sustainability and environmental policies:** With a global shift towards sustainable manufacturing, Telangana's industries are likely to adopt green technologies and practices. This includes the use of renewable energy, waste reduction techniques, and circular economy principles, all of which can be facilitated by Industry 5.0 innovations.
6. **Consumer demand for customization:** The modern consumer's preference for personalized products requires a manufacturing approach that is flexible and responsive. Industry 5.0's emphasis on human-machine collaboration can help manufacturers in Telangana cater to this demand by enabling more bespoke production without sacrificing efficiency.
7. **Investment in research and development (R&D):** The state's investment in R&D, particularly in areas like biotechnology, pharmaceuticals and technology, can



lead to breakthroughs that propel the manufacturing sector forward. This includes the development of new materials, processes, and technologies that are central to Industry 5.0.

8. **Supply chain resilience:** The recent disruptions in global supply chains have underscored the need for resilience and adaptability. Industry 5.0 technologies such as digital twins, blockchain for traceability, and advanced analytics can help Telangana's manufacturing sector develop more robust supply chains capable of withstanding future shocks.
9. **Digital transformation:** The ongoing digital transformation across industries is a natural precursor to the adoption of Industry 5.0. As manufacturers in Telangana become more digitized, they will be better positioned to integrate advanced technologies into their operations.
10. **Public-private partnerships (PPPs):** PPPs can play a crucial role in driving the manufacturing evolution by providing the necessary support, expertise, and funding. These partnerships can help scale Industry 5.0 initiatives, from pilot projects to full-fledged industrial applications.

Projected outcomes of Industry 5.0 adoption in Telangana

1. Pharma manufacturing

- AI-driven drug discovery: Dr. Reddy's Laboratories is incorporating AI into drug development, optimizing processes for personalized medicine. The adoption of collaborative robotics and AI-powered predictive maintenance will further streamline production, ensuring efficiency and sustainability.
- Sustainability in drug manufacturing: AI-driven resource optimization in Telangana's Pharma City can reduce chemical waste and enhance energy efficiency.

2. Automobile manufacturing

- Customization in EV manufacturing: Hyundai Motors in Telangana is moving towards electric vehicles and autonomous driving technologies. Industry 5.0 will enable the company to offer personalized features through AI-driven production systems and predictive maintenance, making the EV sector more agile and responsive to consumer demands.

3. Electronics manufacturing

- Smart factories and hyper-customization: Kaynes Technology has already adopted AI-driven inspection systems and real-time monitoring to improve efficiency and reduce waste. Industry 5.0 will further enable mass customization and smart production systems, allowing Telangana's electronics manufacturers to meet global demand for personalized electronics.



Goal: Make Telangana the global hub for AI innovation and implementation



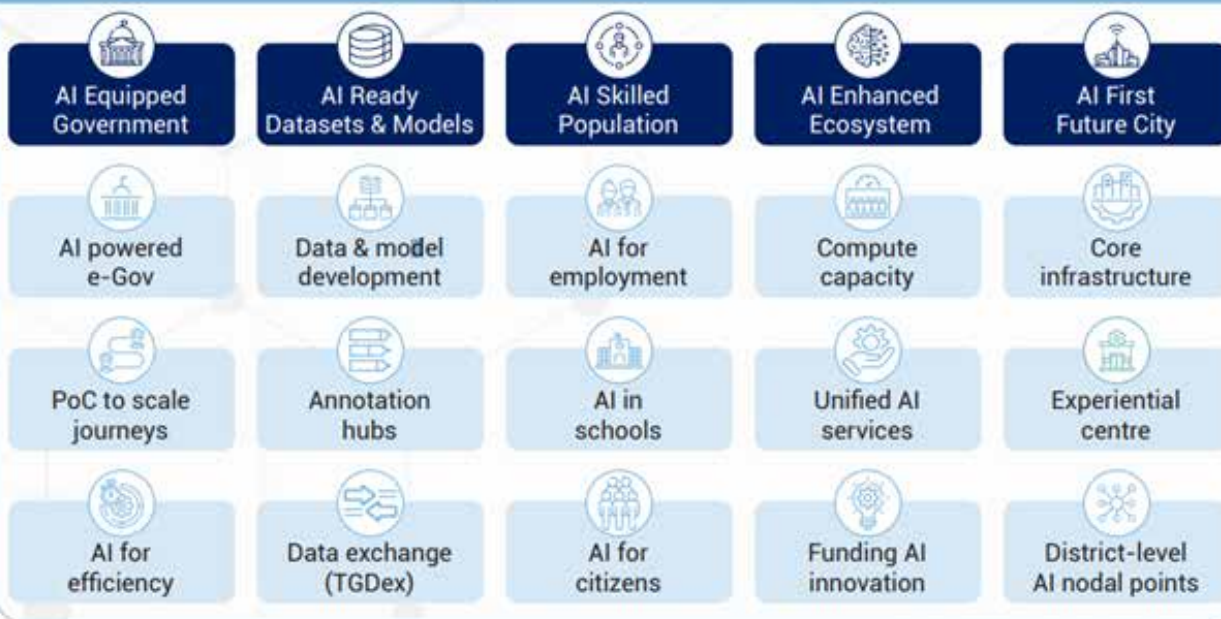
AI Direction Setting



Telangana AI Advisory Council



AI Research & Collaboration Network



Source: AI-Powered-Telangana-Strategy-Documents-and-Implementation-Roadmap.pdf

- Telangana recently signed 26 Memorandums of Understanding (MoUs) with leading tech companies, including OpenAI, Meta, NVIDIA, AWS, and Microsoft, alongside local firms like Yotta Data Services and CDAC. These partnerships span multiple sectors and aim to accelerate AI innovation and technological advancements.
- A key driver behind Telangana's AI progress is its advancement in semiconductor technology. In a major MoU, Kaynes Technology India Ltd has pledged to establish a INR2,800 crore Outsourced Semiconductor Assembly and Test (OSAT) facility in Hyderabad. This development positions Telangana as a pivotal player in the semiconductor industry, which is crucial for AI-driven technologies. The OSAT facility is expected to boost local manufacturing capabilities while attracting further investment in industries such as autonomous vehicles, robotics, and advanced computing.

**As per Gartner's study
in the early 2020s:**



77%

of manufacturers are piloting, implementing, or using the Internet of Things (IoT)



71%

of manufacturers are piloting, implementing, or using artificial intelligence (AI).

By 2025, 65% of global manufacturers will invest in edge AI as a part of their IoT-enabled hyper-automation strategy.

Source: <https://community.nasscom.in/communities/digital-transformation/digital-transformation-manufacturing-industry-towards-industry#:~:text=By%202025%2C%2065%25%20of%20global,are%20adopting%20industrial%20classification%20standards.>

Use case:

1. Product design and prototyping

Generative AI can automatically generate design variations for new product prototypes, optimizing for material usage, performance, and aesthetics. In Telangana, a manufacturer of consumer electronics can use AI tools to generate efficient casing designs that reduce waste and enhance product durability.

For instance: Electronic system design and manufacturing solutions provider Kaynes opened an electronics manufacturing facility near Hyderabad.

Located at the industrial park in Kongara Kalan in Rangareddy district, the new plant is equipped with the latest manufacturing technologies, including high-precision electronic assembly, 3D optical and Artificial Intelligence enabled inspection systems and lead-free/RoHS-compliant processes.⁴

2. Predictive maintenance

Example: AI-based predictive models can analyze equipment performance data to forecast maintenance needs before breakdowns occur.

For example: IFFCO a fertilizer manufacturer is planning to increase focus on AI for deep insights into business operations and predictive maintenance, analytics for sales and production forecasting, with Oracle's Autonomous Database and Analytics.⁵

3. Energy management

Energy consumption forecasting: Generative AI models can forecast energy requirements based on historical usage patterns and production schedules. This allows Telangana's manufacturing sector to plan better, reducing energy costs and contributing to sustainability goals.

Energy optimization: AI algorithms can generate strategies for optimizing energy use by balancing production load and leveraging renewable energy sources.

For example: Schneider Electric's Hyderabad factory manufactures mission-critical electrical equipment and operates with an advanced, cloud-based manufacturing system powered by IoT-enabled devices, leveraging real-time data and predictive analytics for smart decision-making processes.⁶

⁴<https://www.thehindu.com/news/cities/Hyderabad/kaynes-electronics-manufacturing-plant-opened-near-hyderabad/article68559282.ece>

⁵<https://cio.economictimes.indiatimes.com/news/strategy-and-management/iffco-plans-to-increase-focus-on-ai-for-predictive-maintenance/75991008>

⁶https://www.csrwire.com/press_releases/792151-world-economic-forum-recognizes-schneider-electrics-hyderabad-factory

⁷<https://www.businesswire.com/news/home/20221011005778/en/World-Economic-Forum-Recognises-Dr.-Reddy%E2%80%99s-Hyderabad-Factory-as-Part-of-its-Global-Lighthouse-Network>

4. Dr.Reddy's Lab

The journey began four years ago when Dr. Reddy's embarked on an ambitious program to 'digitize its core'. This involved upgrade of infrastructure and digitization of processes for robust and comprehensive data capture. Real-time data and insights laid the foundation for Project 'OpsNext' which was initiated two years ago to transform the plant into an Industry 4.0-driven 'Lighthouse' factory as defined by the WEF.

Deployment of six of the eight technologies of 4IR - Advanced Analytics, Digital Twins, Robotic Process Automation, Augmented/Virtual/Mixed Reality, Digital Performance Management and Industrial Internet of Things (IIoT). The OpsNext team identified 40+ business results linked use cases impacting various aspects of productivity such as customer service, quality, energy consumption, sustainability, equipment efficiency and people productivity. The company also invested heavily in building people capabilities such as digital and analytics translators, data scientists and data engineers.⁷

Significant business results seen - 43% manufacturing cost improvement, 30% reduction in production lead time, 41% energy consumption reduction, and significant dip in quality deviations

Diverse case studies convey a compelling narrative: Key takeaways from implementations across sectors

1. Dr. Reddy's Laboratories - AI-driven pharma manufacturing

- **Implementation:** Dr. Reddy's Laboratories implemented AI and ML algorithms for real-time drug production monitoring, predictive maintenance, and quality control.
- **Results:** This approach aims to reduce drug development timelines by 30-40% and costs by up to 50%
- **Key takeaway:** AI can optimize not only production but also regulatory compliance, a critical aspect in pharma.

2. Jubilant Ingrevia Limited (Bharuch, India):

- **Implementation:** Jubilant Ingrevia deployed Industry 4.0 technologies in global brownfield specialty chemical manufacturing and reskilling over 2000 employees.
- **Results:** Through 30+ integrated use cases

leveraging artificial and machine learning, IoT-based digital twin and predictive platforms, Jubilant Ingrevia's site reduced the overall process variability by 60% and almost doubled production volume.

- **Key takeaway:** Artificial and machine learning, IoT-based digital twin and predictive platforms are essential for achieving operational efficiency in Industry 5.0.

3. Schneider Electric - IoT-Enabled Smart Factory in Hyderabad

- **Implementation:** Schneider Electric adopted IoT-enabled devices and digital twin technology to monitor production lines in real time and optimize energy usage.
- **Results:** The plant saw a 40% reduction in energy consumption and was recognized by the WEF as a Sustainability Lighthouse.
- **Key takeaway:** Real-time data analytics and digital twins are essential for achieving sustainability and operational efficiency in Industry 5.0.

4. Tata Motors - Human-machine collaboration in EV production

- **Implementation:** Tata Motors' plant in India integrated cobots and AI for personalized vehicle production.
- **Results:** The introduction of customizable EV designs led to a 25% increase in global demand for Telangana-manufactured vehicles.
- **Key takeaway:** The automotive sector's shift to human-machine collaboration enables greater flexibility and personalization, key drivers of Industry 5.0.

Telangana readiness to adopt Industry 5.0

1. Technology and innovation ecosystem

Telangana, particularly its capital city Hyderabad, has a robust technology and innovation ecosystem. The presence of major IT and tech companies, along with startups and innovation hubs like T-Hub, provides a strong foundation for the adoption of advanced technologies central to Industry 5.0.

2. Government initiatives

The Government of Telangana has been proactive in embracing digital transformation and innovation. Initiatives such as the Telangana State Industrial Project Approval and Self-Certification System (TG-iPASS) for promoting industrial growth, and policies aimed at fostering innovation and technology development, indicate a supportive environment for Industry 5.0.

3. Education and skill development

Telangana has a focus on education and skill development in technology fields, with numerous institutions offering courses in IT, engineering, and related areas. This focus on education is crucial for developing the skilled workforce required for Industry 5.0.

4. Infrastructure development

Investments in infrastructure, including digital infrastructure and smart city projects, are essential for the integration of Industry 5.0 technologies. Telangana's efforts in improving infrastructure can facilitate the adoption of smart manufacturing and other Industry 5.0 innovations.

5. Collaboration with industry

The state's collaboration with industry players for technology development and implementation is another positive sign. Partnerships between the government, academia, and industry can drive the adoption of Industry 5.0 technologies and practices.

For instance, Mr. Reddy, accompanied by Industries and IT Minister D. Sridhar Babu and senior bureaucrats, made a strong pitch for investment at the WEF and succeeded largely in convincing global players to look at Telangana.



Recommendations for key stakeholders to accelerate India's manufacturing growth through Industry 5.0

India's path to adopting Industry 5.0—a future-oriented manufacturing model that emphasizes human-machine collaboration, sustainability, and personalized production—will require a multifaceted approach beyond the groundwork laid by Industry 4.0. While India has made significant strides through initiatives like Digital India and Make in India, embracing Industry 5.0 presents both opportunities and challenges.

Here are some key steps India needs to take to facilitate the adoption of Industry 5.0:

The Confederation of Indian Industry (CII) has put forward several key recommendations to unlock India's growth potential in the manufacturing sector. These recommendations are aimed at making the country a global manufacturing hub and boosting economic competitiveness.

1 Set up a mission on advanced manufacturing

Creation of a dedicated Mission on Advanced Manufacturing to push India into the next phase of industrial growth by leveraging emerging technologies. Advanced manufacturing techniques, such as automation, robotics, 3D printing, artificial intelligence (AI), and the Internet of Things (IoT), can significantly improve productivity and product quality while reducing costs. This mission should:

- Promote the adoption of Industry 4.0 technologies across sectors.
- Encourage public-private partnerships to drive innovation and the development of cutting-edge manufacturing solutions.
- Offer incentives, such as tax rebates or subsidies, for businesses adopting advanced manufacturing technologies.
- Create centers of excellence for research and development (R&D) in advanced manufacturing, especially in key sectors like automotive, aerospace, and electronics.

By establishing a national mission, India can foster an environment where companies of all sizes can integrate advanced technologies into their operations. This will help the manufacturing sector become more competitive on a global scale.

2 Set up a mission on advanced materials

To complement the Mission on Advanced Manufacturing, the CII also recommends a Mission on Advanced Materials. Advanced materials, such as high-performance composites, smart materials, and lightweight alloys, are critical in sectors like aerospace, defense, automotive, and renewable energy. The objectives of this mission should include:

- Encouraging research and innovation in material science to develop new, cost-effective, and environmentally sustainable materials.
- Enhancing domestic production of advanced materials, reducing dependency on imports, and ensuring supply chain resilience.
- Supporting the adoption of new materials in industries that are transitioning towards sustainability, such as the electric vehicle (EV) sector or renewable energy sectors like solar and wind power.
- Fostering collaboration between academic institutions, R&D labs, and industry to promote the development and commercialization of advanced materials.

Advanced materials can play a transformative role in improving product efficiency and durability while reducing environmental impact. This will enable Indian manufacturers to innovate and produce world-class goods.

3 Continued thrust on strengthening ease of doing business

A consistent focus on enhancing the Ease of Doing Business is critical for India's manufacturing growth. Over the past few years, India has made significant strides in simplifying business regulations, as reflected in its improvement in global Ease of Doing Business rankings. However, CII recommends sustained efforts in the following areas:

- Streamlining regulatory approvals: Continue to simplify and fast-track regulatory approvals, including environmental clearances, land acquisition, and building permits.
- Reducing compliance burden: Implement reforms to reduce the compliance burden on businesses, particularly small and medium enterprises (SMEs), by reducing the number of mandatory filings and digitizing key procedures.
- Enhancing contract enforcement: Strengthen judicial processes to improve the speed and reliability of contract enforcement and dispute resolution, which is vital for investor confidence.

- Improving infrastructure: Focus on enhancing critical infrastructure like roads, ports, railways, and logistics hubs to reduce transportation costs and improve the efficiency of supply chains.
- Facilitating digitalization: Encourage digitalization across government agencies to create a more efficient interface between businesses and government services.

Ensuring that businesses can operate without bureaucratic delays and unnecessary regulatory hurdles will further encourage both domestic and foreign investments in India's manufacturing sector.

4 Continued thrust on reducing the cost of doing business

High operating costs remain a significant barrier to competitiveness for Indian manufacturers. To reduce the Cost of Doing Business, CII recommends:

- Lowering power costs: Address high electricity tariffs by promoting renewable energy adoption, improving grid efficiency, and rationalizing tariffs for industrial users. Competitive power pricing is crucial for energy-intensive sectors such as steel, chemicals, and cement.
- Reducing logistics costs: Government should invest in multi-modal transport networks, improve port infrastructure, and encourage the use of Dedicated Freight Corridors (DFC) for faster, more reliable freight movement.
- Improving access to credit: Expand access to low-cost financing, particularly for SMEs, by introducing financial instruments such as credit guarantees and facilitating better lending rates through public sector banks.
- Lowering compliance costs: Reducing the compliance costs related to taxes, labor laws, and environmental regulations through streamlined digital platforms and reducing redundant paperwork will save businesses time and money.
- Tax and incentives framework: Revise tax incentives to ensure they are industry-specific and productivity-driven, encouraging companies to invest in innovation, R&D, and skill development.

By reducing operational costs, Indian manufacturers will be better positioned to compete globally, thus enhancing India's attractiveness as a manufacturing destination.

5 The government, industry bodies and private sector must collaborate and actively invest in accelerating Industry 5.0 adoption

With well concerted efforts, the country can accelerate its realization of sustainable, inclusive, and human-centric growth in the new industrial era.

A. The role of the government: Creating the foundation for Industry 5.0

The government will be instrumental in laying the groundwork for Industry 5.0 adoption through well-structured policies, financial incentives, and infrastructure development.

i. Policy frameworks to drive innovation

India's transition to Industry 5.0 will require an evolution of existing initiatives such as 'Digital India' into a more comprehensive, sector-wide policy framework. Developing nationwide strategies that promote AI, human-machine collaboration, and sustainable manufacturing is essential for guiding industries through this transformation.

ii. Financial incentives for industry-wide adoption

To foster widespread adoption of Industry 5.0, the government must offer financial support in the form of subsidies, grants and tax incentives. This will reduce barriers for industries, particularly SMEs, to invest in and adopt advanced technologies. Targeted funding for R&D in areas like AI, robotics and automation will drive innovation and position India at the forefront of the global industrial revolution.

iii. Infrastructure and skill development

A robust physical and digital infrastructure is vital for Industry 5.0. Investments in high-speed internet, innovation clusters, and smart manufacturing hubs will ensure the right environment for advanced industries. Moreover, expanding educational initiatives to include STEM disciplines and skills relevant to Industry 5.0, such as robotics, AI, and digital literacy, will create a workforce that can seamlessly integrate with advanced systems.

B. Industry bodies: Facilitating collaboration and knowledge sharing

Industry organizations such as the Confederation of Indian Industry (CII) play a catalytic role in fostering cross-sector collaboration, ensuring the smooth exchange of knowledge and best practices for Industry 5.0 implementation.

i. Enabling cross-sector synergies

By fostering collaboration across industries—such as manufacturing, IT, and agriculture—industry bodies can accelerate the development of Industry 5.0 solutions. These synergies will allow industries to adopt technologies that meet the needs of diverse sectors, from personalized production to sustainable practices.

ii. Advocating for industry-centric policies

Industry organizations must work closely with the government to advocate for policies that facilitate Industry 5.0 adoption. Regulatory reforms that encourage R&D, protect data privacy, and promote green practices will support India's long-term industrial growth.

C. The private sector: Innovators and leaders in the Industry 5.0 era

Private players, from large conglomerates to start-ups, are critical in driving Industry 5.0 forward through innovation, sustainability, and competitive business practices.

i. Innovation and investment in R&D

Private companies need to invest heavily in R&D to create human-centric technologies, such as AI, IoT, and robotics, that are integral to Industry 5.0. This focus on innovation will lead to personalized production systems and collaborative environments where humans and machines work together seamlessly.

ii. Embracing sustainability as a competitive advantage

Sustainability is a core principle of Industry 5.0. By integrating green technologies and sustainable practices into their operations, businesses can meet growing consumer demands for environmentally conscious products while remaining competitive in the global marketplace.

iii. Promoting healthy competition and collaboration

Private companies must foster healthy competition, which drives technological advancement and industry-wide improvement. At the same time, forming alliances with start-ups and academic institutions will enhance innovation and accelerate the pace at which Industry 5.0 technologies are developed and deployed.

6 Addressing certain key challenges will be essential to ensuring maximum realization of Industry 5.0

1. Building an Inclusive National Policy Framework

- India needs to advance sectoral policies into a comprehensive national strategy that encompasses all key economic sectors. By leveraging the diverse skill sets of its workforce and focusing on human-centric automation, India can achieve a seamless transition into Industry 5.0. As India embarks on its Industry 5.0 journey, it is crucial to ensure that the benefits of this technological revolution are distributed equitably. Bridging the digital divide, fostering social equity, and developing a resilient workforce are essential to creating a human-centric industrial landscape where technology serves humanity's greater good.
- Data governance and security: With the increasing integration of human-machine interactions, protecting sensitive data and ensuring cybersecurity becomes paramount. Regulatory frameworks must address these concerns to build trust in digital transformation.
- Industry 5.0 policy roadmap: Developing a national Industry 5.0 policy roadmap that outlines goals, strategies, and timelines for adoption will give the country direction.

2. Enhancing education and skill development

To prepare future generations for Industry 5.0, educational institutions must incorporate STEM disciplines, digital literacy, and interdisciplinary approaches into their curricula. Encouraging a culture of innovation through collaborative research and real-world applications will create a workforce capable of driving industrial transformation.

3. Promoting a cultural shift toward technology as an enabler

To harness the full potential of Industry 5.0, a cultural shift is needed. Industry stakeholders must work to change public perceptions of technology from a threat to an enabler of progress, fostering an environment where human creativity and technology can coexist.

a. Digital infrastructure expansion

A robust, nationwide digital infrastructure is critical for ensuring seamless connectivity and real-time collaboration between machines and humans.

- Investment in 5G and fiber optics: India needs to accelerate the deployment of 5G technology to support the high-speed, low-latency communication required for Industry 5.0. Initiatives like BharatNet are steps in the right direction, but their reach must extend to rural areas to close the digital divide.
- Internet of Things (IoT) ecosystem: Creating an extensive IoT ecosystem that connects machines, tools, and human operators is vital. This infrastructure will

enable real-time data flows and predictive analytics that improve decision-making.

b. Bridging the digital divide

The adoption of Industry 5.0 will require inclusivity across India's diverse regions.

- **Equitable access to technology:** Many rural and semi-urban areas still lack adequate access to digital infrastructure. Expanding connectivity and affordable access to technology will ensure that all parts of the country can benefit from Industry 5.0.
- **Government and private sector collaboration:** Joint efforts between the public and private sectors can help close this gap through subsidies, incentives for technology adoption, and the establishment of smart cities and smart villages.

c. Sustainability and green manufacturing

A core principle of Industry 5.0 is sustainability, integrating green technologies into manufacturing.

- **Renewable energy integration:** The use of renewable energy sources like solar, wind, and bioenergy should be scaled up within the industrial sector to power operations with a low carbon footprint.
- **Circular economy models:** Encouraging industries to adopt circular economy practices, such as waste minimization, recycling, and resource efficiency, will help drive sustainable manufacturing.

7 R&D investments in AI and Advanced Automation

Industry 5.0 demands that machines do more than automate—they need to adapt and work alongside human counterparts.

- **R&D investment in AI and Robotics:** India must continue investing in AI research, machine learning, and robotics. Collaboration with international firms and academia can help create advanced solutions that enhance productivity and enable adaptive automation.
- **Intelligent Robotics and Cobots:** The introduction of collaborative robots (cobots) that can work side-by-side with human operators will increase efficiency and allow for more flexible production processes.

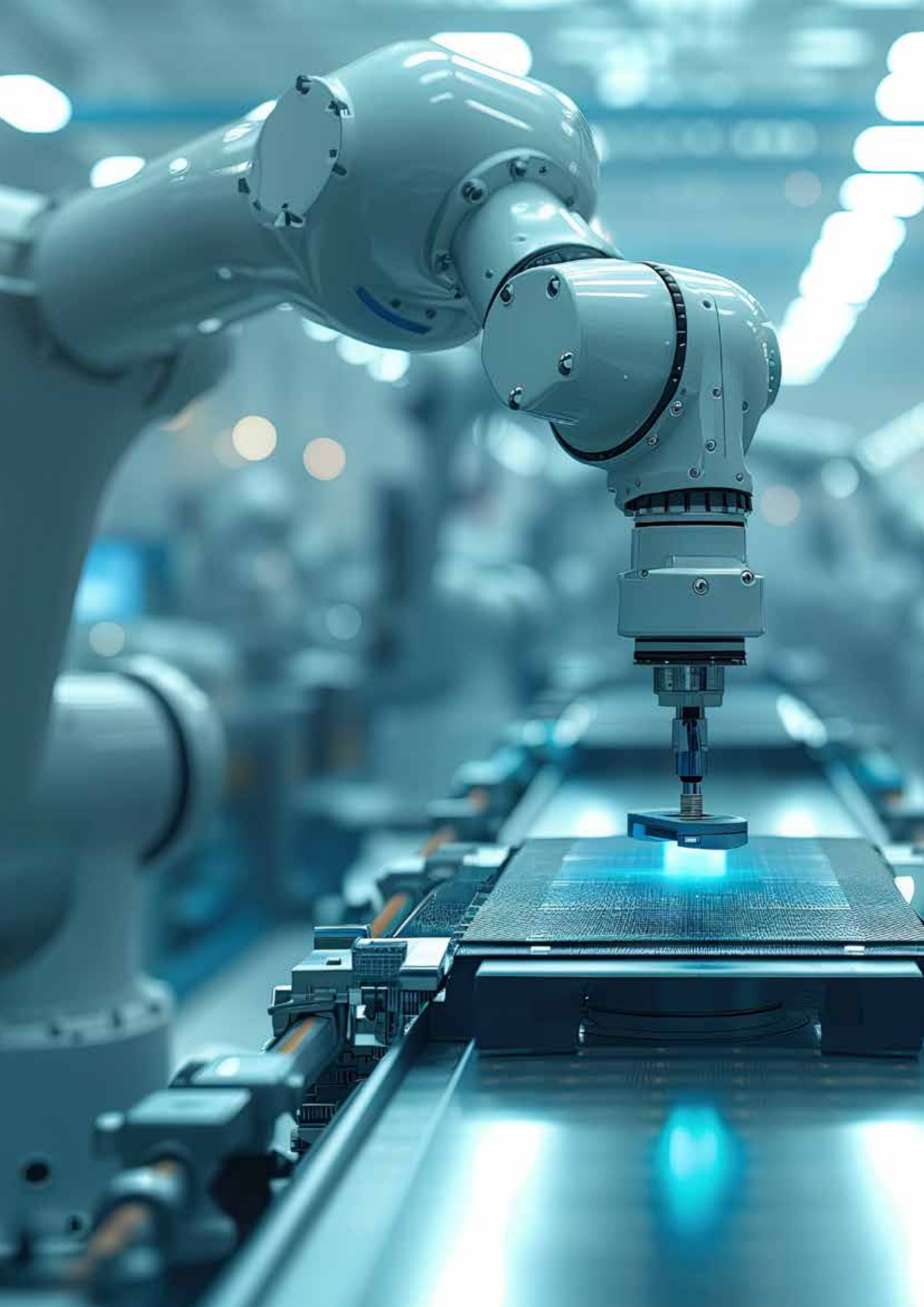
8 Skill ecosystem for the workforce of tomorrow

- **National upskilling initiatives:** Government-led initiatives like Skill India should be expanded to focus on the skills necessary for collaborative AI, cognitive technologies, and human-machine interaction.
- **Lifelong learning platforms:** Programs should be designed to continually upgrade the skills of the existing workforce. Online learning platforms and corporate training partnerships can provide accessible, flexible learning opportunities.
- **Empowering future workforce:** The Telangana government has launched a strategic initiative to build a strong skill development ecosystem aimed at preparing the workforce for future opportunities. A key part of this effort is the creation of the Young India Skilling University, which will provide vocational training, and educational courses designed to empower individuals with the skills needed to succeed in emerging industries. This initiative focuses on offering alternative livelihood options and equipping the state's population with relevant, future-ready skills to foster economic growth and sustainability.

9 Building a culture of innovation

Industry 5.0 is not just about technology but also about innovation and creativity.

- **Innovation hubs and incubators:** India should promote innovation hubs that focus on the development of new manufacturing techniques and business models through research and startup support.
- **R&D in personalization and customization:** Developing technologies that enable personalized products and customized manufacturing will place India at the forefront of Industry 5.0.

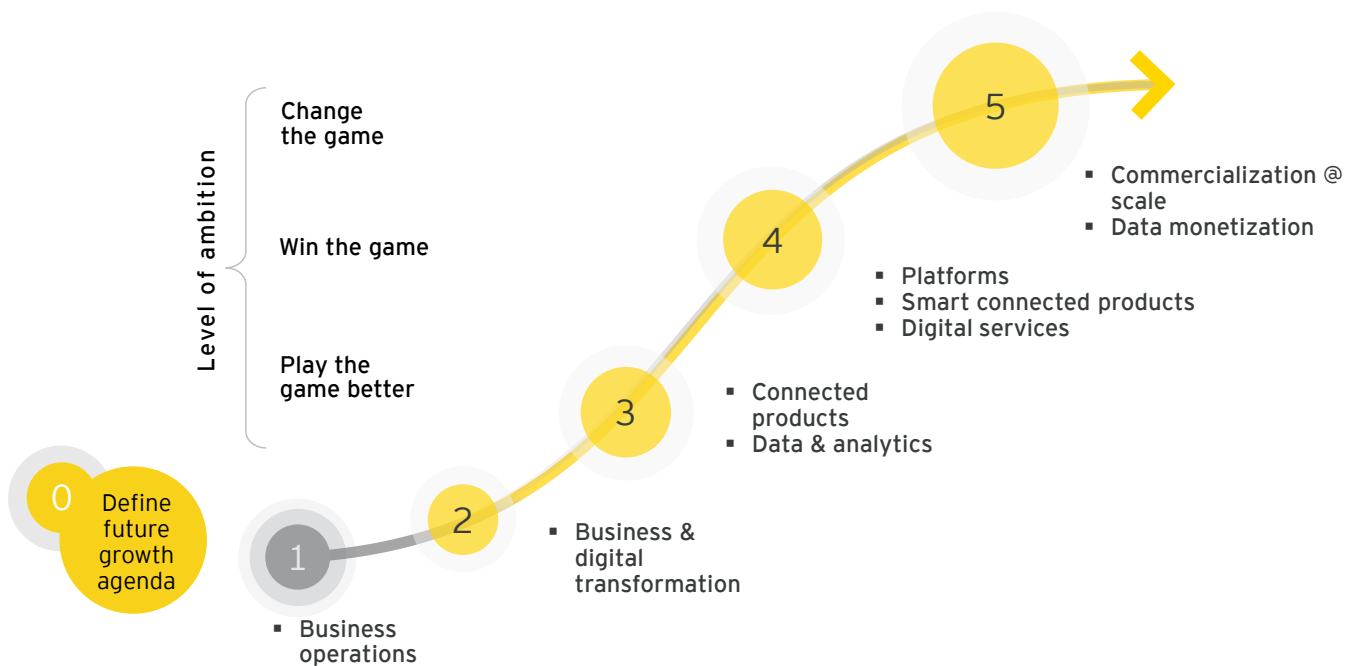


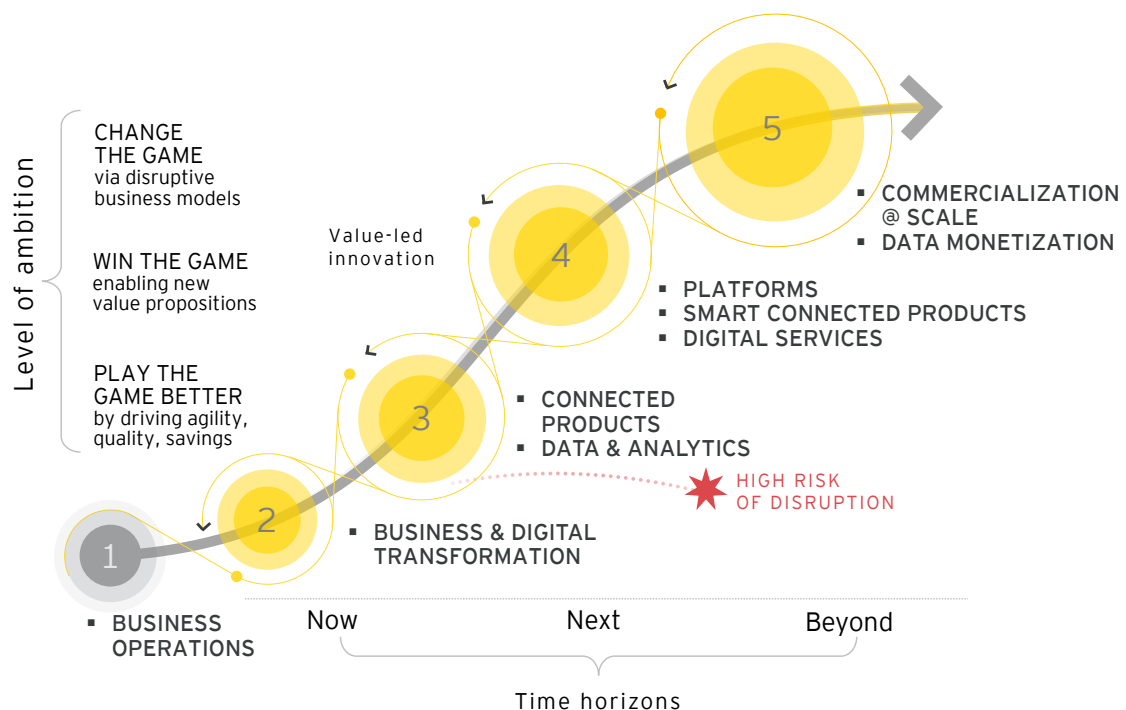
6

Blueprint for transformation: A step-by-step roadmap to Industry 5.0

Roadmap to harnessing emerging technologies for Industry 5.0 in Telangana

This roadmap outlines the key stages for Telangana to transition from Industry 4.0 to Industry 5.0, focusing on Generative AI (GenAI), cybersecurity, and green manufacturing. Telangana, with its strong industrial base in pharmaceuticals, electronics, and automotive sectors, is well-positioned to lead India's shift towards Industry 5.0. The roadmap prioritizes human-machine collaboration, advanced AI adoption, and a sustainability-driven approach to manufacturing.





1. Assessment and awareness (Year 1)

Objective: Identify readiness levels and create awareness among stakeholders.

■ Technological infrastructure and readiness assessment:

Telangana's industrial sectors should conduct Smart Industry Readiness Index (SIRI) assessments or digital maturity audits. This will evaluate existing AI, IoT, cloud computing, and automation adoption in manufacturing.

KPI: 100% completion of readiness assessments for Pharma City, Hyderabad's automotive plants, and electronics sectors by the end of Year 1.

■ Stakeholder engagement:

Conduct workshops on human-machine collaboration, Lean Six Sigma, sustainability-driven manufacturing, and digital factory principles to align stakeholders with Industry 5.0 goals.

KPI: 10 industry-wide workshops with major stakeholders from Telangana's top industries by Year 1.

2. Productivity and process optimization (Year 1-2)

Objective: Maximize efficiency before scaling digital transformation.

- Existing plants:
Manufacturers should focus on optimizing throughput using Lean and Six Sigma methodologies, improving output by 12% to 15% before investing in expansion or new facilities.
- Holistic productivity enhancement:
Improvements should extend beyond manufacturing to QA/QC processes, ensuring product quality and compliance are also enhanced.
- Foundation for digital/smart factory:
Once optimal productivity levels are achieved, digital transformation initiatives should be introduced to sustain efficiency gains.
- KPI: Lean Six Sigma initiatives in 50% of Telangana's key manufacturing units by Year 2.

3. Technology integration (Year 2-3)

Objective: Leverage Industry 4.0 as the foundation for Industry 5.0 transformation.

- Built-in digital capabilities for new facilities:
For new plants or extensions, smart factory elements should be integrated during installation to avoid retrofitting challenges.

KPI: 80% of new manufacturing plants in Telangana adopting smart factory principles from day one.

- AI and robotics adoption:
 - Deploy cobots in high-tech industries like pharma and electronics.
 - Utilize Generative AI for predictive analytics, decision support, and product customization.
 - Implement AI-driven energy management solutions for sustainability.
- KPI: 50% of manufacturers to integrate cobots and AI-powered decision systems by Year 3.

4. Pilot programs and smart factory prototyping (Year 2-4)

Objective: Test Industry 5.0 technologies before large-scale adoption.

- Implement pilot projects in pharma, automotive, and electronics. Focus areas:
 - AI-driven predictive maintenance.
 - Cobot-assisted assembly lines.
 - Digital twin simulation for process optimization.
- KPI: 10 pilot projects initiated with documented benefits by Year 3.

5. Scale-up and workforce development (Year 3-5)

Objective: Gradually expand Industry 5.0 adoption while training the workforce.

- Iterative scaling:
 - Expansion of AI, cobots, and smart systems based on pilot project results.
 - Built-in AI for decision-making and process automation in more sectors.
- KPI: 50% of Telangana's manufacturing facilities adopting Industry 5.0 technologies by Year 5.
- Skill development for a human-centric workforce:
 - Expansion of TASK (Telangana Academy for Skill and Knowledge) programs to include robotics, cybersecurity, and AI-driven manufacturing.
 - Use of AR/VR-based immersive learning platforms.
 - KPI: AI and smart factory training integrated into 70% of Telangana's workforce development programs by Year 5

6. Sustainability and compliance (Year 2-5)

Objective: Ensure long-term sustainability through AI-driven resource optimization.

- AI-enabled green manufacturing:
 - AI-powered energy management solutions for efficiency.
 - Circular economy models to minimize waste and optimize resource usage.
- KPI: Telangana's industrial zones to achieve global sustainability certifications by Year 5.
- Regulatory compliance:
 - Ensure AI and cobot deployment adhere to ethical and safety standards.
 - Drive compliance automation for pharma and automotive sectors.
- KPI: 100% regulatory compliance for AI and automation systems by Year 5.

7. Pilot programs and prototyping (Year 2 - 4)

Objective: Test the feasibility of Industry 5.0 technologies through pilot projects before scaling.

- Government-industry-academia collaboration:
 - Engage IIT Hyderabad, RICH (Research and Innovation Circle of Hyderabad), and private industry players to drive research and workforce training.
- KPI: 20 joint research initiatives on AI and robotics launched by Year 3.
- Public-private partnerships:
 - Partner with Tata Motors, Microsoft, Siemens, and Dassault to scale AI-driven manufacturing solutions.
- KPI: 10 high-impact public-private partnerships established by Year 4.

By following this strategic roadmap, Telangana can become a leader in human-centric, sustainable manufacturing, leveraging emerging technologies like Generative AI, cobots, and cybersecurity to secure its position in the global manufacturing ecosystem. This transition will create a robust, future-ready industrial landscape while fostering innovation, sustainability, and workforce development



7

Conclusion

Telangana is at the cusp of a transformative industrial shift from Industry 4.0 to Industry 5.0, positioning itself as a leader in human-centric, sustainable, and personalized manufacturing. The state's key industries—pharmaceuticals, automotive, and electronics—are embracing this change by leveraging mass personalization, human-machine collaboration, and AI-driven efficiency to meet the evolving demands of consumers while maintaining high production standards.

The shift from mass production to mass personalization is a defining feature of Industry 5.0. Telangana's industries, especially automotive and pharma, are already adapting. Companies like Hyundai Motors are integrating AI-driven customization systems to offer personalized EV features, while pharmaceutical companies such as Dr. Reddy's Laboratories are utilizing advanced analytics and AI for drug discovery, recommendation and production. These innovations enable tailored products without compromising efficiency or scalability, giving Telangana's manufacturing sector a significant competitive advantage.

At the heart of this transformation is human-machine collaboration, where collaborative robots (cobots) work alongside human operators, enhancing flexibility and operational efficiency. This collaborative dynamic is a cornerstone of Telangana's vision for the future of manufacturing, where AI and automation handle repetitive tasks, allowing humans to focus on creativity and decision-making. To support this, the state is making strides in cybersecurity, ensuring that the integration of AI, IoT, and smart factory technologies remains secure

from digital threats, thereby safeguarding critical manufacturing data and infrastructure.

Sustainability is another critical theme in Telangana's industrial strategy. By promoting green manufacturing and circular economy principles, the state's industries are reducing their environmental footprint, optimizing resource usage, and increasing energy efficiency. For example, AI-powered energy management systems are enabling factories to reduce waste and adopt more sustainable practices, aligning with global environmental goals.

This rapid transformation is being driven by Telangana's proactive government policies. Initiatives like the Telangana State Industrial Project Approval and Self-Certification System (TG-iPASS) streamline the process of setting up industries with single-window clearances and time-bound approvals, making it easier for companies to establish operations and expand. Additionally, Telangana's focus on industrial infrastructure development through projects like Pharma City and Hyderabad's industrial corridors creates an environment conducive to technological advancement and industrial growth.

The Confederation of Indian Industry (CII) has played and continues to play a pivotal role in enabling Telangana's industrial growth. Through fostering public-private partnerships, advocating for policies that promote innovation, and encouraging the adoption of advanced manufacturing technologies, CII has been instrumental in positioning Telangana as a hub for Industry 5.0. CII's collaboration with government bodies and industry leaders has helped



bridge the gap between policy formulation and industrial execution, ensuring that Telangana's industries remain competitive on the global stage.

Moreover, Telangana's emphasis on skill development, particularly through initiatives like TASK (Telangana Academy for Skill and Knowledge), is ensuring that the workforce is well-prepared for the demands of Industry 5.0. With a focus on upskilling in areas like AI, robotics, and data analytics, the state is cultivating a tech-savvy, adaptable labor force ready to drive innovation in human-machine collaboration and smart manufacturing.

As Telangana accelerates its journey toward mass personalization, sustainability, and advanced cybersecurity, the state is laying the foundation for a resilient and globally competitive industrial ecosystem. Supported by forward-thinking policies, CII's leadership, and strategic industry partnerships, Telangana is well on its way to becoming a global leader in human-centric, sustainable, and personalized manufacturing, setting new benchmarks for innovation, productivity, and environmental stewardship.



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Confederation of Indian Industry (CII)

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, with over 9000 members from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 300,000 enterprises from 294 national and regional sectoral industry bodies.

For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes. Partnerships with civil society organizations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, livelihoods, diversity management, skill development, empowerment of women, and sustainable development, to name a few.

As India strategizes for the next 25 years to India@100, Indian industry must scale the competitiveness ladder to drive growth. It must also internalize the tenets of sustainability and climate action and accelerate its globalisation journey for leadership in a changing world. The role played by Indian industry will be central to the country's progress and success as a nation. CII, with the Theme for 2023-24 as 'Towards a Competitive and Sustainable India@100: Growth, Inclusiveness, Globalisation, Building Trust' has prioritized 6 action themes that will catalyze the journey of the country towards the vision of India@100.

With 65 offices, including 10 Centres of Excellence, in India, and 8 overseas offices in Australia, Egypt, Germany, Indonesia, Singapore, UAE, UK, and US, as well as institutional partnerships with 350 counterpart organizations in 133 countries, CII serves as a reference point for Indian industry and the international business community.

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