Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 14th International Scientific and Practical Conference. Volume 2, 46-49

From Industry 4.0 Paradigm Towards Industry 5.0

Zofia Gródek-Szostak
College of Management and Quality Sciences
Cracow University of Economics
Cracow, Poland
grodekz@uek.krakow.pl

Luis Ochoa Siguencia
Faculty of Sport and Tourism management
Academy of Physical Education in Katowice
Katowice, Poland
l.ochoa@awf.katowice.pl

Agata Niemczyk
College of Management and Quality Sciences
Cracow University of Economics
Cracow, Poland
niemczya@uek.krakow.pl

Anna Szeląg-Sikora
University of Agriculture in Krakow
Faculty of Production and Power Engineering
Cracow, Poland
anna.szelag-sikora@urk.edu.pl

Abstract. **In 2021. European Commission formally called for a fifth industrial revolution (Industry 5.0). Discussions by participants from all over Europe in two virtual workshops organised by Directorate "Prosperity" of Directorate-General for Research and Innovation on 2 and 9 July 2020 resulted in the document "Industry 5.0: Towards a Sustainable, Human-centric, and Resilient European Industry" issued on 4 January 2021.**
Industry 5.0 recognises the power of industry to achieve societal goals beyond job creation and growth to become a resilient provider of well-being, making production respect the limits of the planet and placing the well-being of industrial workers at the centre of the production process. Industry 5.0 complements the existing Industry 4.0 paradigm as research and innovation drives the transition to a sustainable, human-centred and resilient European industry. Given that technological advances are changing the way value is created, exchanged and distributed, there is an urgent need to design these technologies to support future societal values. The emergence of these changes and the questions closely linked to technological innovation require industry to rethink its position and role in society.
The purpose of this article is to analyse the assumptions of Industry 5.0 and compare them with the Industry 4.0 paradigm.

Keywords: Industry 5.0, Industry 4.0, management, development.

I. INTRODUCTION

The Industrial Revolution can be defined as the transformation of traditional industrial practices into new techniques dominated by the technologies available at the time. The first three industrial revolutions were driven by mechanisation, electrification and automation respectively, which gradually transformed the agricultural economy into a manufacturing-based economy [1]. This helped to improve the lifestyles of factory workers and the health care system, which improved the overall quality of life. Industries that have adapted to the changes have seen increased production, improved competitive advantages and cross-border business opportunities. While we are now living in a time when the fourth industrial revolution (also known as Industry 4.0) is unfolding all around us, the world is ready for the next big leap, the fifth industrial revolution or Industry 5.0. [2].

Innovations in technology are transforming both traditional products and business procedures. The digital revolution is transforming technology into a digital format. Industry 4.0 is a combination of physical assets and advanced technologies such as artificial intelligence, IoT, robots, 3D printing, cloud computing, etc. Organisations that have embraced 4.0 are flexible and prepared to make data-driven decisions [3]. Industry 5.0 is the upcoming previous generation technology for efficient and intelligent machines. The purpose of this paper is to analyse the assumptions of Industry 5.0 and compare it with the Industry

Print ISSN 1691-5402
Online ISSN 2256-070X
https://doi.org/10.17770/etr2023vol2.7192

4.0 paradigm. The paper is theoretical and conceptual in nature, and typical research methods for this type of study were used: critical literature analysis, document analysis, logical operations.

II. INDUSTRY 4.0 OR ALREADY 5.0 - PILLARS OF THE CONCEPTUAL APPROACH

The ongoing fourth industrial revolution, commonly referred to as Industry 4.0 or 4IR, is evolutionarily based on the third industrial revolution, which relied on transistors, sensors and microelectronics to generate data. The term Industry 4.0 was first used by German professor Wolfgang Wahlster in 2011 at the Hannover Fair [4], [5], [6]. The term encompasses the computerisation of production, in which advanced digital technologies are combined with industrial machines and processes. The interconnection of these technologies with the production setup aims to achieve operational efficiency, productivity and automation to the highest possible degree [7], [8]. This in turn creates a manufacturing ecosystem that is smart, connected and data-driven.

The basic model of Industry 4.0 can be broken down into digital or computing technologies that are connected to the systems of the physical world. While artificial intelligence, machine learning, big data, cloud computing and cyber security are part of the core computing technologies, other technologies such as automation and robotics, IoT, CPS and AM are part of the physical. Together, these technologies realise the benefits of Industry 4.0 systems, enabling the agile, flexible, on-demand manufacturing that is an essential part of smart manufacturing or smart factories. While there are tremendous benefits for industry in implementing these technologies to achieve competitive advantage and higher operational efficiency [9], [10], [11].

While the world of science and practice is still trying to adapt and exploit the potential of Industry 4.0, policy makers, industrialists and scholars have started to discuss the next industrial revolution - Industry 5.0 [12], [13]. If Industry 4.0 is about digitally connecting machines to enable a seamless flow of data and the highest possible optimisation, Industry 5.0 is considered to, as it were, 'bring people back into the game' for collaboration and bring people into manufactured products, while focusing on such an important aspect as sustainable production [14], [15], [16].

Rather than treating technology as a key element, the European Commission [17] sees three key factors as being at the heart of the new Industry 5.0 industrial paradigm:

1. A human-centred approach that places human needs at the centre of the production process, asking what technology can do for workers and how it can be useful.
2. Sustainability, which focuses on reusing, repurposing and recycling natural resources and reducing waste and environmental impact.
3. Resilience, which means bringing robustness to industrial production. This robustness provides support through flexible processes and resilient production capacity, especially in the event of a crisis.

In the European Commission's view, Industry 5.0 is a necessary evolutionary step of Industry 4.0 due to [18], [19]:

1. Industry 4.0 is not the right framework to achieve Europe's 2030 goals, because the current digital economy is a winner-take-all model, creating a technological monopoly and gigantic wealth inequality.
2. Industry 5.0 is not a technological leap forward, but a way of looking at the Industry 4.0 approach in a broader context, providing a regenerative purpose and focus for the technological transformation of industrial production for the benefit of people, planet and prosperity.
3. Industry 5.0 is a transformational model that reflects the evolution of our thinking after the COVID-19 pandemic, taking into account the lessons from the pandemic and the need to design an industrial system that is inherently more resilient to future shocks and truly integrates social and environmental principles.

In early 2022. European Commission took a stance against Industry 4.0, arguing that this paradigm cannot be considered an appropriate framework for dealing with the prevailing climate crisis and social tensions [18]. According to the position presented, Industry 5.0 represents a new vision for the industry, redefining the role and functionality of value chains, business models and digital transformation in a hyper-connected business environment. As demonstrated in studies [20], [21], [22], Industry 5.0 differs from Industry 4.0 in the following ways:

- Industry 5.0 values both performance-based competitiveness and sustainability;
- Industry 5.0 strengthens the human workforce by promoting a human-centred approach to technological development;
- Industry 5.0 develops technological innovations (such as smart renewable systems) in the field of environmental sustainability;
- Industry 5.0 promotes stakeholder primacy in technology management, innovation growth and sustainable performance management;
- Industry 5.0 refers to certain technologies and functional principles to extend the scope of corporate responsibility along the entire value chain.

There is a consensus in the literature that Industry 5.0 differs from previous industrial revolutions because it represents a stakeholder-driven socio-technological phenomenon that systematically shifts classic profit- and consumption-driven economic models to a circular economy, sustainability and sustainable development and economic value-creating models.

III. SUSTAINABLE INDUSTRIAL DEVELOPMENT FUNCTION 5.0

Industry 5.0 relies on the most disruptive technological innovations to achieve its core objectives of human-centredness, resilience and sustainability [23]. Among other things, Agenda 21 adopts Principle 1, stating that humans are agents of sustainable development and have the right to live healthy and productive lives in harmony with nature [24]. This transformation is intended to promote the development of society, influence the reduction of climate change and environmental degradation and thus improve the quality of life for present and future generations. In the Industry 5.0 concept, the human factor regains its rightful place at the centre of the production process. According to this approach, it is technology that should serve man, not the other way around, and the aim should therefore be to ensure full cooperation between humans and machines [15]. Industry 5.0 complements the existing Industry 4.0 paradigm, as research and innovation drive the transition to a sustainable, human-centred and resilient European industry [25]. The European Economic and Social Committee's Consultative Commission on Transition [26] identified the key challenges of Industry 5.0 at a conference on 22.11.2018. Human-robot collaboration is a marker of the new economy, where the role of humans is changing, as there will be jobs operated autonomously by robots. The challenge will be the social and ethical risks associated with the new industrial revolution, in which humans will increasingly be replaced by machines to create society 5.0. Society 5.0 is a new social model with humans at its centre. Humans are the creators of content and analyse networked data, but they cannot share knowledge and information effectively without digitalisation and automation [27], [28], [29]. Therefore, there is a need for infrastructure and information systems connected to people in cyberspace and artificial intelligence to process data and generate results into virtual space. The new generation of development is a super intelligent society, based on data and knowledge. Such a human development trend is linked to smart manufacturing systems and social infrastructure [15].

IV. CONCLUSIONS

The notion of Industry 5.0 complementing and extending the distinctive features of Industry 4.0 suggests that they should be considered alongside each other, i.e. the coexistence of technology-based Industry 4.0 and value-based Industry 5.0. The growth and development model of Industry 5.0 is based on three fundamental pillars: Ecology-Human-Resilience. Industry 5.0 will benefit workers, entrepreneurs and the environment. Changing the current approach will not only increase production efficiency, but also make more rational use of available natural resources and provide better working conditions.

Acknowledgements: This publication was financed by a subsidy granted to the Cracow University of Economics (057/ZZE/2022/POT). The desk research was carried out withing the ERASMUS+ project “Empower adult educators to support digital social inclusion 2022-1-PL01-KA220-ADU-000088404” in collaboration with researchers of Cracow University of Economics, University of Agriculture in Krakow and Academy of Physical Education in Katowice.

REFERENCES

[1] A. Raja Santhi, P. Muthuswamy. Industry 5.0 or industry 4.0S? An introduction to industry 4.0 and a peek into the prospective industry 5.0 technologies. Int J Interact Des Manuf, 2023. https://doi.org/10.1007/s12008-023-01217-8

[2] M. Breque, L. De Nul., Petridis A. Industry 5.0: towards a sustainable, human-centric and resilient European industry, European Commission, Directorate-General for Research and Innovation, 2021, Luxembourg, LU.

[3] L.A. Leone, S. Fleischhacker, B. Anderson-Steeves, K. Harpe, M. Winkler, E. Racin, B. Baquero, J. Gittelsohn. Healthy food retail during the COVID-19 pandemic: challenges and future directions. Int J Environ Res Public Health 17(20), 7397, 2020.

[4] P. Kowalikova, P. Polak, R. Rakowski. The Challenges of Defining the Term "Industry 4.0". Soc 57, 631-636, 2020. https://doi.org/10.1007/s12115-020-00555-7

[5] J.Ch. Bartodziej. The concept industry 4.0. New York: Springer Berlin, 2016, Heidelberg.

[6] L. Floridi. The 4th revolution: how the infosphere is reshaping human reality. Oxford, 2014, Oxford University Press.

[7] A. Sigov, L. Ratkin, L.A. Ivanov, et al. Emerging Enabling Technologies for Industry 4.0 and Beyond. Inf Syst Front 2022. https://doi.org/10.1007/s10796-021-10213-w

[8] D. Merayo, A. Rodriguez-Prieto, A.M. Camacho, A. Comparative analysis of artificial intelligence techniques for material selection applied to manufacturing in industry 4.0. Procedia Manufacturing, 41, 42-49, 2019.

[9] M. Sony. Pros and cons of implementing Industry 4.0 for the organizations: a review and synthesis of evidence, Production & Manufacturing Research, 8 (1), 244-272, 2020 https://doi.org/10.1080/21693277.2020.1781705.

[10] M. Elnadi, Y.O. Abdallah Industry 4.0: critical investigations and synthesis of key findings. Manag Rev Q 2023. https://doi.org/10.1007/s11301-022-00314-4

[11] K-D. Thoben, S.A. Wiesner, T. Wuest. 'Industrie 4.0' and smart manufacturing-a review of research issues and application examples. Int J Autom Technol 11(1), 4-16, 2017 https://doi.org/10.20965/ijat.2017.p0004

[12] M. Breque (2021). From Industry 4.0 to 5.0 (online only) - Benelux Section Chapter, TEM14 on 06-April-2021. https://www.ieee.be/?q=node/211

[13] K.A. Demir, G. Döven, B. Sezen. Industry 5.0 and Human-Robot co-working. Procedia Comput. Sci. 158, 688-695, 2019. https://doi.org/10.1016/j.procs.2019.09.104

[14] Z. Gródek-Szostak, L. Ochoa Siguencia, A. Szeląg-Sikora, G. Marzano. The Impact of Industry 4.0 on the Labor Market. 61st International Scientific Conference on Information Technology and Management Science of Riga Technical University (ITMS) / edited by Janis Grabis, Andrejs Romanovs, Galina Kulesova - Riga: Institute of Electrical and Electronics Engineers (IEEE), 1-5, 2020 http://dx.doi.org/10.1109/ITMS51158.2020.9259295.

[15] J. Adamczyk, Z. Gródek-Szostak. Challenges of industry 5.0 in the context of sustainable development implementation. In Managing organisations in the information society : strategies, projects, processes. (Eds.) P. Cabała, J. Walas-Trębacz, T. Małkus, Toruń: Towarzystwo Naukowe Organizacji i Kierownictwa. House of Organizers, 399-409, 2022.

[16] Z. Gródek-Szostak, A. Niemczyk, M. Niewiadomski, P. Zamora. Regional determinants of the implementation of Industry 4.0 in the SME sector - study of the Małopolskie voivodeship.

[17] M. Sommer, J. Stjepandic, S. Stobrawa, M. von Soden. Improvement of Factory Planning by Automated Generation of a Digital Twin. In Proceedings of the Advances in Transdisciplinary Engineering; IOS Press: Amsterdam, The Netherlands, 12, 453-462, 2020.

[18] A. Renda, S. Schwaag Serger, D. Tataj. Industry 5.0, A Transformative Vision for Europe: Governing Systemic Transformations towards a Sustainable Industry; Publications Office of the European Union: Luxemburg, 2022.

[19] M.C. Zizic, M. Mladineo, N. Gjeldum, L. Celent. From Industry 4.0 towards Industry 5.0: A Review and Analysis of Paradigm Shift for the People, Organization and Technology. Energies. 2022; 15(14), 5221. https://doi.org/10.3390/en15145221

[20] M. Ghobakhloo, M. Iranmanesh, M. Faraz Mubarak, M. Mubarik, A. Rejeb, M. Nilashi. Identifying industry 5.0 contributions to sustainable development: A strategy roadmap for delivering sustainability values. Sustainable Production and Consumption, 33, 716-737, 2022, https://doi.org/10.1016/j.spc.2022.08.003

[21] S. Grabowska, S. Saniuk, B. Gajdzik. Industry 5.0: improving humanization and sustainability of Industry 4.0. Scientometrics 127, 3117-3144, 2022. https://doi.org/10.1007/s11192-022-04370-1.

[22] P. Kumar Reddy Maddikunta, Q-V. Pham, B. Prabadevi, N. Deepa, K. Dev, T. Reddy Gadekallu, R. Ruby, M. Liyanage Industry 5.0: A survey on enabling technologies and potential applications. Journal of Industrial Information Integration, 26, 100257, 2022, https://doi.org/10.1016/j.jii.2021.100257

[23] P. Johri, J.N. Singh, A. Sharma, D. Rastogi. Sustainability of coexistence of humans and machines: an evolution of industry 5.0 from industry 4.0. Paper Presented at the 10th International Conference on System Modeling and Advancement in Research Trends, SMART 2021 (2021).

[24] UN (2015). Agenda for sustainable development. https://sdgs.un.org/goals accessed 27.04.2022

[25] M. Breque, L. De Nul, A. Petridis. Industry 5.0: towards a sustainable, human-centric and resilient European industry, European Commission, Directorate-General for Research and Innovation, Luxembourg, 2021, LU.

[26] European Economic and Social Committee (2018). Industry 5.0 will bring with it a new paradigm of human-machine collaboration. https://www.eesc.europa.eu/pl/news-media/eesc-info/012019/articles/66151 accessed 27.04.2022

[27] DIGIN. Empower adult educators to support digital social inclusion. 2023. Retrieved April 19, 2023, from https://inbie.pl/digin

[28] R. Ochoa-Dąderska, G. Ochoa-Dąderska, J. Sánchez García, L. Callarisa-Fiol, Z. Navikiene, J. Navikaite, D. Metina, Z. Gródek-Szostak, A. Niemczyk, A. Szeląg-Sikora, A. Checińska-Kopiec, L.Ochoa Siguencia. Professional use of ICT - based solutions for social Integration: DigIN report I,2023. This desk research was carried out within the ERASMUS+ Cooperation partnerships in adult education, Empower Adult Educators to Support Digital Social Inclusion [DigIN], Project number 2022-1-PL01-KA220-ADU-000088404, coordinated by Instytut Badan I Innowacji w Edukacji – Poland. https://zenodo.org/record/7662148#.ZEDZuHZBy3C

[29] J. Sanchez Garcia, L. Ochoa Siguencia, R. Ochoa-Daderska, A. Chęcińska Kopiec, A. Szeląg-Sikora, E. Velinov, J. Sikora, M. Niemiec, Y. Nur Akarçay, Z. Gródek-Szostak. Adult Social Inclusion in a Digital Environment : Digital Needs for Social Services. Report 2. Częstochowa: Research and Innovation in Education Institute, 2020. http://dx.doi.org/10.5281/zenodo.3944800