# X-HuLog4.0 team (2025). Human-Centricity in Industry 4.0 versus Industry 5.0: A Business Perspective

## INTRODUCTION

**Topicality -** Industry 4.0 is a technology-driven revolution in manufacturing, integrating advanced technologies (e.g. AI, IoT, robotics) to automate processes and enable data-driven decision-making (Passalacqua et al., 2024). This paradigm has significantly improved efficiency and connectivity on factory floors. However, early implementations often treated the **human element as secondary**, with automation sometimes aimed at **replacing human labour** rather than empowering it. Research indicates that many Industry 4.0 initiatives **neglected psychosocial and ergonomic factors**, leading to issues like worker stress and lower-than-expected performance gains (Passalacqua et al., 2024). Industry 4.0 concept being focused on technological innovation, lacks a clear framework to ensure technology genuinely served **human well-being**.

Recognizing this gap, thought leaders and policymakers began formulating **Industry 5.0** as a complementary vision to Industry 4.0. **Industry 5.0** shifts focus to **human-centric innovation**, aiming to **support and augment workers** rather than render them obsolete (de Sousa Jabbour et al., 2022). Importantly, this new phase doesn't abandon Industry 4.0's technologies; instead, it builds on them with an added emphasis on human values and sustainability (Grosse et al., 2023a). The European Commission formally introduced Industry 5.0 as a paradigm that frames industry as a driver not just of productivity, but of broader societal goals – emphasizing **sustainability, resilience, and human-centricity** alongside growth. In essence, Industry 5.0 is "a supplement to Industry 4.0" that improves upon its foundation by ensuring advanced technologies are developed and deployed in a **human-centered and sustainable way** (de Sousa Jabbour et al., 2022). Businesses now view this evolution as an opportunity: by balancing technological prowess with human-centric practices, they can achieve innovation that is both high-tech and highly inclusive.

## Defining "Human-Centric"

Because human-centricity is a broad concept, researchers have worked to define it clearly in the Industry 5.0 context. Hermawati et al. (2024) addressed the lack of a consistent definition by conducting a comprehensive review of the literature. The resulting definition characterizes **human-centricity in Industry 5.0 as designing industrial systems around human needs, capabilities, and well-being** (Breque et al., 2021). In essence, technology is viewed as a tool to **augment human work** – assisting decision-making, enhancing safety, and reducing drudgery – rather than a means to replace humans outright. This definition also implies a participatory approach to innovation: workers should have a voice in how new tech is implemented, ensuring it truly supports their tasks and development.

A human-centric Industry 5.0 factory might have **collaborative robots (cobots)** that work alongside operators, adaptive workstations that adjust to individual ergonomic needs, and AI decision-support systems designed with intuitive human-machine interfaces. The **work environment is engineered for user comfort and engagement**. For example, **job roles are reimagined** to be richer and more varied – a principle supported by Winkelhaus et al. (2021), who found that strategies like job enrichment, job rotation, and task expansion can significantly **enhance employee well-being in repetitive industrial tasks**. This insight aligns perfectly with Industry 5.0's ethos: by improving the quality of work life, companies can both boost productivity and ensure their workforce remains motivated and healthy.

## Industry 4.0: Tech-Driven Innovation and the Human Factor Gap

In Industry 4.0, factories became smarter and more connected. Automation and data integration enabled real-time analytics, predictive maintenance, and hyper-efficient production lines (Passalacqua et al., 2024). This tech-centric approach yielded significant productivity gains. For example, AI-driven systems could optimize workflows far faster than manual methods, and IoT sensors provided end-to-end visibility across supply chains. However, as companies raced to digitalize, many **underestimated the human factor**. Early studies of Industry 4.0 implementations pointed out a tendency to overlook workers' cognitive load, stress, and engagement. Neumann et al. (2021) emphasize that **psychosocial and perceptual aspects of work were often neglected** in the Industry 4.0 era. In practice, this meant operators were sometimes thrust into highly automated environments without sufficient consideration for ergonomics, mental workload, or job satisfaction.

## Industry 5.0: Embracing Human-Centric Innovation

**Industry 5.0** emerged as a response, introducing a more **balanced vision of progress**. Rather than focusing solely on automation and efficiency, Industry 5.0 places **human beings at the center of industrial innovation**. This paradigm shift has been described as a "socio-technical revolution that prioritises the well-being of humans in manufacturing systems" (Hermawati et al., 2024). In contrast to the purely technology-driven agenda of its predecessor, Industry 5.0 **explicitly values human creativity, expertise, and needs** as critical components of the production process. Grosse et al. (2023b) argue that a people-centric approach is **essential to ensure technology truly serves human well-being** and not the other way around. In practical terms, this means designing systems where operators collaborate with intelligent machines, and where digital tools are developed with user experience, safety, and satisfaction in mind.

### Comparing Industry 4.0 and Industry 5.0

The transition from Industry 4.0 to 5.0 represents a shift in priorities and approach. The following table provides a high-level comparison of key characteristics:

| Aspect | Industry 4.0 (Tech-Centric) | Industry 5.0 (Human-Centric) |
|---|---|---|
| **Primary Focus** | Automation and digitalization to drive efficiency and productivity (Passalacqua et al., 2024). Technology leads, humans adapt to new tools. | Augmentation and collaboration to drive innovation and well-being. Technology is developed to serve human needs and societal goals (Hermawati et al., 2024) (Grosse et al., 2023a). |
| **Role of Humans** | Often secondary – humans act as operators/monitors of automated systems. Some tasks aimed to be fully autonomous, minimizing human intervention (Passalacqua et al., 2024). | Central – humans are critical actors whose creativity and decision-making are enhanced by machines. Systems are designed around human strengths, and workers are empowered rather than replaced (de Sousa Jabbour et al., 2022) (Breque et al., 2021). |
| **Key Objectives** | Efficiency, throughput, and cost reduction through smart technology. Emphasis on data-driven optimization and connectivity (the **"smart factory"**) for competitive advantage. | Human-centricity, sustainability and resilience in addition to efficiency. Emphasis on long-term value: worker well-being, adaptability to change, and alignment with environmental and social objectives (the "sustainable, human-centric factory"). |
| **Technology Integration** | Implement cutting-edge tech (AI, IoT, robotics) in pursuit of automation. Tendency to implement tech for maximal performance, with humans adapting workflows to machines. | **Human–machine collaboration** is the norm. Technologies (e.g., cobots, AI assistants) are integrated in a way that complements human labour (Grosse et al., 2023b). System design considers ergonomics and user experience, ensuring tech adapts to humans as much as humans adapt to tech. |
| **Workforce Development** | Focus on technical skills training so employees can keep up with complex systems. Less emphasis on job redesign; roles may narrow as automation takes over routine tasks. | Focus on holistic development – technical **and** soft skills (creative thinking, problem-solving) for working alongside intelligent machines. Job roles are often enriched or redefined to be more engaging, reducing drudgery and improving job satisfaction (Koreis et al., 2025). Continuous learning and involvement in innovation are encouraged. |

### Key Differences Between Industry 4.0 and Industry 5.0

Integrating new technologies without a human-centered design led some employees to experience the change as "burdensome and stressful," ultimately impacting their well-being and performance. Grosse et al. (2023b) note that while advanced Industry 4.0 tools show **the lack of a people-centered approach** could minimise those gains in reality – a phenomenon sometimes termed "phantom profits," where expected productivity improvements are lost due to human-factor issues in implementation. In short, **Industry 4.0's tech-first strategy often failed to fully account for the people operating the technology**. This gap created a practical and strategic need for a new approach that puts humans back into the loop in a meaningful way.

Industry 5.0 is not a replacement for Industry 4.0 but an **evolution that addresses its limitations**. Castagnoli et al. (2024) describe Industry 5.0 as an "improved supplement" to the existing Industry 4.0 framework – one that **builds upon advanced digital tools while injecting a human-centric perspective** to make systems more adaptive and humane (de Sousa Jabbour et al., 2022). For businesses, this means leveraging the same technologies (AI, robotics, big data) but implementing them in ways that **empower employees, encourage collaboration between humans and machines, and create sustainable value**. Early adopters of Industry 5.0 strategies have reported benefits such as higher workforce engagement, more innovation on the factory floor (as employees are given freedom to apply their insight alongside AI recommendations), and stronger organizational agility in the face of change (Grosse et al., 2023a).

## Implications for Businesses and Leadership

Adopting a human-centric Industry 5.0 mindset has practical implications for business strategy and operations. First, **leadership and culture** must embrace the value of workers as key stakeholders in innovation. Companies may need to invest in change management and involve employees in the design of new workflows or the selection of new technologies. As Battini et al. (2020) suggested in early discussions, transitioning to a human-centric approach requires a deliberate shift in mindset – leveraging Industry 4.0 technologies **while simultaneously adopting human-centered goals** in system design. In practice, this could mean setting up cross-functional teams of engineers, operators, and ergonomists to co-create solutions. It also means measuring success not just by output metrics, but by human-centric KPIs like employee satisfaction, skill growth, and work-life balance.

Second, businesses should review and possibly **redesign job roles and processes** in the light of Industry 5.0 principles. An operations manager might ask: Which tasks can we automate to reduce worker strain, and how can we elevate the human role in tandem? For example, if a manufacturing line introduces an AI quality inspection system, the human inspectors could be upskilled to handle complex quality analytics or to focus on process improvements that the AI flags. This approach aligns with the findings of Winkelhaus et al. (2021) on job design – rather than displacing workers, automation is used to **make their work more meaningful and less physically overloaded**, which improves morale and performance. Companies like automotive manufacturers have already begun re-training assembly workers to work alongside collaborative robots, resulting in higher productivity and safer workplaces, a clear win-win.

From a technology investment standpoint, Industry 5.0 implies choosing solutions that **are flexible and user-friendly**. For instance, when implementing an autonomous logistics system in a warehouse, a human-centric strategy would favor a system that allows human override, provides intuitive feedback to workers, and even learns from operator input over time (a human-in-the-loop AI). This echoes the notion from Ivanov (2023) that viability comes from integrating resilience (human adaptability) into technology deployment. Businesses might pilot new tools with extensive user testing, ensuring the technology genuinely assists employees and is accepted by them. The result is often a smoother integration and faster realization of benefits, as workers cooperate with – rather than resist – the change.

Finally, **organizational resilience and sustainability** gain a boost under Industry 5.0. A human-centric operation is typically more agile, because empowered employees are better able to respond to unexpected issues (like supply chain disruptions or surges in demand) with creative problem-solving. Castagnoli et al. (2024) observe that by integrating the advanced tools of Industry 4.0 with a human touch, companies can develop systems that are not only efficient but also **robust and adaptable in the face of change**. Additionally, a focus on human well-being often correlates with attention to environmental well-being – for example, optimizing processes to be less wasteful and safer for workers goes hand in hand with reducing environmental impact. Many firms are finding that Industry 5.0's **people-first approach also drives sustainability**, because it encourages looking at production holistically, considering societal and ecological outcomes, not just immediate output.

## FINDINGS AND DISCUSSION

As shown in the key characteristics section, **Industry 4.0 vs. 5.0** is not about choosing technology or people – it's about recalibrating the relationship between them. Industry 5.0 retains the advanced tools that Industry 4.0 introduced but applies them in a more people-oriented and purpose-driven manner. For example, where an Industry 4.0 approach to a problem might be to automate a process entirely, an Industry 5.0 approach might deploy an assistive robot that works with a human operator to make the process faster and safer, while also redesigning the operator's role to be more rewarding. The result is a synergy: humans and machines each do what they do best. **Workers contribute flexibility, creativity, and oversight**, while machines handle heavy computation, precision, and repetitive tasks. This synergy can unlock higher levels of innovation and productivity than either humans or automation could achieve alone (Koreis et al., 2025). Moreover, by prioritizing factors like worker well-being and engagement, Industry 5.0 firms can reduce turnover, improve compliance with safety and labour standards and cultivate a positive brand image as sustainable and socially responsible businesses.

Another aspect of human-centricity is acknowledging and integrating the **psychosocial factors** of work. Under Industry 4.0, as noted, these were too often an afterthought. Industry 5.0 requires **designing systems that account for human psychology** – from reducing cognitive overload with better interfaces to providing social support through team-based workflows. Neumann et al. (2021) highlight that proper supervision, training, and co-worker support are important dimensions for operator well-being in high-tech environments (Thylén et al., 2023). A human-centric operation might therefore include robust training programs to upskill staff for new digital tools and a change management process that addresses worker concerns and stress. The end goal is an **empowered workforce** that feels in control of **technology on the factory floor, rather than feeling controlled by it. When humans are central to design, technology becomes an enabler of human potential** – leading to more innovative problem-solving and a safer, more satisfying workplace (Hermawati et al., 2024).

## CONCLUSIONS

Industry 5.0 represents a **strategic evolution** in how we view the role of technology and people in industry. Where Industry 4.0 brought unprecedented levels of automation and data intelligence, Industry 5.0 brings balance – ensuring that these advancements are harnessed in service of human progress. The shift toward human-centricity is backed by academic research and early industrial case studies showing that companies can achieve superior results by designing systems around people's strengths and needs (Hermawati et al., 2024). In practical terms, embracing Industry 5.0 means fostering workplaces where humans and machines collaborate seamlessly, innovation is inclusive of worker input, and success is measured in more than just output – it's also measured in enhanced **employee well-being, system resilience, and sustainable impact**.

Three core principles define Industry 5.0's value proposition: **human-centricity, sustainability, and resilience** (Breque et al., 2021). Human-centricity implies that any new technology or process should enhance human roles – for instance, by automating repetitive tasks to free up workers for more creative, fulfilling work – and support workers' mental and physical health on the job. Sustainability in Industry 5.0 extends the focus beyond profit, ensuring that industrial growth aligns with environmental and social well-being (e.g. greener processes, meaningful jobs). Resilience refers to building operations that can adapt and thrive amid disruptions, often by leveraging human flexibility and problem-solving alongside smart technology. Ivanov (2023) notes that integrating these three dimensions requires rethinking traditional operations management so that **efficiency, innovation, and human values co-exist by design** (Passalacqua et al., 2024).

For business leaders, the message is clear: **technology alone is not enough**. The next leap in productivity and innovation will come from integrating smart tech with human insight. Firms that proactively cultivate this human-centric approach stand to gain not only efficiency, but also a more agile, loyal, and creative workforce – a true competitive advantage in the modern economy. As Grosse et al. (2023b) posit, making industry truly "people-centered" ensures that progress in automation and AI genuinely translates into progress for organizations and society. In summary, Industry 5.0 is about "putting people back at the heart of industry" – a shift that promises to transform manufacturing from a purely efficiency-driven endeavour into one that is **innovative, sustainable, and rich human-centric**.

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