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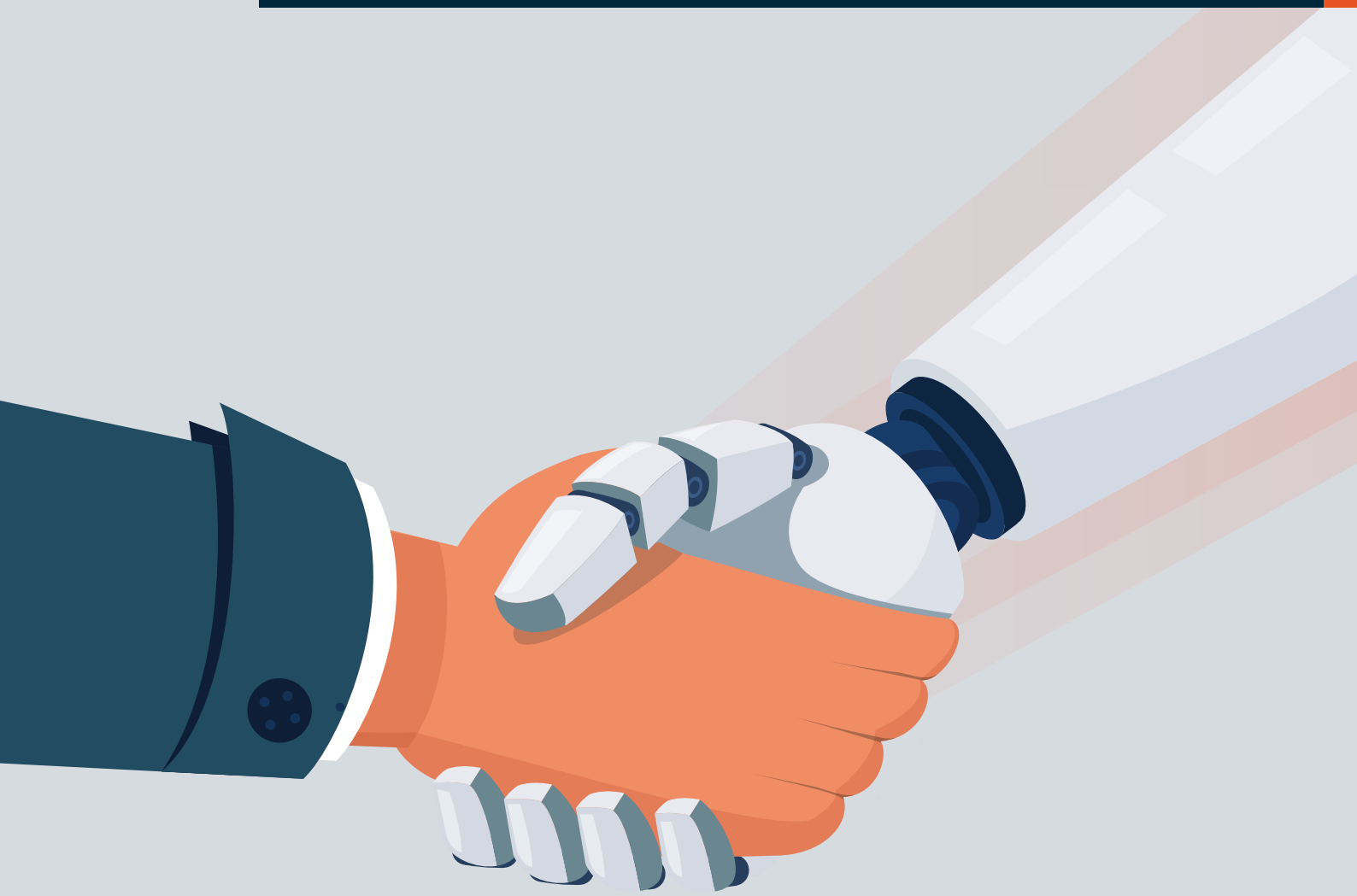
INDUSTRY 5.0

Purpose-Driven Technology Adoption for People and the Planet



Purpose-Driven Technology Adoption for People and the Planet

Technology, at once, has been both the pariah and the hero in the world of industry. For more than a decade, companies have had to live with the specter of either embracing a digital transformation, or sullenly standing by while competitors become stronger, faster, more efficient – and more financially successful.

But this digital embrace – including Industry 4.0 -- has delivered significant positive impacts while sometimes supplanting humans in the workflow process. Technology, as a silo unto itself, tends to deliver the goods while keeping humans on the sidelines – relegated to less hands-on, and more analytical, roles.

According to the report "Technological trends and policies" produced by the European Union, the cresting wave of a digital transformation extends beyond the factory floor and into society, creating uncertainties for industry workers who have had to find new purpose to conform to changing roles.

At the same time, rapid advances in the power of technology easily outpace the ability of organizations to align priorities to take effective advantage of new capabilities, leading to the need for vision – and guidance to help put things into perspective.

This is where Industry 5.0 comes in. Conceived as a way to complement the groundwork laid by Industry 4.0, it seeks to advance the cause of human-machine symbiosis – ensuring that the economic, environmental, and societal impact of digital transformation are held in the same regard as technological advances.

This report has been produced to familiarize you with the forces behind the Industry 5.0 industrial wave, as it already laps at our shores. We will start back at the dawn of industrial revolution and proceed on a multigenerational journey of innovation which has led to the dawn of the Industry 5.0 principles.

We will look at:

PART 1: Industry 5.0 – The ESG Union of Man and Machine
PART 2: The (R)evolutionary Foundations of Industry 5.0
PART 3: A More Human-Centric Approach to Emerging Technologies
PART 4: The Evolution of More Beneficial Outcomes
PART 5: How to Get Ready for Industry 5.0

Part 1:
Industry 5.0 – The ESG Union of Man and Machine

Technology has driven progress in industry, business, and society in ways that once seemed unimaginable. Automation, analytics, and connectivity have reshaped how we work, how goods are manufactured, and how supply chains are linked together.

But these rapid advances in the power of technology easily outpace the ability of organizations to align priorities to take effective advantage of new capabilities, leading to the need for vision and guidance to help put things into perspective.

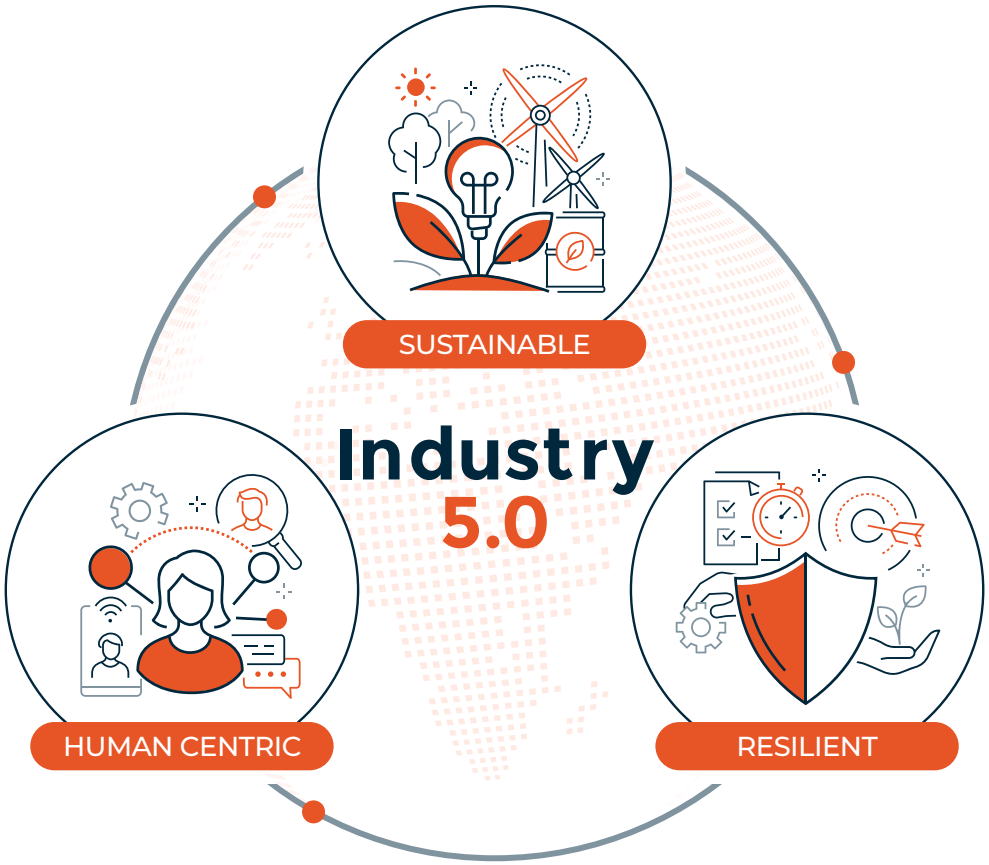
With so many changes afoot across the technology landscape, with evolving workforce demands, and an evolving backdrop of shifting societal and regulatory priorities, there's a need for a set of guiding principles to help set the course for the future of Digital Industry.

This is where Industry 5.0 comes into play. Industry 5.0 is a framework for re-imagining the future of energy, manufacturing, mobility, and supply chains that build upon and complement the meaningful groundwork paved by the vision of Industry 4.0.

Industrial Revolution, Revised

The vision of Industry 4.0, initially meant for the German manufacturing industry, was officially presented in 2011 at the Hannover Messe fair. The vision was about transforming the value chain through "smart" technologies like connected physical systems, cloud computing, artificial intelligence, and the Internet of Things. Just three years later, Japan published a complementary vision, termed Society 5.0, at the CeBIT fair – focused on the human impact of automation.

The European Union has merged these perspectives to create a manifesto for "purpose-driven" technology adoption: Industry 5.0. This vision emphasizes a triple-bottom-line of economic, environmental, and societal impact, bringing ESG (Environment, Social and Governance) perspective and balance to what have often been technology-led and economic-driven choices. The core principles of Industry 5.0 are that the industry is Human-centric, Sustainable,



In the EU's words

"Industry 5.0 is characterized by going beyond producing goods and services for profit. It shifts the focus from the shareholder value to stakeholder value and reinforces the role and the contribution of industry to society. It places the well-being 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."

A People-Centric, ESG-Driven, Post-Pandemic Shift

The guiding tenets of Industry 5.0 draw upon the growing interest in the factors that are also driving increased interest in ESG investing. Some of the key related themes include sustainability and the environment, purpose, and values, corporate ethics, diversity, as well as circular economies.

In the wake of the disruption and dislocations caused by the global COVID-19 pandemic, along with increasing reliance on digital infrastructure, there is also a focus on organizational, economic, and cyber resilience. Lastly, the integration of human factors into complex technology value chains is paramount with priority on the role of people in the future of work with increased human-machine collaboration and human-centric solution design.

Industry 4.0 and the Internet of Things

The vision for Industry 4.0 gained steam with the emergence of the Internet of Things (IoT) technologies, including the proliferation of smaller, cheaper, and better-performing sensors. When deployed across factory floors and mated with advanced equipment, IoT sensors generated petabytes of data that facilitated extremely detailed measurement, monitoring, and analysis of systems and processes.

It didn't take long for Industry 4.0 to deliver financial efficiencies – companies that fully embraced the fourth industrial wave saw the cost of processing, bandwidth, storage, and sensors drop by huge margins that were measurable on the bottom line.

> As these costs declined, Industry 4.0 accelerated – and thus sped up the digital transformation to follow.

With advances in wireless technology, including 5G and wide-area, low power communications standards such as LoRaWAN, data can be uploaded to the cloud for high-performance analytics processing. Advances in artificial intelligence (AI) and machine learning (ML) technologies have accelerated the development of powerful algorithms that can drive real-time actionable insights.

A recursive loop evolves – collect data, analyze, measure, refine, predict – that enables self-improving (and correcting) automation. The business benefits from the decreased downtime, improved operational efficiency, and better quality that are central guiding tenets of Industry 4.0.

Beyond the Machines

Though highly automated processes work well, there are limitations. Automated, repetitive functions benefit from consistent improvements, and for scenarios that involve producing identical products manufactured through pre-defined processes, the combination of powerful technologies generates compelling benefits.

Though this works well for homogenous products, it tends to fall short where greater customization and sophistication is demanded.

> Herein, incorporating the role of humans into automated manufacturing processes, building upon the powerful capabilities of Industry 4.0, and complementing and augmenting processes with true human-machine collaboration, lies the promise of Industry 5.0.

Part 2:
The (R)evolutionary Foundations of Industry 5.0

The promise of Industry 5.0 – and the vision for its immediate predecessor, Industry 4.0, has been nearly 250 years in the making.

The First Industrial Revolution dates back to the 1780s, with the innovations around generating power from water, steam, and fossil fuels. The Second Industrial Revolution emerged in the 1870s, with the introduction of electrical energy, which allowed for the development of assembly lines and mass production. The Third Industrial Revolution emerged in the 1970s, with the rise of Information Technologies and semiconductors, enabling unprecedented automation across industries. The Fourth Industrial Revolution – which we have referred to as Industry 4.0 -- incorporates the components of Internet of Things (sensors, low power connectivity, etc.) with cloud computing and advanced analytics to create real-time interactions between virtual and physical environments – giving rise to cyber-physical systems.

Industry 4.0 originated from a German government strategy project focused on transforming manufacturing into cyber-physical systems that generate significant savings in costs of production, logistics, and improved quality management.

Industry Waves

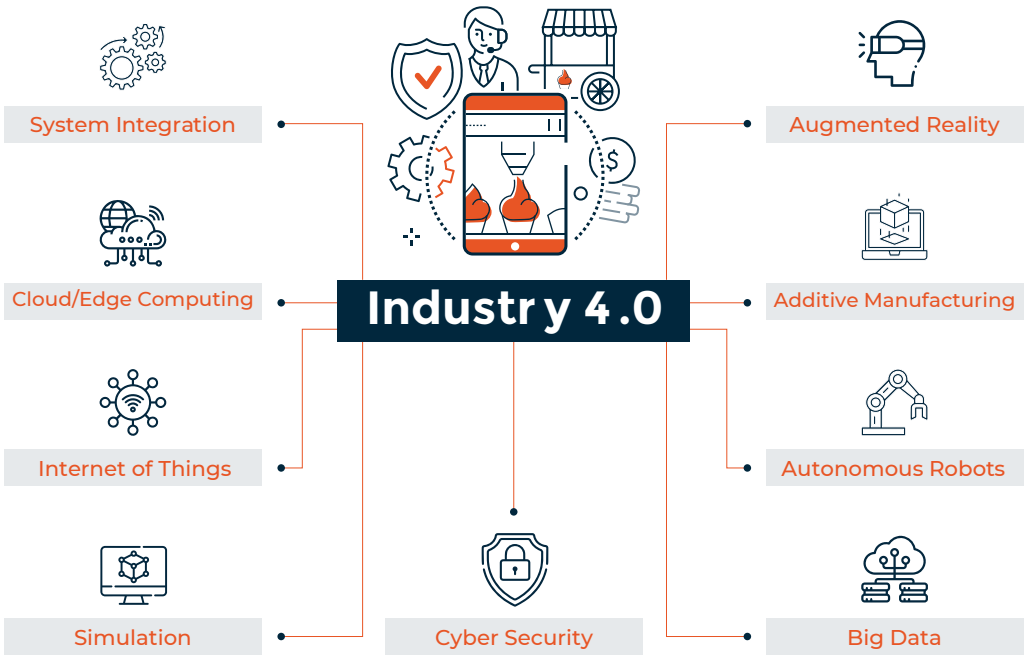
1. Water/Steam: The mechanics of the steam engine to power industry
2. Electricity: The innovation of the assembly line enabling mass production
3. Automation: The speed of the computer to automate production
4. Cyberphysical Systems: Digital systems to optimize production
5. Societal: Balancing industrial productivity with the impact on people and planet

The essential Industry 4.0 approach involves the deployment of IoT technologies in manufacturing facilities to collect and analyze data using cloud computing – then, using big data insights to power more efficient value chains. Effectively, Industry 4.0 is about automating processes and incorporating edge computing (both sensors and actuators) – the pure application of technology to create smart factories, leverage digital twins, and realize hyper-optimized production lines and smart products.

In short, Industry 4.0 has been characterized as a term for the present trend of automation and data interchange in manufacturing technologies, encompassing cyber-physical systems, the Internet of Things, cloud and edge computing, and cognitive computing, as well as the creation of the smart factory.

Industry 4.0 – the digital transformation

3rd platform, innovation accelerators, OT and manufacturing meet in transformation



While Industry 4.0 is still in the initial stages of evolution, industry leaders have been looking ahead to the concept of a Fifth Industrial revolution that incorporates the principles of human-centricity, sustainability, and resilience.

Part 3:
A More Human-Centric Approach to Emerging Technologies

One of the core tenets of Industry 5.0 is to make processes more human-centric. Part of the motivation is to mitigate the concerns and resistance to automation from labor unions and politicians concerned that Industry 4.0, in theory, could create crises of technological unemployment.

From a practical perspective, highly automated processes can deliver highly consistent and repeatable output, but this does not address the need to provide increasingly customized or personalized products (as customer expectations become increasingly sophisticated).

> The human-centric vision involves active collaboration between people and machines.

Historically, automation and robotics have tended to be isolated from humans on the factory floor (often behind cages for safety reasons). A new generation of collaborative robots (also known as cobots) incorporates enhanced sensor and vision technologies to enable humans to work alongside cobots. In addition to being inherently safer, the new generation of cobots is easier to program and set up. They can be "trained" to work alongside humans on the factory floor and can be reprogrammed to perform a wider range of tasks as needed. The vision of Industry 5.0 is to harness the creativity of humans in a far more extensible framework to deliver a more dynamic range of manufactured products.

Sustainability at its Core

There has been a significant focus on sustainability coming from the European Union, figuring prominently in policy. The EU has been fully committed to delivering on the United Nations' 17 Sustainable Development Goals, including the adoption of more green energy, the reduction of environmental impact, and the promotion of social goals such as the empowerment of women, particularly in developing countries.

> Sustainability is becoming a higher priority for businesses, as investors place a greater emphasis on environmental, social, and governance (ESG) factors when making investment decisions.

The Industry 5.0 vision seeks to offset the typical increases in energy consumption and carbon emissions from the expansion of industrial production. Improvements can come from increased energy efficiency, sourcing of clean power sources, focusing on reducing pollutants and their environmental impact, and using new materials. The concept of "circular economy" — in which materials and waste products are recycled to minimize any negative impact on the environment — figures prominently, though this will require significant research and innovation ahead.

A More Resilient Society

There has been no more dramatic illustration of the need for resilience than the severe supply chain and employment disruptions created by the COVID-19 pandemic and related responses. Manufacturers have had to re-evaluate their supply chains and the reliability of vendors. In many regards, ensuring resilience can be at odds with the hyper-efficient model of "just-in-time" principles – but in times of disruption, the downside of reliance on global suppliers (and static processes) can be far more costly.

The other dimension of resilience is societal – again, the potential downsides of widespread technological unemployment created by hyper-efficient automation can result in heightened – and potentially dangerous social instability. The incorporation of the human element and sustainable principles into manufacturing processes promises improved resilience on multiple counts.

> The human-centric, sustainable, and resilient principles of Industry 5.0 address a broader range of considerations than the pure technologically driven efficiencies envisioned by Industry 4.0.

Part 4:
The Evolution of More Beneficial Outcomes

Given the commitment by the European Union, and others with a stake in a more sustainable future, it's easy to understand why Industry 5.0 is seen – rightly so – as an evolution, incorporating foundational elements of Industry 4.0 into a more broadly encompassing vision that delivers a wider range of benefits to a broader set of stakeholders.

> The goal is to move past economic and resource extractive models to new forms of sustainable, circular value creation that allow for a broader and fairer distribution of economic prosperity.

It's a broader mission guided by principles of regenerative purpose, along with the transformation of industrial production, to deliver broader value to society and the environment, rather than a singular focus on shareholder value. The table below outlines key distinctions.

Industry 4.0

- **Centered around enhanced efficiency** through digital connectivity and artificial intelligence
- **Technology** — centered around the emergence of cyber-physical objectives
- **Aligned with optimization of business models** within existing capital market dynamics and economic models — i.e., ultimately directed at minimization of costs and maximization of profit for shareholders
- **No focus on design and performance** dimensions essential for systemic transformation and decoupling of resource and material use from negative environmental, climate, and social impacts

Industry 5.0

- **Ensures a framework** for industry that combines competitiveness and sustainability, allowing industry to realize its potential as one of the pillars of transformation.
- **Emphasizes Impact of alternative modes** of (technology) governance for sustainability and resilience.
- **Empowers workers** using digital devices, endorsing a human-centric approach to technology.
- **Builds transition pathways** towards environmentally sustainable uses of technology.
- **Expands the remit of corporation's** responsibility to their whole value chains.
- **Introduces indicators** that show, for each industrial ecosystem, the progress achieved on the path to well-being, resilience, and overall sustainability.

Let's take a deeper look at the six trends shaping this more sustainable future:

1. **Digital twins and simulation.** The more forward-looking firms in discrete manufacturing and industrial design are already embracing these technologies, driving new standards of quality, efficiency, and anticipatory visibility into their products and ecosystems.
2. **Data transmission, storage, and analysis technologies.** The fuel that powers innovative industry is data. The massive advances in connectivity, storage and data analytics, including cloud and edge-based systems, are foundational not just to industry but to every type of organizational venture across the globe.
3. **Artificial Intelligence (AI).** Machine learning and AI technologies drive quantum acceleration in innovations, quality, and production, becoming an essential toolkit for all manufacturers.
4. **Individualized Human-machine interaction.** This is perhaps the most important distinction of Industry 5.0 – re-introducing the human element into processes and systems that have been automated to hyper-efficiency through information technologies. In one sense, the human element brings the soul back to manufacturing by enabling collaborative production – the imagination and flexibility of the human worker becomes empowered and advanced with the ability to harness collaborative robots (or cobots). The combination of smart machines and savvy humans will allow for true "mass personalization" and more nimble production.
5. **Bio-inspired technologies and smart materials.** There is no greater model of efficiency and sustainability than nature. Producers face limits of purely industrialized processes – particularly the extractive nature of certain industries, wasteful use of resources, and negative environmental impact remain challenges. Innovations in lighter, stronger, and more flexible materials, with an increased eye on being bio-friendly, promise a new generation of better products – for companies, customers, and the planet.
6. **Technologies for energy efficiency, renewables, storage, and autonomy.** The transition from fossil fuel-powered transportation to Electric Vehicles is accelerating. At the same time, wind and solar power adoption continue to grow due to the declining cost curves and economies of scale in battery production. Advances in autonomous technologies promise to enable new business models for transportation while improving safety and reducing pollution.

Realizing the updated vision for Industry 5.0 will require new economic priorities to measure industry performance, new structure and design of business models, value chains and supply chains, updated objectives for digital transformation, innovative approaches to policymaking that better align the interests with business and industry, new ways to drive innovation and research capabilities, while better aligning the interests of businesses with broader society, government, and environment.

> The lessons learned from the pandemic underscore the compelling need to build resilience across value chains, while securing jobs and economic security.

Part 5:
How to Get Ready for Industry 5.0

As we have discussed previously, the vision for Industry 5.0 builds upon the technological and business principles of Industry 4.0 with a focus on three ESG-like tenets: Human Centricity, Resilience, and Sustainability. With many businesses completely committed to adopting technology-enhanced processes and systems, it's an ideal time to look ahead to the next generation of innovation.

Industry 5.0 can be rightly seen as an evolution, incorporating foundational elements of Industry 4.0 into a more broadly encompassing vision that delivers a wider range of benefits to a broader set of stakeholders.

Multiple Forces are Driving Change

It's become axiomatic that change is a constant for firms across industries, and businesses need to plan how to ensure their value chains can weather disruptions and ensure that there is an ample, appropriately trained workforce sufficient to meet production, sales, and support demands.

The "great resignation" wave, in which employees are leaving their jobs at record rates, along with difficulties in filling open roles, underscores the value of talent management and particularly the need to attract and retain highly skilled workers. Increased trade protectionism, overwhelmed cargo chains along with shortages of key components and materials highlight the role of resilience. Greater focus on Environmental, Social, and Governance (ESG) factors from the investment community, regulatory emphasis on clean energy, and rising societal prioritization, are compelling organizations to articulate sustainable strategies.

> In short, multiple drivers are forcing forward-thinking firms to incorporate Industry 5.0 principles into their planning.

Positioning For the Future of Manufacturing

The World Manufacturing Forum has identified 10 critical skills that will be needed in future manufacturing, and what's important is that the mix of skills includes both digital and technology as well as cross-functional skills that relate to creativity, flexibility, and open-minded thinking.

Leaders, managers, and line workers will all need to adapt and upgrade their own skills and capabilities to meet Industry 5.0 demands:

Source: The World Manufacturing Forum - Adapted by Momenta

Aligning Priorities for Industry 5.0

The concepts and principles of Digital Transformation have been explored at length in recent years. Most executives have gained fluency in the capabilities of technology and Digital Business. Building upon these foundational ideas, it's prudent to focus on incorporating the principles of Human Centricity, Resilience, and Sustainability. The following are a few key concepts upon which to focus:

1. **Re-Orienting for Human Centricity:** There are several dimensions to advancing human-centric business. The first, and top priority, should be attracting and retaining talent. Particularly to technology-centered organizations, human capital is the most strategic asset and businesses will need to accommodate the growing cohort of Gen-Z and Millennials' changing needs. For younger generations of workers, the commitment to environmental and social factors becomes increasingly important in their choice of employer, and this may include a commitment to community initiatives, flex working arrangements, and the cultivation of historically underrepresented minorities in leadership roles.

   The human-centric vision also critically involves re-thinking how workers and machines collaborate. Traditionally static manufacturing processes can be updated with new collaborative robotics (co-bots) with line workers empowered to exercise greater flexibility in production. Worker safety and health can also be improved with advanced monitoring capabilities and ergonomic design. A healthy and happy workforce with opportunities for creative personal and professional advancement is likely to create lasting value for the business.

2. **Bolstering Resilience:** Recently, businesses have been forced to cope with increased uncertainties and adapt to cope with change. It's important for organizations to engage in planning exercises that account for potential disruptions across the value chain, from the factory floor to the supplier network, to transportation channels, to regulatory and geopolitical change. Digital technologies and methodologies (simulations and AI-enhanced modeling) can help identify optimal alternative paths in the event of disruption, weighing different factors such as cost, substitution, quality, and logistical concerns into the mix. Start with identifying the greatest points of vulnerability (whether in process or supply chain), isolate the key inputs, and then formulate contingency planning for any disruptions. It's better to have a plan and not need it than be caught unprepared.

3. **The Importance of Sustainability:** With the growing regulatory and investor emphasis on reducing carbon emissions and environmental impact, businesses need to evaluate their resource footprint. This may involve analyzing the source of raw materials, the proportion of waste generated, along with an evaluation of the environmental impact, the energy efficiency of processes, as well as the sources of energy. Many firms have committed to specific reductions of fossil fuels and clean energy generation sources. Additionally, the adoption of new materials and composites (away from petroleum-based for instance) can reduce environmental impact while increasing the practices of recycling and repurposing materials can also help to achieve objectives.

Beyond Better, Cheaper, and Faster

Preparing for Industry 5.0 is not inconsequential, but there are multiple forces arraying to compel businesses to adopt the core principles of human-centricity, resilience, and sustainability. It's far better to take the opportunity to prepare ahead of time, rather than react to an unanticipated shock to the system. Beyond better, cheaper, and faster, the technology-enhanced mantra **Industry 5.0 promises to lead the next generation into a balance of decisions that support smarter, cleaner, and more resilient industries.**