

Industry 5.0: A Human-Centric and Sustainable Approach to Industrial Development

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Abstract

Industry 5.0 is a new phase of industrial development that aims to enhance sustainability, resilience, and human well-being by integrating advanced technologies and human skills in manufacturing processes. This paper provides a comprehensive overview of the concept, characteristics, and challenges of Industry 5.0, and discusses its implications for industrial practice and policy. We review the literature on Industry 5.0 and its relation to the previous industrial revolutions, and identify the main drivers, enablers, and barriers for its implementation. We also analysed the potential benefits and risks of Industry 5.0 for the environment, society, and economy, and propose some recommendations for fostering a human-centric and sustainable industrial transition. We conclude that Industry 5.0 represents a promising opportunity for achieving the United Nations Sustainable Development Goals and enhancing the quality of life of industrial workers and consumers, but it also requires careful management and regulation to avoid negative impacts and ensure ethical and responsible use of technology.

Keywords: Human-centrism; Industry 4.0; Industry 5.0; Resilience; Smart supply chain management; Social sustainability.

1. Introduction

Industry 5.0 introduces the potential for sustainability improvements. By placing humans at the centre of manufacturing processes, it can lead to more responsible decision-making regarding environmental impact and social consequences. Human involvement in complex tasks can enable better judgment in ethical and sustainability-related issues. **Michael Rada (2015)** is founder of the concept industry 5.0. This is a systematic process of industrial up-cycling for prevention of wastage.

We can perceive this phenomenon as we witnessed during first phase of industrial revolution, where humans were ignored, and mechanisation was preferred. Later during human relation era of management, it was realised that humans have equal significance as machines in manufacturing process. Similarly, we observed that during the age of artificial intelligence under industrial revolution 4.0, human capabilities are being ignored thus we need to shift to industrial revolution 5.0 to make a perfect collaboration between human and machined (artificial intelligence).

However, transitioning to Industry 5.0 poses its own set of challenges. We should focus on designing systems that ensure the well-being of workers in this new environment, balancing automation with human needs. Moreover, the environmental impact of technological advancements should remain a central concern for the implementation in Industry 5.0. Where Industry 4.0 laid the groundwork for increased efficiency, Industry 5.0 envisions a future where technology complements human skills to drive sustainability. This transition, if managed responsibly, has the potential to align industrial progress with environmental and social goals.

The transition to Industry 5.0 presents challenges, including designing systems that prioritize employee welfare and balance automation with human needs. Moreover, sustainable supply chains, waste reduction, and energy-efficient technologies should remain focal points for the adoption of Industry 5.0.

2. Industrial revolutions

World has witnessed several types of revolution in the area of industrialisation. We have travelled a long journey from the steam engines to artificial intelligence. Industrial revolutions can be categorized in to following phases. (Berlanstein, 2003)

Industry 1.0: The First Industrial Revolution (Late 18th Century to Early 19th Century) includes Key Innovations of Steam engine, mechanization, textile industry advancements. Agrarian economies transited to industrial and manufacturing economies. Mass production in factories replaced manual labour.

Industry 2.0: The Second Industrial Revolution (Late 19th Century to Early 20th Century) witnessed electricity, internal combustion engine, steel production, telegraph. Further advancements were seen in manufacturing and transportation. The rise of mass production, expansion of railroads, and the beginning of the automotive industry.

Industry 3.0: The Third Industrial Revolution (Late 20th Century) introduced electronics, computers, automation, internet. The digital age began with the advent of computers and the internet. Automation in manufacturing processes and the rise of information technology led to increased productivity and globalization.

Industry 4.0: This revolution (Current Era) is observing Cyber-physical systems, IoT (Internet of Things), AI (Artificial Intelligence), big data, 3D printing. Combination of technologies with various areas of industry, creating more efficient factories and supply chains. Enhanced connectivity, data analytics, and automation enable more efficient and customized production.

Industry 5.0: The Fifth Industrial Revolution (Emerging Concept) expects Human-machine collaboration, advanced AI, decentralized manufacturing, sustainable practices. Industry 5.0 is seen as a continuation to forth phase of industrialisation but with a greater emphasis on human-machine collaboration. Its main objective is to harmonise technology and human workforces, combining the creativity, problem-solving abilities, and emotional intelligence of humans with the accuracy and efficiency of machines. Additionally, there's a focus on sustainability and environmentally friendly manufacturing processes.

The concept of fifth phase of industrialisation is still evolving, and its specific characteristics and impact may vary as technology continues to advance. Additionally, shifting from one industrial revolution to the next is not always linear, and elements of previous revolutions may coexist with newer technologies and practices in modern industries.

3. Literature Review

While Industry 4.0 ushered in advanced technologies for efficiency and productivity, Industry 5.0 emphasizes a more human-centric approach. This literature review explores the intersection of these transitions and their impact on sustainable business.

Industry 4.0, or the Fourth Industrial Revolution, has been characterised by the integration of digital technologies into manufacturing. Numerous studies have highlighted its impact on efficiency and productivity. Technologies such as IoT (Internet of Things; Cloud computing), AI (Artificial Intelligence), and automation have enabled real-time data analytics, predictive maintenance, and streamlined supply chains. This technological leap has led to reduced waste, improved resource utilisation, and energy efficiency (Porter & Heppelmann, 2015).

However, the rapid adoption of Industry 4.0 technologies has raised concerns regarding sustainability. Critics argue that the increased reliance on automation may lead to job displacement and exacerbate social inequalities (Brynjolfsson & McAfee, 2014). Furthermore, the environmental impact of increased digitization, including e-waste and energy consumption, must be carefully managed to ensure sustainable development (GeSI, 2019). Despite its efficiency gains, Industry 4.0 has raised concerns regarding sustainable business practices. The rapid automation of jobs and the unequal distribution of benefits have been noted as potential downsides. Additionally, the environmental footprint of increased digitization and electronics production must be addressed.

As Industry 4.0 matures, Industry 5.0 emerges as an evolving paradigm. Industry 5.0 seeks to address the limitations of full automation by emphasizing human-machine collaboration. This approach aims to enhance creativity, customization, and flexibility in manufacturing (Nahavandi., 2019). It acknowledges the importance of human skills and decision-making in complex and non-standardized tasks. As Industry 4.0 matures, Industry 5.0 emerges with a focus on human-machine collaboration. This paradigm shift acknowledges the role of human creativity, adaptability, and ethical decision-making in manufacturing. It represents a more sustainable business approach by promoting responsible production and job retention.

Industry 4.0, also known as the Fourth Industrial Revolution, saw the integration of digital technologies into production processes. Research indicates that these technologies have enhanced operational efficiency and reduced resource waste (Deloitte, 2017). IoT, AI, and automation have enabled predictive maintenance, minimized energy consumption, and optimised supply chains.

Bartłomiej (2023) discussed that study of divers of industry 4.0 can lead toward developing industry 5.0 in most practical manner. Erro-Garcés (2023) explained that human resource management practices (HRMP) are relevant to explain firms' profits. Human Resource practices and use of technology Therefore, human resource practices and technology are complementary resources to achieve higher results.

4. Industry 5.0 and sustainable business

In business sustainability means doing business without affecting business environment negatively. Sustainability generally addresses two main categories.

- Business and its impact on environment
- Business and its impact on society

Integration of human with machines may be helpful in achieving both the objectives. Sustainable business is not just side by side work to humans with the robots but it's a way of thinking. Many business leaders still perceive that ultimate goal of a business is profit maximisation. Such mentality may lead us towards corrupt ways of doing business. Industry 5.0 may provide us an opportunity to change this taking of doing the business. Since the first industrial revolution we are trying to active something which can contribute more to increase the productivity but not its time to take a pause and think about the environment and society.

It's clear that there is growing social and corporate pressure to address environmental issues and promote sustainability. The combination of human activity and advanced technology has indeed amplified the negative effects on our planet over the past century. Corporate responsibility is becoming a competitive advantage, driven by investor expectations and customer attitudes.

Regarding India's situation, the statistics highlight the urgent need to address issues of poverty and inequality alongside sustainability efforts. It is a right step to make corporate social responsibility mandatory, but integrating the three Ps (profit, people, and planet) into core business operations is a more comprehensive approach to creating positive change. It will require commitment from the government, financial markets, CEOs, civil society, and the media to influence both public opinion and policy in favour of sustainable practices.

A sustainable business model with backward and forward integration, aiming for zero emissions, zero waste, and zero discrimination, can help achieving major goals of industry 5.0. This target can efficiently be achieved by the use of information technology. Here's a brief overview of what each of these elements could entail:

4.1 Zero Emissions:

- Implement clean energy sources for operations.
- Optimise transportation and supply chain logistics to reduce carbon emissions.
- Invest in energy-efficient technologies and practices.
- Offset any remaining emissions through initiatives like reforestation or carbon credits.

4.2 Zero Waste:

- Reduce waste generation through product design and packaging.
- Implement recycling and composting programs.

- Collaborate with suppliers to minimise waste throughout the supply chain.
- Embrace a circular economy model by reusing and repurposing materials.

4.3 Zero Discrimination:

- Foster a diverse and inclusive workplace culture.
- Implement anti-discrimination policies and training.
- Promote gender and racial equality in leadership positions.
- Support equal opportunities for employees and suppliers.

4.4 Backward Integration:

- Consider owning or controlling the supply chain to ensure transparency and sustainability.
- Engage with suppliers who share your commitment to sustainability.
- Develop eco-friendly sourcing practices for materials and resources.

4.5 Forward Integration:

- Innovate and create products or services that promote sustainability.
- Educate consumers about the environmental and social benefits of offerings.
- Explore partnerships or distribution channels that align with sustainability goals.
- Consider end-of-life solutions for your products, such as recycling or take-back programs.

4.6 Information Technology:

- Use data analytics to monitor and optimise energy and resource consumption.
- Implement IoT (Internet of Things) devices to analyse emissions and waste in real time.
- Leverage AI and machine learning to improve sustainability practices.
- Transparency and Reporting
- Use blockchain or other technologies to provide transparency in supply chain.
- Regularly report on sustainability efforts and achievements.

Such a business model would require a holistic approach, strong leadership commitment, and ongoing measurement and reporting of progress. It aligns with the principles of a triple bottom line, focusing not only on profits but also on people and the planet, while striving for a more sustainable and equitable future. This transformation will take time and resources, but the long-term benefits include reduced environmental impact, a positive brand image, and increased competitiveness in a world where sustainability is becoming increasingly important to consumers and investors.

5. Conclusion

In conclusion, Industry 5.0 shows transition in our approach to sustainability along with efficient manufacturing. As we've journeyed through the various industrial revolutions, we've witnessed the evolution of technology, from steam engines to artificial intelligence. Each phase brought its own set of challenges and opportunities.

Industry 5.0 stands out by emphasising the crucial role of human-machine collaboration, bridging the gap between technology and human ingenuity. It recognises that sustainable progress requires a harmonious balance between automation and human judgment, particularly in complex and ethical decision-making.

While Industry 4.0 brought impressive gains in efficiency and productivity through digitalisation, it also raised concerns about job displacement and environmental impact. Industry 5.0 seeks to address these issues by focusing on responsible production, job retention, and sustainable business practices. It encourages us to rethink the purpose of business beyond mere profit maximisation, urging us to consider the well-being of the environment and society.

Sustainable business considering Industry 5.0 involves no emissions, no waste, no discrimination, smart supply chain management, and the strategic use of information technology. It requires concerted efforts from governments, businesses, and society as a whole. It involves a commitment to transparency, accountability, and continuous improvement. By embracing Industry 5.0's vision of sustainable collaboration between humans and machines, we can aim for a more equitable, environmentally friendly, and prosperous future for all.

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