Industry 5.0 Community of Practice (CoP 5.0)

Pilot phase, Nov. 2023 – Oct. 2024

Draft final report

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Acknowledgements

Executive Summary

The concept of Industry 5.0 elevates the role of industry from merely driving economic growth to becoming a key contributor to societal well-being and environmental sustainability. It envisions an industrial future that balances technological advancement with human-centric values, emphasizing the importance of resilience, sustainability, and the well-being of workers. By fostering an industry that is adaptable, inclusive, and aligned with the broader needs of society, Industry 5.0 seeks to transform traditional business models and redefine the value that industry delivers to all stakeholders.

Recognizing the need for continuous innovation to maintain global competitiveness, the European Commission has taken concrete steps to promote Industry 5.0 and create a platform for stakeholders and Industry 5.0 pioneers to share good practice and co-create initiatives to support Industry 5.0 implementation.

This report presents an analysis of the work conducted by CoP 5.0 members during the pilot phase, detailing the collaborative efforts to define Industry 5.0 and develop the necessary tools for its implementation. Chapter 1 delves into the transformative agenda for industrial R&I, while Chapter 2 outlines the creation of the Industry 5.0 Learning and Assessment Tool. Chapter 3 proposes a future agenda for further development of CoP 5.0.

Through a co-creative methodology, the CoP 5.0 pilot aimed to harness the collective expertise of stakeholders across Europe to support the practical implementation and acceleration of Industry 5.0. This initiative contributes significantly to building the business case for Industry 5.0, positioning it as a vital component of the sustainable competitiveness of European industry as defined in the report on the Future of EU competitiveness published by the former ECB President M. Draghi on 9 September 2024.

Introduction

Industry 5.0 recognizes the power of industry to achieve societal goals beyond jobs and growth, to become a resilient provider of prosperity, by making production respect the boundaries of our planet and placing the wellbeing of the industry worker at the centre of the production process. Since the first industrial revolution, industry has been an engine for European prosperity. Through its various historical stages, industrial development has had a tremendous impact on European society, perhaps more so than any domain of human effort. However, European industry continuously needs to innovate to stay competitive.

Industry 5.0 is the vision of a future-proof industry, which leads actions on sustainability and resilience and which is agile with flexible and adaptable technologies. An industry, which achieves sustainability, resilience and long-term competitive advantage by investing in skills, which promotes talents, diversity and empowerment. It is in line with the future of EU competitiveness outlined by the former ECB President M. Draghi ([1]). It moves focus from solely shareholder value to stakeholder value, for all concerned.

Industry 5.0 builds on Industry 4.0 framework and provides a holistic approach to green and digital transition-driven challenges. ([2]) As the economist Carlota Perez explains, "technological revolutions are not merely about material technologies: crucially, they are a process of organisational, social and institutional change" ([3])*. The way societal, organisational and institutional changes are shaped in combination with the technological changes, while taking into account environmental, geopolitical and economic constraints is crucial in deciding the success of the transformation.

In 2022, the European Commission expert group on the economic and societal impact of R&I (ESIR) issued a policy brief "Industry 5.0 – a transformative vision for Europe"([4]), outlining a transformative vision and description of the framework conditions necessary for Industry 5.0 implementation. It recommended a series of actions aimed at the transformation of business models for industry, and the development of Industry 5.0

([1])   [EU competitiveness: Looking ahead - European Commission (europa.eu)](#)

([2])   More information on Industry 4.0: www.plattform-i40.de

([3])   Perez, 2023: Learning From History: Succeeding In The Digital Age, in [Oeij et al (eds), 2023: The Practical Side Of Digital Transformation: A Tool Book For Practitioners,](#) Horizon 2020 BEYOND 4.0 project deliverable.

([4])   [Industry 5.0, a transformative vision for Europe - European Commission (europa.eu)](#)

metrics and indicators. The recommendations provided the backdrop for the high-level roundtable on Industry 5.0 with leading industries and key stakeholders.

Industry 5.0 is charted as part of the strategic areas of intervention related to meeting environmental, economic and societal challenges in Europe by 2050 ([5]). It emphasises the industry's role in offering good jobs and contributing to wellbeing as one of the key levers towards a new social contract that can maintain democracies thriving during sustainability transitions.

The targeted 2021-2022 awareness-raising at EU level included as well a first Industry of the Future Award during the 2022 R&I Days edition celebrating EU-funded projects that support Industry 5.0.

In addition to Horizon Europe and various other EU programs, Industry 5.0 initiatives are beginning to surface at various levels, laying the groundwork for the Industry 5.0 implementation.

The emerging Industry 5.0 ecosystem necessitated a platform for exchanging best practices, fostering new collaborations, and facilitating mutual learning.

In November 2023, the European Commission launched a pilot phase of Industry 5.0 Community of Practice (CoP 5.0). CoP 5.0 has attracted more than 100 stakeholders from various sectors across Europe. It serves as a platform for sharing best practices, co-creating implementation actions, fostering collaborations and helping industrial stakeholders to adapt organizational models to the ongoing green and digital transition. It draws on experience and insights which are needed to outline future direction for the EU level to adopt these approaches.

The CoP 5.0 pilot phase (November 2023 to October 2024) has zoomed in at both, horizontal/ecosystem and company levels. It streamlined its work around two objectives: a) defining challenges and drivers of Industry 5.0 as a transformative agenda for industrial R&I in the context of ongoing twin (green and digital) transition; and b) co-development of Industry 5.0 learning and assessment tool helping organisations, and in particular companies, to better understand interlinkages between the three pillars of human-centricity, sustainability and resilience and provide inspiration for transforming their organisational models during the process of ongoing twin (green and digital) transition.

([5]) Matti, C., Jensen, K., Bontoux, L., Goran, P., Pistocchi, A. and Salvi, M., Towards a fair and sustainable Europe 2050: Social and economic choices in sustainability transitions, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/804844, JRC133716.

This report analyses the co-creative work conducted by CoP 5.0 Members during the pilot phase on defining Industry 5.0 as a Transformative Agenda for Industrial R&I (chapter 1) and on co-developing the prototype Industry 5.0 Learning and Assessment Tool (chapter 2). It also indicates a possible agenda for further CoP 5.0 development (chapter 3).

 CoP 5.0 pilot has been based on co-creative methodology, in order to capture expertise and profound knowledge of a broad range of European Innovation Ecosystem stakeholders. The key objective of CoP 5.0 pilot has been to co-create actions with stakeholders to support implementation and acceleration of Industry 5.0 in practice at local, regional, ecosystem and EU level. It contributes to building Industry 5.0 business case as an important component of the sustainable competitiveness of European industry.

Chapter 1: Industry 5.0 as a Transformative Agenda for Industrial R&I

Research and Innovation is a key driver for strengthening the global competitiveness of European industry and for promoting a systemic industrial transformation across the European economy. Industry 5.0 is a vision capturing the interdependent changes in economic, technological, and institutional/organisational practices. The Community of Practice members emphasise the urgent need for Industry 5.0 action. The competitiveness pressure of adopting digital technologies coupled with ongoing ecological, demographic and globalization trends are currently felt across industrial ecosystems in Europe, transforming the nature of work, value chains, or the organizational dimensions of businesses and industries. The Industry 5.0 credo is that industry can take a leading role in steering the use of new technologies, in developing new products and services and in offering employment towards more human-centric, resilient and sustainable scenarios, while maintaining competitiveness.

CoP 5.0 discussions confirmed **an important role of Industry 5.0 in building a transformative agenda for industrial R&I.** In Europe, 50 % of productivity levels are explained by human capital ([6]). Related challenges such as a rapidly ageing workforce, difficulty in attracting new talent or in retaining them due to insufficient growth opportunities, and the need to close the skills gap and further innovate to stay competitive are adding pressures to industrial competitiveness. ([7]) CoP 5.0 members engaged in a series of workshops to identify new ways to foster Industry 5.0 driven innovations and provide alternative routes to competitiveness, human-centricity, resilience and sustainability for industrial ecosystems.

Digital transformation is an important component of an ongoing twin (green and digital) transition but to contribute to sustainable competitiveness - **complex approaches and system thinking** are needed in transformation processes. This means focusing on building the skills, organisational capabilities, information flows and operational models

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([6])   European Commission, Directorate-General for Research and Innovation, *Science, research and innovation performance of the EU 2022 – Building a sustainable future in uncertain times*, Publications Office of the European Union, 2022, **https://data.europa.eu/doi/10.2777/78826**

([7])   See also more details and thorough analysis of the challenges in the Draghi Report, EU competitiveness: Looking ahead - European Commission (europa.eu)

that go hand-in-hand with the technological transformation of industry, to achieve Industry 5.0 goals.

At the moment, a large share of production facilities in the EU are "legacy factories" based on purchasing low- to medium complexity technologies and deploying outdated and disempowering approaches to work organization, as acknowledged by CoP 5.0 participants. The legacy approach is a key challenge for innovation and industrial transition. To tackle this challenge and prepare industrial ecosystems for post twin-transition era, it is important to create the demand for complex technologies, organisational and social innovations.

This narrative is also in line with the April 2024 OECD Agenda for Transformative Science, Technology and Innovation [8], which outlines three goals for science, technology and innovation to pursue, including i) sustainability transitions, ii) inclusive socio-economic renewal and iii) resilience and security.

The **key drivers for transformative innovation in industry** were identified based on a methodology taking into account systemic challenges in the existing industrial ecosystems (e.g. paradigms, structures, design principles, networks or information flows) [9] when adopting principles of human-centricity, resilience and sustainability. Based on this approach, discussions with the CoP 5.0 members revealed the following important **actions towards scaling-up Industry 5.0, which would be part of a transformative innovation policy agenda:**

1. **Fostering new innovation to support Industry 5.0 goals:**

- **Responsible design practices**: Include in the transformation process research and technology design approaches that are human-centric and end-user driven, but also take into account nature-based, bio-inspired and / or sustainable design principles.

- **Investing in Industry 5.0 innovations & skills:** building the I5.0 skills, prototyping of new value chains, organisational and enterprise models, and production system innovations for competitiveness and shared value creation towards Industry 5.0 goals. Such innovations may include open source manufacturing, workplace innovation, commons-based production, manufacturing as a service etc., in response to evolving market demand and the polycrisis (e. g. pressures of scarce resources (energy, materials) and international competition, climate adaptation and

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nature preservation, geopolitical pressures, ageing societies and changing societal values).

2. **Measures to enable the scaling up of Industry 5.0 innovations:**

- **Accelerating learning** in organisations and ecosystems to strengthen organisational learning capacity and evolution of industry and stakeholders' readiness towards Industry 5.0, as prerequisite for post twin transition preparedness.

- **Open social innovation** support activities to foster institutional, social and organisational innovations, as well as adoption of new production paradigms.

- **Anticipatory innovation capacity, improved KPIs and digital infrastructures** for Industry 5.0 progress**,** for dynamic capturing of industry intelligence and more tailored service provision to better support the measurement of Industry 5.0 goals and contribute to building Industry 5.0 business case. **Improved incentives for Industry 5.0 uptake** are also needed, including fostering enterprise models beyond shareholder-driven ones, given evidence that cooperatives, steward-ownership enterprises, family-owned or worker-owned enterprises are providing better incentives for worker productivity, well-being and autonomy ([10]).

Good practice: Mondragon Corporation
The Mondragon Corporation takes a cooperative model, developed in 1956, embedding into the firm mission to also contribute to improving the quality of life in the areas where the subsidiary firms are concentrated. The members are both the owners and the workers in their firms, and the firms have a deep commitment to their host communities. More information: Link: MONDRAGON

The following sub-sections detail the suggested actions and policy orientations towards scaling-up Industry 5.0 provided by the Working Group on Thematic Analysis and propose options for the next steps of CoP 5.0.

([10]) See Bartl M., Claasen R., 2023, Industrial Policy for a Sustainable European Economy: Toward Ownership that Works for People - Transformative Private Law

1.1. Fostering Industry 5.0 innovation

Industry 5.0 can contribute to sustainable competitiveness of the European industry by introducing (currently missing) complexity approach inspired by systems thinking. Bringing new angles in the design of technologies, products, services and industrial organization, production systems and value chains would contribute to a better understanding of the full complexity and interdisciplinarity of industrial decisions within the wider perspective of an ongoing twin (green and digital) transition. Factors such as expected market demand and customer preferences evolution, demographics and skills, international competition, environmental pressures, societal values, geopolitical factors, regulatory changes etc. require embedding systems thinking in design and decision-making processes.

Discussions in the CoP 5.0 confirmed the important role of technology governance, including embedding design principles for human-centricity that can enable the development of technologies as means to augment human creativity, production and learning capacity.

Responsible and ethical technology design practices and innovations should also incorporate more biomimetic approaches, ensuring technology development aligns with natural processes and sustainability, and contributes to nature, rather than depletes the environment of resources. There is a need to put emphasis on the concept of human-being and organisations as part of nature rather than disconnected from it.

More focus on participatory processes in design and adoption of technologies can contribute to the mainstreaming of new design principles (see the example of FORGING project below). The ERA Industrial Technologies Roadmap on Human-Centric Research & Innovation ([11]) also recommends the need to broaden the scope of human-centric design processes, towards incorporating more systemic approaches, which take into account other aspects influencing technology design and implementation, such as environmental considerations.

> *Good practice: FORGING Academia-Industry Forum for Emerging Enabling Technologies in Support to the Digital and Green Transitions through Value Sensitive Innovations*

FORGING is a Horizon Europe funded project that is highly participative as it is developing a new methodology of value-sensitive innovation journey that is human-centric in alignment with the Industry 5.0 concept.

The processes of technology uncovering, the societal futures scenarios co-creation, the co-creation of use cases and the co-creation of the technology pathways are crucial contributors to the FORGING TOOLBOX, which aims to guide R&D projects in industry and academia and consequently the funding agencies in their decision-making, making them attentive to the societal and environmental (sometimes unintended) impacts that the technologies may have.

The core focus of FORGING is on social and environmental sustainability of innovations throughout the different stages of the innovation journey.

More information: https://forging-hub.eu/

Fostering the prototyping of production system innovations and demonstration of new paradigms of production like open-source manufacturing, commons-based production, manufacturing as a service etc. were further highlighted by the CoP 5.0 as promising innovation niches to be further developed. Horizon Europe investments in such research projects are already contributing to re-imagining what future production systems could look like ([12]). The next steps would be to assess more the results of such early projects and to better understand the framework conditions for scaling up such innovations, to further contribute to Industry 5.0 goals.

Good practice: OPEN! NEXT – transforming collaborative product production

As part of this Horizon Europe funded project, SMEs (small medium enterprises) and maker communities across Europe are coming together to fundamentally change the way we create, produce, and distribute products. The project is establishing new collaborations between companies and consumers, focusing on eco-friendly mobility, consumer electronics and built-to-order furniture. OPEN!NEXT seeks to empower both companies and consumers to co-design and co-manufacture products based on new mindsets, new business models, and new collaborative software solutions.

More information: OPEN!NEXT – Transforming Collaborative Product Creation (opennext.eu)

([12]) See European Commission, 2023: Human-centric manufacturing: How new approaches to technology design can transform European industry, CORDIS results pack

Continuing to support the growth of start-ups and companies that are by design tackling systemic challenges as a core element of their business models, products or services and develop as human-centric organisations is also key. In 2022, the Industry 5.0 Award identified such companies and initiatives and awarded the most systemic project (see below). Horizon Europe projects like SoTecIn Factories ([13]) are already supporting the incubation and development of steward-owned businesses that aim to improve circularity in 4 out of seven key product value chains, as defined by the EU Circular Economy Action Plan: packaging, plastics, textiles, food, water and nutrients. More initiatives like this need scaling up and matching with investment.

Investment and acceleration initiatives such as the EIC Accelerator Challenge on Virtual Worlds for Industry 5.0, EIT Manufacturing or EIT Climate-KIC or the Industry 5.0 Fund of Momenta are already important steps in providing start-up and scale-up funding for companies incorporating Industry 5.0 principles. Further mobilisation of patient capital would be welcome to strengthen the pipeline of Industry 5.0 innovations that can fuel wider industry and SME transformation in Europe.

Good practice: Rosi Solar
Solar energy has become the leading source of renewable electricity worldwide. The photovoltaic industry needs new technologies to make its supply chain more sustainable in a renewable future. ROSI Solar team is dedicated to making the photovoltaic industry a circular model and to reducing its carbon footprint. The company won the Industry of the Future Award from the European Commission in 2022. More information: https://www.rosi-solar.com/about

1.2 Accelerating learning and adaptability at organisational and ecosystem level for Industry 5.0

CoP 5.0 Members agreed that a shift is needed in the traditional models companies offer for learning and development, in upskilling, and in offering opportunities for the workforce at any age to upgrade skills at a faster pace, to cope with new demands for a competitive industry. Moreover, as company structures are changing towards flatter

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([13]) See more information here: The Project - SoTecIn Factory

organisations, growth opportunities for younger workers should be re-thought, orienting towards the skills that can be acquired and purpose of the work as key factors of talent attraction.

The Horizon 2020 Beyond 4.0 ([14]) project identified the **learning capacity of organisations** ([15]) as key to explain knowledge production & innovation**,** next to digital and R&D direct investments **–** hence **fundamental to competitiveness.** The learning capacity of an organisation is understood as its **ability to adapt and compete at competitive cost through learning.** Learning capacity is related to an organisation's **absorptiveness**, namely identifying what's out there and relevant, making sense of it in context, and finally deploying it in ways which add value ([16]). It is related to the skills, management tools and organisational practices that support individual and organisational learning leading to more innovativeness and improved socio-economics outcomes, such as more employee resilience, accelerated innovation if combined with digital technologies. Important features of learning organisations that the Community of Practice identified are further outlined in the Industry 5.0 Learning and Assessment tool (chapter 2).

Learning ecosystems for Industry 5.0 are place-based and future-oriented environments centred on learners, building skills and enabling (latent) entrepreneurship and intrapreneurship towards Industry 5.0, as well as fostering organisational learning. They may act at multiple levels: in organisations, at inter-organisational / value chain level, inter-regional level etc.

While the concept of "learning ecosystems" in industry per se has received limited research focus, learning generally happens through social interaction and knowledge exchange between Industry 5.0 innovation ecosystem stakeholders. Moreover, it can also include learning in strategic alliances or partnerships, innovation networks and social networks, as well as in collaboration in supply chains ([17]). Furthermore, company-level learning ecosystems are increasingly centred on learners and enhanced by

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([14]) https://www.beyond4-0.eu/

([15]) Greenan N., Napolitano S., 2024: Digital technologies, learning capacity of the organization and innovation: EU-wide empirical evidence from a combined dataset, *Industrial and Corporate Change*, Volume 33, Issue 3, June 2024, Pages 634–669, https://doi.org/10.1093/icc/dtad064

([16]) Zahra, S. A. and G. George (2002.). "Absorptive capacity: A review, reconceptualization and extension." Academy of Management Review, **27**:: 185-194.

([17]) Kohtamäki M., et al, 2023: Learning in strategic alliances: Reviewing the literature streams and crafting the agenda for future research, in Industrial Marketing Management, Volume 110, 2023, Pages 68-84, https://doi.org/10.1016/j.indmarman.2023.02.011.

technology. They include tailoring learning to every learner's different style of participation, social learning, teamwork and peer coaching, among others. ([18])

Aside from needed deep changes in the educational curricula and approaches will need to be made to upgrade the education system and life-long learning paths, CoP 5.0 discussions highlighted the following **key drivers to support learning ecosystems** as part of a transformative Industry 5.0 agenda:

- Catalyse company learning capacities, through measures such as:

    o Supporting companies to create a central place for learning and upskilling in the organisation and the organisations' partners, where decisions are driven by the learners,

    o Create support services for "learning how to learn" at organisational level, in Industry 5.0 contexts, improving peer-to-peer company learning, improving knowledge exchange and cooperation opportunities on upgrading company learning capacities etc.

    o Develop learning mechanisms and strategies targeting specific leverage points of the transition towards Industry 5.0 goals. Such leverage points could includemindsets and purpose, structures and relationships, information flows, resources or behaviours (see example below). The involvement of companies together with other supply chain partners and/ or stakeholders or community actors in a common learning process can be a success factor.

Good practice: Horizon Europe ReSChape project
The EU-funded ReSChape project analysed social, economic and environmental changes and disruptions, including the COVID-19 pandemic, and evaluated their impact on supply chains. New supply chain models will be proposed, aiming towards a more streamlined supply chain process to assure humans (workers, consumers and in general citizens) to be at the center of the business also thanks to new digital technologies. It will be studied how to assure a positive social impact and innovative policy scenarios will be developed with recommendations to support the future supply chains.

([18]) Schipperheijn K. 2022: Learning ecosystems. Creating innovative, lean and tech-driven learning strategies, Kogan Page books, London

Learning mechanisms identified by the projects with support of European case studies are portrayed in the picture below.

Examples of learning mechanisms identified by the projects based on European case studies

Mindset and purpose	Structure, Rules and Relationships	Behaviours, Resources
• Strategies for anticipation, foresight, strategic intelligence, designing the supply chain • Support new opportunities identification • Creating shared purpose with society	• Fostering learning to re-design & reconfigure organisational structures • Fostering experimentation and cooperation • Responsible technology development & adoption	• Coaching/education programmes • Standards, certifications • Create consciousness in customers, workers • Cultivating cooperating& learning behaviours
A4: Alliances to push ecosystem's compliance to environmental and social standards in SMEs C2: Partnerships with competitors to increase society's awareness on sustainability with cross-company actions D1: Creating shared goals for preserving crafmanship skills for the Made in EU E1: Transition to new business models for sustainable services (i.e. collection EOL products, repairing service) J1: Industrial symbiosis on by-product with municipalities and utility companies. F4: Customers' awareness on the costs generated by fair and ethical business (EE)	A2: Responsible and transparent procurement pratices with residential coach to support supplier development A3: Regular performance monitoring of outsourcing processes to implement preventive measures for sustainability compliance B1: Boosting learning capacity for environmental and social sustainability compliance along the value chain E1: disintermediated network for sustainable services (i.e. collection EOL products, repairing services)	A1: Empowering workers with Induction programmes specifically on sustainability and talent management O2: Promote the worker's skills and knowledge: dedicated training programmes on resource savings F2: Selection and training of suppliers in developing countries based on sustainability parameters F3: Specific training and wealth initiatives for workers in developing countries with support of local institutions and NGOs F4: Increase customers' awareness on the costs generated by fair and ethical business K1: green steel certification for definition of standands along supply chain

Selection of case studies
Case A: BCorp certified startup in developing countries.
Case B: Luxury large company with social and environmental sustainability target.
Case C: Craftmanship and local communities for Made in Europe products.
Case D: Holding for networking SMEs for sustainability.

Selection of case studies
Case E: Ecosystems for circular economy in footwear sector.
Case F: Global and transparent value chain for sustainable products.
Case J: Large steel company with Eletric arc furnace.
Case K: Green transition in steel company for decarbonisation.
Case O: Freight logistics service for zero emissions

More information: About ReSChape - ReSChape Project
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More information: About ReSChape - ReSChape Project

- Foster industry commons to accelerate learning by <u>improving digital and organisational learning infrastructures and services</u>. More can be achieved by pooling resources together based on partnerships between industry, education, R&I, public sector and civil society organisations, in order to foster skills upgrades and strengthen organisational learning capacities, as well as to build capacities to systemically tackle Industry 5.0 challenges. Potential enablers include:

  o Technology infrastructures can host a series of solutions such as **didactic factories, learning factories** or other emerging new educational practices based on new learning paradigms relevant to industry, including centred on sustainability, human-centricity, resilience and new production systems paradigms. Developing AI-enabled and other technology-driven solutions to support personalised learning journeys for companies and workers.

- Building the readiness for industry and other stakeholders to share data and knowledge in a way that enhances the ecosystem's competitiveness and ability to reach Industry 5.0 goals.

- <u>Improve orchestration for learning ecosystems</u> to mobilise organisations towards industry 5.0 transformation and update curricula and organisational practices. This would also involve intermediaries and facilitators that can work towards supporting Industry 5.0 implementation. European initiatives related to Industrial Symbiosis Skills Alliances (see SPIRE-SAIS) or curricula development (see INSIGHT project) are good examples in this sense. Likewise, the Katapult Network in the Netherlands is another example of learning ecosystem facilitator.

Good practice: Katapult Network

Katapult is building a network of Public-Private Partnerships to develop mutually beneficial relationships between the education and commercial sectors, in order to meet business and societal challenges.

An example of PPP is the ACE Mobility partnership, in view of education-labour-smart innovation, together with experts from over 60 companies, industry leaders and top universities, including applied sciences and vocational education. One of its goals is to *establish pre-competitive leading partnerships* to tackle identified challenges, including through building Human Capital Agendas embedding needs for new skills in the National Growth Fund, supporting a learning culture in companies etc.

More information: We are Katapult   ACE Mobility's Role

1.3 Foster open social innovation to solve Industry 5.0 challenges

Open social innovation requires the capacity to work together across the boundaries of different organisations to create value for Industry 5.0 projects, and scale them up.

Having an open innovation ecosystem is about joint value creation, in a way that the whole is more than the sum of the parts. In an open innovation process, the challenge is to set up the governance so that we share the value created and create the social value Open social innovation could facilitate the development and implementation of experimental business models & institutional models for Industry 5.0, which would enable industry to cope easier with the speed of technological evolution.

Good practice: Tech to the Rescue

Tech to the Rescue organises open innovation campaigns and initiatives of the NGO that match tech companies and non-profits to solve societal challenges with local interventions with high impact potential. Key success factors are the focus on curating high-impact NGO challenges to be matched with digital solutions, and providing personalised support along the match-making process. Identifying strategic partners and "superscaler" non-profits and change-makers with ecosystems of partners and the support to forming trusting and meaningful connections were two further strengths of the Tech to the Rescue approach.

More information: Tech To The Rescue

1.4 Anticipatory innovation capacity for Industry 5.0 transformation

Anticipatory innovation governance is a practice that could support organisations across different sectors to "consistently perceive, understand and act on the future as it emerges in the present." ([19]) In the context of Industry 5.0, similar capacities are needed for industry players at different levels (e.g. in clusters, value chains or at local level) and for policy-makers developing supportive measures for Industry 5.0.

CoP 5.0 discussions also brought up the role of **digital infrastructures for strategic intelligence** - as another tool that could be offered as industry commons for anticipation, foresight, and for (re-)imagining different scenarios for future industrial developments. This could help companies understand weak signals, anticipate change & align agendas across industry/ supply chain /regions for formulation of bolder industry 5.0 strategies. It could also provide motivations to make learning, technological and organisational adjustments with an Industry 5.0 lens as a strategic choice of the organisations.

Good practice: Teaching & Learning Factory Unit at am-LAB (Szombathely, Hungary) Learning Factories (LF)

([19]) OECD (2024), "Framework for Anticipatory Governance of Emerging Technologies", *OECD Science, Technology and Industry Policy Papers*, No. 165, OECD Publishing, Paris, https://doi.org/10.1787/0248ead5-en.

This initiative can contribute to more efficient regional ecosystems by enhanced digital maturity (Industry 4.0) and accelerated modernisation and restructuring (Industry 5.0). New services and business models can be developed for business incubation services for AI utilisation which can also lead to new markets within cross-sectoral value chains (like the circular economy) and horizontal integration (supply chains). The Learning Factory operates within an integrated business model to achieve its objectives. The physical and virtual infrastructure and services provide both the framework for awareness raising, engagement and systematic competence development; the testing environment for effective iteration; and the structural conditions for experimentation. A distinctive feature is that it offers the opportunity to gain experience in a closely realistic or explicitly realistic manufacturing environment. From the academic's point of view, however, an LF centre is not only a "teaching workshop", but also a research laboratory, demonstration, and testing environment. Learning Factories are also open to external partners for experimental experience therefore the LF act also as a manufacturing data lake that collects and shares various collected manufacturing data from and among its partners.

More information:

https://www.am-lab.hu/main.php?Lang=EN#Teaching___Learning_Factory_Unit-2

1.5 Next steps and possible future actions

The policy orientations provided by the CoP 5.0 members will be translated into the next phases of developing Industry 5.0 as a Transformative Agenda for Industrial R&I.

In particular, the following options have been identified as a means to achieve the desired shift in enabling framework conditions and to achieve Industry 5.0 goals:

- Build a **Transformative Innovation Policy Agenda for Industry 5.0**, taking into account the systemic aspects and key drivers already provided by the CoP 5.0 and the interlinkages between the three Industry 5.0 pillars. This would build on the actions identified in the three Industrial Technology Roadmaps already developed at European level with R&I and industry stakeholders, on Circular Business Models, Low-Carbon economy and Human-centric Research & Innovation [20], and focus especially on the transformative elements. The

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[20] ERA industrial technology roadmaps - European Commission (europa.eu)

Agenda would focus on the portfolio of actionsthat the European Commission could further take, combined with the commitment of CoP 5.0 members and other European partners.

- Develop **Hubs 5.0 as system innovation orchestrators** to provide an experimentation and demonstration infrastructure for R&I, industry, policy and societal partners towards Industry 5.0 transformation and building the business case for Industry 5.0:

    o Mobilise industrial ecosystem actors towards translating competitiveness, human-centricity, sustainability and resilience goals into own commitments of concrete transformative challenges and creating the demand for Industry 5.0 innovations.

    o Support learning ecosystems to increase learning capacities of organisations, building skills, foresight and anticipatory innovation governance capacities for Industry 5.0.

    o Support the demonstration of projects scaling up the Industry 5.0 innovations (human-centric, bio-inspired design practices, new organisational and business models, new designs for value chains etc), through open social innovation and other processes, as means to reach the identified transformative challenges.

    o Demonstrate incentives for paradigm change towards Industry 5.0, together with industry, social partners and policy-makers.

Chapter 2: Company level approach - Industry 5.0 learning and assessment tool

An ongoing twin (green and digital) transition and the need to attract the best talent bring new challenges and put additional burden on business and organisational models at company level. Combining a human-centric approach, sustainable practices and resilient methods in company processes requires a shift in thinking at company level (system thinking) and change in behaviours and decision-making process. Adoption of Industry 5.0 principles and methods in business practice could result in enabling companies to attract the best talents and maximise the benefits from the collective experience and know-how of its employees. It could help reducing the vulnerability to costly disruptions of supply chains and the lack of critical skills.

The prototype Industry 5.0 learning and assessment tool co-developed by CoP 5.0 ([21]) could help in achieving these goals. The prototype tool aims to:

- Encourage companies/organisations to check their performance against human-centricity, sustainability and resilience at different stages of the production process;
- Inspire organisations (in particular start-ups) to design impact-driven organisational models aligned with green, digital and social transformation;
- Provide an overview of company's impact-driven performance for policy-makers and investors.

In addition, the tool could serve as an integral part of education and training schemes (capacity building) for local businesses provided by respective regional and local entities (such as business support agencies etc.).

The prototype tool is composed of two parts: **qualitative ("learning") and visual ("assessment")**. The <u>qualitative part</u> zooms-in on individual pillars of Industry 5.0 (human-centricity, sustainability and resilience) and their key dimensions.

([21]) CoP 5.0 focused on co-development of the qualitative part of the prototype tool. At the moment the tool is in a prototype version which will need further elaboration and fine-tuning to get a maturity level required for its practical application.

It is structured in a matrix combining the three Industry 5.0 pillars with individual phases of production process (inputs-processes-outcomes):
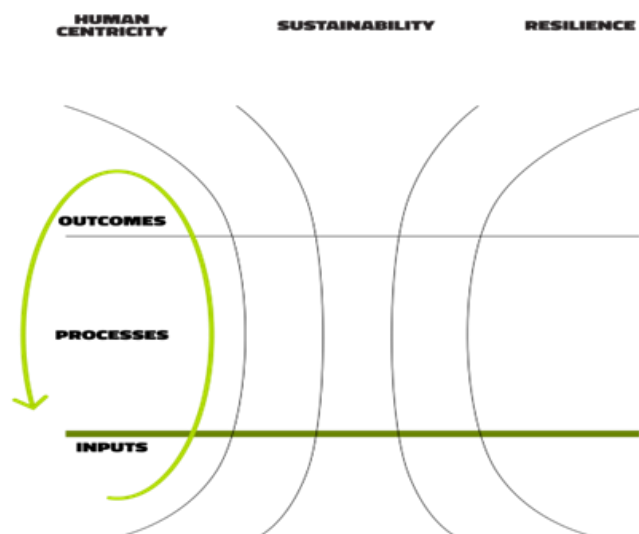
While the "pillar part" of the matrix axe allows organisations to better understand and zoom-in on dimensions of human-centricity, sustainability and resilience at company level, the "production process part" of the axe divided into input-process-outcome assists organisations in getting an overview and compare their impact-driven activities before (input) and during (process) the production activity. It can help identify gaps between the two phases. Key dimensions of the matrix are further broken down into customized set of questions for each dimension. Color-coded responses enable the visualization of Industry 5.0 performance at company level, facilitating the identification of variations between different phases of the production process.

The visual part "regenerative tree" provides a visualisation of a company's Industry 5.0 performance and enables the identification of advanced areas and those which require further attention. It helps better understand interlinkages between different components.

Prototype Industry 5.0 Learning and Assessment Tool – two component structure and methodology:

2.1 Qualitative component of the prototype tool – key dimensions

Human centricity is a multidimensional framework that places human needs, characteristics, motivation and experiences at the centre of design, development, and implementation of technological solutions and organisational practices that not only meet functional requirements but also enhance human well-being, capabilities, skills, and working conditions. ([22])

As organisations increasingly digitise and automate, a human-centric approach considers human-centred factors in both the development and adoption of technology at the organisational level.

On a technological level, human centricity aims to optimise interactions between individuals and machines. This encompasses the joint design of processes, systems, and work environments aimed at enhancing employee engagement, safety, well-being, and

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([22]) European Commission, Directorate-General for Research and Innovation, ERA industrial technologies roadmap on human-centric research and innovation for the manufacturing sector, Publications Office of the European Union, 2024, https://data.europa.eu/doi/10.2777/0266

productivity, while strengthening the human role through technology integration. The objective is to ensure the ethical development and adoption of technologies, preserving individuals' autonomy and control, while respecting human values.

At an <u>organisational level</u>, the human-centric approach places a particular emphasis on achieving the well-being and satisfaction of workers simultaneously with improved performance, taking into account their specific needs, skills, and perspectives. This approach highly values the contribution and expertise of employees, thus fostering a culture of collaboration and inclusivity. It also actively encourages skill development and continuous learning among employees, ensuring they have the necessary abilities to adapt to the constantly evolving technology. Additionally, it ensures a healthy balance between work and personal life. By prioritising individuals, a human-centric approach leads to improved employee motivation, efficiency, and overall organisational success. Furthermore, it ensures that the company has the capabilities needed to adapt to the rapidly advancing pace of technology.

Against this background, the human-centric pillar of the prototype tool encompasses a set of key dimensions for input and process stage of the production activity, such as: innovative technologies with potential to enable human-centricity in work-related context, job design, self-organised teams, delegated decision-making and flatter structures, employee-driven improvement and innovation, co-created leadership, a skilled/knowledgeable workforce, common vision/purpose, inclusive/diversified workforce, learning organisation model, workforce well-being, impactful customer and community relations etc. These are accomplished by a set of "outcome" dimensions which could serve as a useful set of information for potential investors and policymakers.

A full list of the human-centricity dimensions and sub-dimensions of the prototype tool co-developed by CoP 5.0 Members can be found in annex 1.

Good practice: Workplace Innovation Europe, Ireland

Workplace Innovation Europe has developed the Fifth Element framework for companies to understand and introduce workplace innovation as a means of achieving enhanced performance and innovation capacity simultaneously with human-centricity. The Fifth Element introduces four bundles ('elements') of workplace practices which, in combination, lead to improved business competitiveness by redesigning jobs, working practices and organisational structures in ways that use and develop workforce potential to the fullest extent possible, thereby improving wellbeing and intrinsic job quality. Workplace Innovation Europe also developed a portfolio of tools and resources based on The Fifth Element, offering practical support to companies.

More information: Workplace Innovation

Within the prototype tool's matrix structure, the **sustainability** is understood as a combination of strategies, approaches and processes a company/organisation applies internally in order to align its activity with ESG[19], EU Taxonomy[20] and other existing EU frameworks and initiatives aiming at achieving the Green Deal driven performance at company level such as negative emissions, zero-waste, positive impact on biodiversity and restoration of natural ecosystems or positive environmental impact on local communities etc. In this context a set of dimensions have been co-developed by CoP 5.0 Members and proposed to be included in the prototype tool's qualitative component, such as environmental strategy, renewable input energy sources and materials, ethical sourcing practices, regenerative production processes, green procurement, environmental impact analysis, engagement with local communities etc. These are accomplished by a set of "outcome" dimensions which could serve as a useful set of information for potential investors and policymakers. A full list of sustainability related dimensions and sub-dimensions is in annex 1.

Good practice: Institute of Communication and Computer Systems (ICCS), Greece

ICCS develops automated sorting systems, which are responsible for the categorisation and separation of different types of wastes, such us urban wastes, plastic, textiles, wood, construction & demolition wastes, metal, WEE, batteries, etc. The sorters by using multi-sensing systems and advanced robotic mechanism along with AI-based models are able to classify and separate the samples with accuracy level more than 90%. Thus, the reduction of unexploited wastes is achieved enhancing the reusability and re-manufacturability of products, while reinforcing the sustainability of numerous industries by creating a closed loop of their manufacturing process. Finally, in order to assess the overall techno-economical level of the provided solutions in terms of energy consumption, ICCS developed a green ICT tool. In accordance with the European Standards for Green ICT operations, this tool improves the maintainability and adaptability of each legacy ICT system by incorporating it into the new eco-friendly technological era, while in parallel facilitates the creation of new ICT systems environmentally sustainable.

More information: ICCS.gr – Ερευνητικό Πανεπιστημιακό Ινστιτούτο Συστημάτων Επικοινωνιών & Υπολογιστών

Resilience is the ability not only to withstand and cope with challenges but also to undergo transitions, in a sustainable, fair, and democratic manner[30].

For the purpose of the prototype tool, the resilience is understood a combination of financial, supply chain related resilience, IT/OT security, cyber-security and investment in R&I at company/organisational level. A full list of dimensions and sub-dimensions of the prototype tool under the resilience pillar can be found in annex 1.

Good practice: COGITO, High-tech start-up, Italy

COGITO has developed advanced systems equipped with artificial intelligence (AI) and augmented reality (AR) which have significantly reduced the risks of machine downtime in production lines (resilience building). Predictive maintenance through AI has elevated the levels of availability and reliability of industrial processes, thus Additionally, advanced AI diagnostics reduce the downtime (and, in some cases, eliminate it) in production processes, increasing the resilience of industrial processes.

More information: www.cogitoprediction.com

# 2.2 Visual component of the prototype tool – regenerative tree

The system of colour-coded standardised answers to customised questions in the qualitative part of the prototype tool (Annex 1) allows transformation of the answers into the visual "regenerative tree". The greener the regenerative tree is the more impact-driven performance is applied at company level. The regenerative tree helps companies and organisations to better understand their Industry 5.0 performance and spot areas for further improvement. It also helps companies/organisations to understand inter-linkages and inter-dependencies between the three pillars of human-centricity, sustainability and resilience.

Model example A

Company A specializes in production of eco-packaging materials. The company invests in workforce upskilling training schemes and offers various well-being benefits to its employees. The management consults new policies with employees and values their input through the support of a Worker Council. The company embraces technologies that are designed with a human-centric approach. It actively engages with local communities and customers, seeking their feedback through surveys and social media channels.

The company applies green technologies in production processes and consistently monitors its environmental, social, and governance (ESG) performance. Furthermore, it actively collaborates with local environmental agencies to explore opportunities for further improvement of its local impact.

With a diversified mix of suppliers, Company A ensures ethical practices by thoroughly checking the suppliers' conduct. It has a robust IT infrastructure in place, along with strong cybersecurity policy. Additionally, the company invests in research and innovation (R&I) and maintains a strong financial position, making it both resilient and viable.
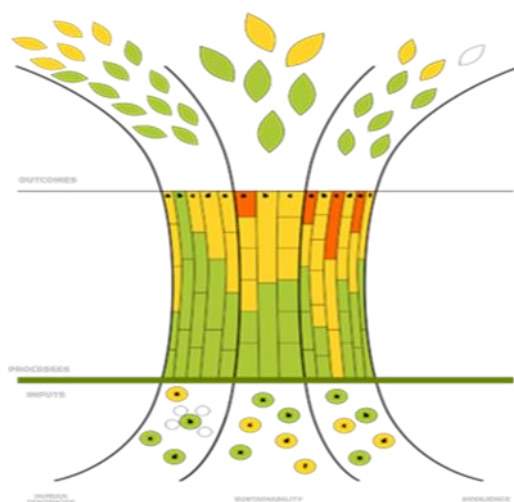

Model example B

Model example B
Company B specializes in 3D food printing of animal-free meat. It claims to use only natural and sustainable inputs (ingrediencies), environmentally friendly production technologies with positive impact on biodiversity (water conservation and reuse of waste water, no livestock slaughtering). It works with eco-friendly packaging materials and is situated in an energy-efficient building.
It emphasizes the adoption of an inclusive and diversified recruitment policy.
The company does not invest in the well-being or upskilling training schemes and programmes of its employees. Decisions primarily reside with top-level managers. The company's client engagement takes place only through social media channels.
Company B operates with only one supplier. It doesn't have a contingency (business continuity) strategy to adapt to risk events and lacks financial reserves to resist possible future financial shocks.
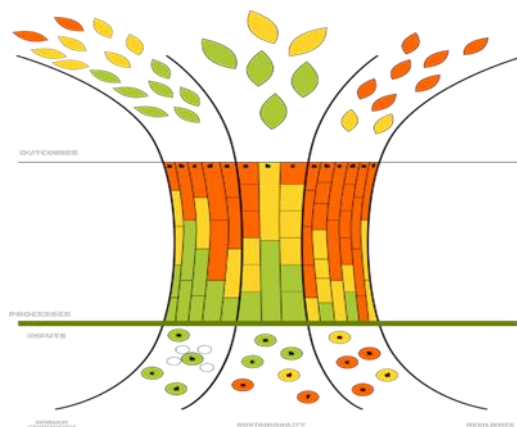
2.3 Next steps and possible future actions

The prototype Industry 5.0 Learning and Assessment Tool will be tested, validated and further fine-tuned with a broad range of European innovation ecosystem stakeholders in order to achieve a maturity level required for its practical application.

Inter-active discussions among the Industry 5.0 Community of Practice Members resulted in tabling the following options for future use and development of the prototype Industry 5.0 Learning and Assessment Tool:

- (following the validation phase) considering metrics and benchmarking for monitoring the maturity level of Industry 5.0 performance at company level;

- Capacity building: including the tool in the training schemes of regional and local entities such as business support agencies and in respective universities/business school curricula.

Chapter 3: Recommendations for future CoP 5.0 orientations and joint actions

Co-creative discussions, sharing of good practice and generating new ideas on how to foster Industry 5.0 implementation in practice confirmed that it is important to continue with this community engagement in the future.

Collaborative actions on the first set of deliverables and inter-active discussions during the CoP 5.0 initial phase (November 2023 – September 2024) resulted in tabling several proposals for future actions which could be implemented by CoP 5.0 beyond 2024.

The CoP 5.0 Members supported the idea of **co-developing a business case for Industry 5.0** in order to provide evidence on the economic viability of the emerging framework which contributes to a long-term sustainable competitiveness of EU industries and economy.

To provide a unique space for stakeholders to connect the dots, share good practice, discuss new partnerships, connect already existed fragmented Industry 5.0 platforms, provide information and updates on Industry 5.0 driven projects and initiatives, it was proposed to establish an **Industry 5.0 Platform at EU level**.

To follow-up on the above-mentioned complex approach to tackle the challenges related to the ongoing twin (green and digital) transition, it was proposed to deepen the **understanding of interactions and interlinkages between/across the three Industry 5.0 pillars** aiming at providing a **new perspective on how to approach industrial innovation** and create the societal/environmental/economic impact.

To contribute to bringing evidence and building the Industry 5.0 monitoring framework, it was suggested to further improve the prototype tool and develop **KPIs based on the prototype Industry 5.0 Learning and Assessment Tool**.

CoP Members agreed that Industry 5.0 framework should be further developed and labelled as a "**Transformative industrial R&I policy Agenda**" fostering place-based experimentation based on complexity approaches and system thinking, combining actions of the European Commission, CoP 5.0 members and other European partners for Industry 5.0 transformation .

Last but not least, it was suggested to explore the idea of **Hubs 5.0 as system innovation orchestrators,** to support the implementation of transformative challenges for industry, by fostering learning ecosystems and learning capacity improvements, and facilitating the development of incentives for the uptake of Industry 5.0 innovations and for paradigm change. By promoting digitalisation to achieve societal objectives, rather than to support traditional consumption patterns, Industry 5.0 could also contribute to post-GDP objectives.

In the context of the Future of EU competitiveness report published by the former ECB President M. Draghi on 9 September 2024 – CoP 5.0 could also explore how to align its future actions to some of the concrete recommendations outlined in the report, in particular those related to addressing skill shortage in critical value chains.

CoP 5.0 Plenary Session in October 2024 will elaborate on the proposed actions and propose a streamlined approach to be reflected in CoP 5.0 Work Plan 2025.
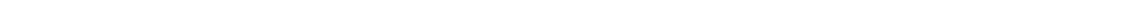
Annex 1: Prototype Industry 5.0 Learning and Assessment Tool – key dimensions and sub-dimensions of the three-pillar structure

HUMAN-CENTRICITY

INPUT

A. Innovative technologies with potential to enable human-centricity in work-related context

1. Computation: technologies supporting the interplay with multimodal communication for seamless interaction (natural language processing, affective computing for experience optimisation etc.)

2. AI and machine learning: technologies facilitating the implication of big data and AI for data driven experience optimisation and improved analytical capabilities (human intention and support need recognition, user modelling for behaviour prediction etc.)

3. Simulation and immersion: technologies facilitating remote presence and creating new capabilities for operating, maintaining, training, guidance and co-design of workplaces (Digital Twin for real-time data integration and synchronisation, Extended Reality etc.)

4. Robotics: technologies supporting the interplay of machine and workforce for an improved physical and psychological safety in collaborative task performance (robot learning by demonstration, learning by interaction, Intuitive robot programming etc.)

5. Industrial wearables and smart artefacts: technologies increasing individual competences and usability of manufacturing equipment, giving feedback on well-being and achievements, leading to higher work satisfaction and well-being of workforce (Exoskeleton for physical support, smart glasses for remote assistance, smart gloves for enhanced interaction etc.)

6. Knowledge management: technologies supporting the contextual training, skill development and personal development of workforce (data visualisation for decision support, process visualisation for compliance/motivation/understanding etc.)

7. User interface: technologies supporting new forms of human machine interaction by providing real-time feedback on personal performance and holistic intuitive workplace interfaces (multimodal HMI for seamless interaction, situation aware assistance systems, adaptive dialogue/conversational systems etc.)

8. Connectivity: technologies upskilling and motivating workforce, making skills and qualifications more visible, and facilitating knowledge sharing for a learning organisation (Internet of Everything IOE etc.)

9. Personalised systems: technologies designed in accordance with user expectations offering the labels and links a user of a given profile will use (real time feedback on personal performance, adaptive interaction technologies etc.)

10. Miscellaneous HC enabling technologies: 6G and beyond, additive manufacturing, cloud/edge computing, blockchain etc.)

B) Skilled/knowledgeable workforce ([23])[]

1. Digital literacy as a holistic skill to interact with, understand, enable, and even develop new digital manufacturing systems, technologies, applications, and tools

2. AI literacy as ability to use new AI and data analytics solutions while critically interpreting results

3. Creative problem solving in times of abundant data and technological opportunities in smart manufacturing systems

4. A strong entrepreneurial mindset including proactiveness and the ability to think outside the box

5. Ability to work physically and psychologically safely and effectively with new technologies

6. Inter-cultural and inter-disciplinary inclusive, and diversity-oriented mindset to address new challenges arising from a more diverse workforce

7. Cybersecurity, privacy, and data/information mindfulness to reflect the rapidly increasing digital footprint of respective value chain

8. Ability to handle increasing complexity of multiple requirements and simultaneous tasks

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([23]) 2019 World Manufacturing Forum Report, Skills for the Future of Manufacturing

9. Effective communication skills with humans, IT, and AI systems through different platforms and technologies

10. Open-mindedness towards constant change, and transformation skills that constantly question the status quo and initiate knowledge transfer from other domains

C) Common vision/purpose that motivates employees (purpose-driven company/organisation)

D) Diversified and inclusive workforce

1. Diversified workforce in terms of gender, age, nationality, ethnicity, impairments, socio-economic backgrounds etc.

2. Inclusive workforce in terms of fostering an atmosphere where everyone can contribute their unique skills and perspectives without facing discrimination or exclusion.

PROCESS

A. Learning organisation model ([24])[16]

1. Preservation of the cognitive dimension of work

2. Training opportunities

3. Autonomy in cognitive tasks

4. Stimulation of intrinsic motivation

5. Autonomous teamwork practices

6. Social support

7. Supportive supervisory style and trust-based management

8. Direct participation

9. Workforce empowerment

10. Experimentations and new ways of working

([24]) Greenan, Napolitano, 2024 and H2020 BEYOND 4.0 project results

11. System thinking (understand how different parts of the organisation interact and affect each other)

B. Workforce well-being

1. Variety of health and well-being programs for employees (health screenings, stress management programs, employee assistance program, fitness programs etc.)

2. People focused flexible working arrangements (teleworking, voluntary part-time working etc.)

3. Recognising and rewarding the hard work and achievements of employees via targeted measures such as promotions, bonuses, individual recognition and other incentives

4. Supporting workforce engagement via creating a positive work environment and encouraging open communication

C) Human-centric and purpose-driven approaches in design and deployment of technologies ([25])[1]

1. Innovative technologies with potential to enable human-centricity enhancing the quality of workforce life, stimulating creativity and workforce interaction

2. Application of concrete technologies as a result of a co-decision process

*3-6 only relevant for companies/organisations who design new technologies as their key activity

3. Human needs and experiences at the centre of the HCT design process

4. The HCT design as an outcome of a co-creative process with stakeholders

5. Multidisciplinary design teams (could include art, design, social scientists, culture and creativity experts etc.)

6. HCT design process in full compliance with ethical rules

D) Impactful customer and community relations

([25]) Human-centric manufacturing: How new approaches to technology design can transform European industry (europa.eu)

1. Listening to customers' experiences in an open way as part of the constant learning and improvement process

2. Engaging with customers via different channels (social media etc.) to intensify mutual relationships and foster engagement

3. Supporting local neighbourhood/communities by participating in local events, sponsoring local organisations and/or contributing to local charities; and collaborating with local suppliers/communities during design and manufacturing processes.

4. Open and transparent communication with customers and local neighbourhood communities

5. Empowering workforce to actively build relationships with customers and local communities.

OUTCOME

    A. ESG compatibility in social dimension (company's social impact [26])

    B. Happy/motivated/satisfied workforce

    C. Improving trend of productivity and performance

    D. Reduced staff turnover and improved staff retention

    E. Ability to attract the best talents

    F. Innovative technologies with potential to enable human-centricity in work-related context

    G. Positive social impact on local communities

    H. Positive organisation/brand reputation

<u>SUSTAINABILITY</u>

INPUT

    A. Environmental strategy

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(26) [Overview of sustainable finance - European Commission (europa.eu)](#)

1. Climate change mitigation actions in place to ensure that a company/organisation's business model is aligned with transition to a sustainable economy

2. Environmental (EMS) and energy (EnMS) management system and compliance with respective ISO 14001 ([27]) and ISO 50001 ([28])

3. Regulatory compliance with local, national and European climate/environmental regulations/standards applicable to the company's operations

B. Renewable input energy sources derived from naturally replenishing or virtually inexhaustible resources and innovative green technologies (such as solar photovoltaic, battery/storage, heat pumps, electrolysers, carbon capture, grid, sustainable biogas/biomethane technologies as identified by the Net Zero Industry Act)

C. Repurposed-reused-recycled input materials ([29]) designed/labelled in compliance with the EU Eco-design Directive/Eco-design for Sustainable Products Regulation (ESPR) ([30])[1] (more sustainable, circular and energy-performing design)

D. Ethical sourcing practices to ensure that the company/organisation's supply chain operates in a way that minimizes negative impact on people, communities and environment ([31])

([27]) ISO 14001 is the internationally recognized standard for environmental management systems (EMS). It provides a framework for organizations to design and implement an EMS, and continually improve their environmental performance. By adhering to this standard, organizations can ensure they are taking proactive measures to minimize their environmental footprint, comply with relevant legal requirements, and achieve their environmental objectives

([28]) ISO 50001 is an international standard that provides a framework for establishing, implementing, maintaining, and improving an Energy Management System (EnMS) within an organization. The purpose of ISO 50001 is to help organizations systematically manage their energy performance, improve energy efficiency, and reduce greenhouse gas emissions. The standard is designed to be applicable to various types and sizes of organizations, regardless of their geographical, cultural, or social conditions.

([29]) Aligned with the EU Circular Economy Action Plan: Circular economy action plan - European Commission (europa.eu)

([30]) Ecodesign for Sustainable Products Regulation - European Commission (europa.eu)

([31]) Examples of ethical sourcing practices include: labour standards (prohibition of child labour, fair wages etc.), environmental responsibility (promoting environmentally sustainable production and harvesting practices, minimizing environmental degradation in

E. Inputs non-hazardous to people and environment (REACH ([32]) compatible)

F. Nearly zero energy buildings (NZEB) ([33])

PROCESS

A. Regenerative production processes

1. Inputs processed in a sustainable way (regenerative management of natural resources, green agricultural practices etc.)

2. Optimised use of energy

3. Eco-friendly packaging (recyclable/biodegradable packaging materials)

4. Water conservation methods during production process (closed-loop systems recirculating water within the production facility, technologies that reduce water consumption, rainwater harvesting/collecting systems for non-potable uses such as cooling or irrigation etc.)

5. Training schemes for employees and managers on sustainability/environmental impact

6. Employee-driven innovation uses workforce knowledge and creativity to identify reductions in environmental impact.

7. Green procurement ([34])

B. Environmentally friendly transport/logistics processes (efficient and low-emission freight transport modes, green logistics practices)

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the sourcing process etc.), supply chain transparency (traceability of the origin of raw materials and components in value chain, providing clear and accurate information about sourcing practices to stakeholders etc.)

([32]) REACH Regulation - European Commission (europa.eu)

([33]) NZEB targets a very low energy demand and require that the remaining energy needs are met by renewable sources. NZEB is a broader concept that encompasses both, energy-efficient buildings and passive buildings. To boost the energy performance of buildings, the EU has established a legislative framework that includes the Energy Performance of Buildings Directive EU/2010/31 and the Energy Efficiency Directive EU/2023/1791, both revised in 2023.

([34]) Green Public Procurement - European Commission (europa.eu)

C. Environmental impact analysis

1. Product life cycle assessment (LCA) to evaluate the product's environmental impact throughout its life cycle from raw materials extraction to disposal

2. Energy consumption monitoring

3. Greenhouse Gas (GHG) emission monitoring

4. Water/waste use monitoring

5. Environmental KPIs to track progress towards environmental goals

D. Engagement with local communities

1. Data collection on the current environmental conditions and community needs in the area where our organisation/company operates

2. Environmental KPIs relevant to local communities (waste management, biodiversity preservation, local transport etc.)

3. Engaging with local communities (local authorities, local NGOs, environmental agencies) to gather their feedback and reflect it in company/organisation's decision-making process

OUTCOME

A. ESG compatibility in environmental dimension

B. Alignment with EU Taxonomy ([35])

C. Negative emissions

D. Green/Net Zero Technologies

E. Zero-waste or waste as resource

F. Positive impact on biodiversity and restoration of natural ecosystems

G. Positive environmental impact on local communities

H. Positive organisation/brand reputation

RESILIENCE

INPUT

([35]) EU taxonomy for sustainable activities - European Commission (europa.eu)

A.   Diversified revenues or ability to generate income from multiple sources

B.   Flexible supply chains/diversified suppliers , or ability to respond to short-term changes in market demands

C.   Sustainable profit ([36])

D.   Critical skill redundancy ([37])

E.   Intellectual assets (such as patents, licences etc.)

F.   Robust and scalable IT/OT infrastructure ([38])

G.   Robust and scalable cybersecurity infrastructure ([39])

PROCESS

A.   Measures/policies to ensure a company/organisation's resilience in general

1.   Regular foresight/risk-assessment;

2.   Business continuity strategy/plan;

3.   KPIs for risk management and financial performance;

4.   Employee-driven innovation uses workforce knowledge and creativity to identify improvements in supplier performance and cyber security.

   5. Resilience audits (on systems/processes/controls) to identify areas for improvements);

   6. Regular stakeholders/customers' feedback exercises to identify strengths and weaknesses.

B.   Measures/policies to ensure financial and corporate resilience

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([36]) Long-term viability of a company profitability while simultaneously considering and managing social, environmental and governance factors

([37]) Ability of a company/organisation to ensure that essential skills and knowledge are not solely concentrated in a single individual or a limited group of employees

([38]) Adaptive and flexible information and operation technologies, robust hardware/software framework and supportive mechanisms enabling efficient and secure function of a company/organisation's information technology operations

([39]) Comprehensive set of measures to protect a company/organization's digital assets, data, and systems (firewalls and network security, secure network architecture etc.)

1. Financial indicators such as liquidity/solvency/profitability ratios and cash-flow patterns' analysis to assess different aspects of a company/organisation financial health and to ensure absorption of market shocks;

2. Re-investing in low-risk and/or sustainable financial products (such as green bonds);

3. Necessary financial reserves on preventive measures against anti-competitive behaviour and monopoly practices;

C. Measures/policies to mitigate the risks of supply chain disruptions

1. Adequate stockpile to ensure smooth production, timely order fulfilment and the ability to respond to unexpected fluctuations in demand or supply;

2. Diversification of suppliers;

3. Suppliers' risk assessment and suppliers' risk profiles;

D. Mix of policies and measures to ensure an adequate cybersecurity level

1. Secured IT/OT infrastructure (advanced solutions and services);

2. Flexibility of IT/OT infrastructure (in case of crisis – possible immediate replacement of an outsourced IT/OT infrastructure);

3. Energy redundancy system in place (back-up electricity generators etc.);

4. Protection of sensitive data from unauthorised access by encryption.

5. Security monitoring/protocols to detect and quickly respond to security incidents;

6. Regular cyber-security trainings.

E. Adequate level of digital technology adoption

1. Online purchasing and e-commerce sale;

2. Fixed/mobile broadband connection, access to internet;

3. Remote staff connection/work;

4. Targeted trainings on digital skills;

5. Company/organisation's website (home page), e-business technologies and high cloud computing services such as CRM (customer relations management) software.

F. Investment in R&I and intellectual assets

1. Resources for R&I and experimentation;

2. Monitoring of trends on new technologies on the market;

3. Development of new intellectual assets (copyrights, trademarks etc.);

4. Strategic partnerships with universities, start-ups, industries and other stakeholders to share knowledge, resources and experiences.

OUTCOME

A. ESG compatibility in financial and corporate governance dimension

B. Adaptable and competitive organisation able to react quickly and recover from disruptions/uncertainties on the market

C. Top market positions of products/services

D. Positive organisation/brand reputation

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Annex 3: Examples of Industry 5.0 related good practices

Workplace Innovation Europe CLG Ireland

A leading role in creating and developing the European Workplace Innovation Network (EUWIN) funded by the European Commission and subsequently maintained by a consortium of stakeholders (www.euwin.net). Develoopment of the Fifth Element as a practical framework for companies to understand and introduce workplace innovation as a means of achieving enhanced performance and innovation capacity simultaneously with human-centricity.

More information: www.workplaceinnovation.eu

Institute of Communication and Computer Systems, Athens, Greece

ICCS develops technologies, systems and tools for multiple fields, such as: Industry 5.0 & Smart Manufacturing, XR, Circular Economy & Traceability, Crisis Management, Autonomous Driving, Earth Observation, Logistics. Specifically, regarding the Industry 5.0 pillar along with the AR (Augmented Reality) field, a smart tool "CirculAR" was created. This AR mobile application aims to improve citizen awareness and engagement towards circular economy principles.

More information: www.iccs.gr

EYDE Cluster – Norwegian Centre of Expertise for Sustainable Process Industry

EYDE Cluster supports Industry 5.0 as an ambitious and holistic vision towards a better future. EYDE develops and implements different activities and projects along this line, to support sustainable competitiveness.

More information: www.eydecluster.com

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V., Germany

The institutes of the Fraunhofer Group for Production perform research on the aspects combined now in Industry 5.0: the human factor in digitalisation and automation, sustainable and resilient production. The institutes conduct applied research on digital transformation methods and technologies and their impact on people in the socio-technological manufacturing systems of the future. Technological, sociological and psychological experts mutually develop human-centred participatory design and

engineering methods and technologies for the flexible work scenarios to respond to the changing production work scenarios driven by the digital transformation of manufacturing through Industry 4.0. They focus on cognitive teaming between humans and cyber-physical systems to improve healthy workplaces as well as manufacturing efficiency and resilience. The experience is being shared in the European Working Group on Human-centred Manufacturing of the European Technology Platform (ETP) Manu*FUTURE*.

More information: https://www.fraunhofer.de/en.html

COGITO s.r.l. Italy

Integration of the three fundamental pillars of Industry 5.0 into operational approach through the development of advanced systems equipped with artificial intelligence (AI) and augmented reality (AR).

More information: www.cogitopredicion.com

The Young Manufacturing Leaders Network

The Young Manufacturing Leaders Network stands at the forefront of the manufacturing industry, driven by a steadfast dedication to cultivating the next generation of leaders and fostering innovation, sustainability, and inclusivity. Since its inception, the Young Manufacturing Leaders Network has spearheaded numerous initiatives aimed at empowering young professionals in manufacturing. Through a diverse array of activities such as the Industry 5.0 Leaders Podcast, the YML Stories and teaching&learning factories' workshops in the local hubs, the Young Manufacturing Leaders Network has provided its members with invaluable opportunities for skill development, industry insights, and professional growth.

More information: https://youngmanufacturingleaders.org/

Augmented Industries

Augmented Industries' mission is to empower people and transform Europe's manufacturing industry with human-centric, responsible artificial intelligence (AI), thus addressing the manufacturing skills gap. Augmented Industries democratises scalable, lifelong learning opportunities for the factory floor by

offering AI-generated microlearnings in the flow of work: Documents like operating procedures or work instructions are transformed by AI into interactive, multi-language courses, enriched by science-based didactic principles. In doing so, Augmented Industries could improve both productivity and employee engagement in close collaboration with stakeholders: With their industry-grade software they could achieve 29.3% higher learning effectiveness than classroom trainings, 64.5% opportunity cost savings, 85.4% seamless workflow integration, and 91.3% employee satisfaction when working with the system. They were recently featured among the Best of Technology awarded by Germany's leading business magazine WirtschaftsWoche, in the category Manufacturing. (https://award.wiwo.de/bot/).

More information: Augmented Industries - Empowering people, transforming manufacturing (augmented-industries.de)