

FORMALISING INDUSTRY 5.0

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A Proposal for a
European
Governance
Framework of
the Paradigm 5.0

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Abstract

This document presents a technical and conceptual contribution toward the formal definition of the Industry 5.0 paradigm, responding to the growing need for a shared operational basis expressed by the European Commission and the Community of Practice on Industry 5.0. The work is grounded in a comparative analysis of major institutional, regulatory, and scientific sources at both European and international levels, with the definition of Industry 5.0 proposed in UNI/PdR 155:2023 serving as a central reference. This definition is assessed in terms of its alignment with the three strategic pillars of the European framework—human-centricity, sustainability, and resilience—and is proposed as an applicable structure for transitioning toward generative and transformative organisational models.

The document is situated within the emerging framework of the Paradigm 5.0, supported by recent scientific evidence and advanced theoretical contributions that outline an integrated vision of industrial evolution based on antifragility, shared value, and systemic responsibility, in support of industrial policies aimed at human well-being and long-term sustainability.

The aim is to demonstrate how this definition can serve as a concrete and replicable reference for future industrial policies, policy tools, technical standards, and European guidelines. In this sense, the paper is framed as an operational proposal addressed to European institutions, intended to fill the current definitional gap that hinders the implementation of the Industry 5.0 paradigm, while contributing to conceptual consolidation and the development of a shared normative language.

Keywords

Industry 5.0; antifragility; organisational well-being; transformative innovation; innovation management systems; ISO 56000; voluntary standardisation; common good; anticipatory governance.

1. Objectives and Context of the Contribution

The evolution of European production and organizational systems today requires not only the adoption of advanced technologies, but also the construction of conceptual and regulatory frameworks capable of guiding innovation towards social, environmental, and systemic objectives. The Industry 5.0 paradigm, promoted by the European Commission since 2021, represents an attempt to overcome the productivity-centric logic of Industry 4.0, introducing the principles of human-centricity, sustainability, and systemic resilience as the foundation for the future competitiveness of European industry.

Despite the widespread use of the concept, a unified definition has yet to be formally codified at a regulatory level. It is in this context that UNI/PdR 155:2023 was introduced—the first Italian reference practice proposing a definition of Industry 5.0 integrated into the logic of voluntary standardization and compatible with the Harmonized Structure (HS) of the ISO family.

This paper aims to:

1. Critically analyse the definition proposed in UNI/PdR 155:2023;
2. Compare it with the main European and international strategic and normative references;
3. Highlight its distinctive elements and potential contribution to the development of shared EU-level frameworks.

These objectives provide the analytical framework for the following chapters, which explore both the conceptual structure and the operational relevance of the proposed definition.

2. Institutional Framework and Key Normative References

The definition of the Industry 5.0 paradigm, as formalized in UNI/PdR 155:2023, is situated within a dynamic and multi-faceted context in which institutional orientations, regulatory indications, and theoretical developments converge around the need to move beyond the exclusively technocentric paradigm of Industry 4.0. Within this context, it is essential to clarify the main references that constitute the cultural and operational basis legitimizing the definitional proposal under analysis. At the European level, the Joint Research Centre (JRC) of the European Commission provided the first strategic references with the document *Industry 5.0: A Transformative Vision for Europe* (2021), which sets out the three founding pillars of the paradigm: human-centricity, environmental sustainability, and transformative resilience. This vision was further developed in the report *Industry 5.0 and the Future of Work* (JRC, 2023), which delves into the organizational dimension, emphasizing the need to structure cooperative, ethical, and adaptive work environments capable of valuing human labour as a generative and irreplaceable resource.

In 2024, the European Economic and Social Committee (EESC) also contributed to the debate with an own-initiative opinion aimed at encouraging the operational translation of the Industry 5.0 principles. The EESC stressed the need to develop a clear, verifiable, and actionable conceptual framework capable of guiding SMEs and European production systems in a transition based on equity, sustainability, and participation. Within this framework, UNI/PdR 155:2023 stands as one of the first coherent and structured normative responses to such calls.

From a normative standpoint, the ISO 56000 series—and in particular the forthcoming ISO 56001 standard on innovation management—is of growing relevance. These standards define a common language and a systemic structure for adopting innovative approaches within business management systems, based on the HLS (High Level Structure) model. UNI/PdR 155:2023 fits coherently within this framework, offering a definition that is compatible with existing normative models and potentially integrable into a transformative innovation management logic.

On the theoretical front, a fundamental contribution to the systematization of the Industry 5.0 paradigm is provided by the collective volume *Paradigm 5.0 – For a Transformative and Systemic Innovation* (edited by A. Pichierri and S. Fontana, 2023). The work articulates the paradigm around seven founding dimensions: participatory governance, systemic harmonization, organizational antifragility, the common good, ethics and technological responsibility, human centrality, and integrated sustainable value. The approach aims at adaptive and verifiable innovation capable of generating positive social and environmental impacts.

In this perspective, the definition contained in UNI/PdR 155:2023 can be read as a technical-normative synthesis of the theoretical and cultural lines outlined in the volume, translating foundational principles into operational and verifiable elements for businesses, institutions, and policy makers.

Taken together, these institutional, normative, and conceptual references constitute the framework within which this contribution is situated—aiming to strengthen the European formalization of the Industry 5.0 paradigm through a solid, shared, and implementation-oriented definition.

3. The Definition of Industry 5.0 in UNI/PdR 155:2023

UNI/PdR 155:2023 defines Industry 5.0 as follows:

"Organizational mode of conducting business that strengthens the role and contribution of the production sector towards society and the environment, placing the wellbeing of people and the ethical use of technology at the center of processes. This approach aims to establish itself as a resilient source of prosperity even in the wake of stressors, shocks, volatility, disorder, mistakes, faults, attacks, or failures, generating shared value beyond growth while respecting the productive limits of the planet, of future generations and of the common good."

This formulation is accompanied by three interpretative notes that clarify its theoretical premises and operational implications. A joint analysis of the definition and its notes reveals the systemic scope of the practice and its alignment with international normative references.

3.1. Evolutionary Nature of the Paradigm

The first note — *"Industry 5.0 evolves over time"* — affirms the evolutionary nature of the paradigm. Industry 5.0 is not conceived as a static model, but rather as a generative framework capable of adapting to emerging technological, social, and environmental changes. This approach incorporates principles of continuous learning and innovation under uncertainty, in line with the concept of antifragility introduced in ISO 56000:2025 (§3.2.14). Industry 5.0 thus marks a transition from the paradigm of resilience — understood as mere adaptive capacity — to that of generative transformation, where the enterprise evolves through crises and creates value under conditions of discontinuity.

3.2. Compatibility with the ISO Harmonized Structure

The second note — *"Industry 5.0 can benefit from the systemic approach inherent to ISO's Harmonized Structure (HS)"* — reaffirms the full compatibility of the definition with the Harmonized Structure of ISO management systems, ensuring its integration with existing standards (ISO 9001, 14001, 45001, 37301) and with emerging standards on innovation (ISO 56001:2024). Although ISO 56001 does not explicitly address value-laden concepts such as wellbeing or the common good, it is built on ISO 56000, which identifies stakeholder value orientation and antifragile capacity as foundational terms. UNI/PdR 155 not only adopts but anticipates these orientations, proposing a systemic and operational model capable of bridging existing standards and the challenges of emerging paradigms.

3.3. DNSH Principle and Systemic Responsibility

The third note — *"Industry 5.0 embraces the Do No Significant Harm (DNSH) principle"* — affirms the alignment of the practice with the European DNSH principle, as laid out in the Green Deal, the taxonomy for sustainable finance, and ESG criteria. The definition does not legitimise any form of innovation unless it is environmentally and socially sustainable, in an intergenerational perspective. The adoption of DNSH positions Industry 5.0 as an operational paradigm of systemic responsibility.

3.4. Ethical Subordination of Technology

The fourth note — *"A prerequisite of Industry 5.0 is that technology and innovation must serve people and the environment, rather than the contrary"* — overturns the technocentric logic of Industry 4.0 by reaffirming the primacy of the human being and the environment. Technology is understood as a means, not an end, and its adoption must be subject to criteria of equity, transparency, inclusion, and positive impact. This principle aligns with the ESIR report *Value Beyond Growth* (2023), which calls for overcoming the equation between innovation and growth, in favour of a broader vision of prosperity based on wellbeing, sustainability, and the creation of shared social value.

3.5. Strategic Alignment and Conceptual Foundations

In summary, UNI/PdR 155:2023 represents a conceptually robust, normatively compatible, and operationally applicable foundation for the formalisation of the Industry 5.0 paradigm at the European level. Its formulation incorporates and synthesises key strategic references from the European Commission, including: *Industry 5.0: A Transformative Vision for Europe* (2022), *Industry 5.0: Towards a Sustainable, Human-Centric and Resilient European Industry* (2021), *Enabling Technologies for Industry 5.0* (2020), *Industry 5.0 and the Future of Work* (2023), as well as theoretical reflections such as Banholzer's work on Industry 5.0 and Society 5.0. Furthermore, it integrates the original scientific contribution of Casale O. and Rinaldi P., *Industry 5.0: The New Industrial Approach* (2022/2023), which outlines the conceptual foundations of antifragility, shared value, and systemic organizational transformation.

4. Methodology of Analysis

The approach followed in this study is comparative and systemic. The objective is to assess the coherence, relevance, and enabling capacity of the Industry 5.0 definition contained in UNI/PdR 155:2023 by comparing it with the main institutional, normative, and scientific sources available at European and international levels.

The study was structured into three phases:

4.1. Document Collection

Twenty documents were selected and analysed, including:

- official texts from the European Commission (DG RTD, Horizon Europe, CoP 5.0);
- strategic reports (CEPS, OECD, WMF, ERA Roadmap);
- relevant ISO standards (ISO 56000:2025, ISO 56001:2024, ISO/DIS 53001:2025);
- Italian best practices (UNI/PdR 155:2023);
- accredited scientific contributions (Casale, Rinaldi and colleagues, 2023–2025);
- technical publications (INAIL, AICQ, Fondazione Brodolini).

4.2. Conceptual and Structural Analysis

Each document was analysed according to three main criteria:

- presence or absence of a definition of Industry 5.0;
- coherence of key concepts with the UNI/PdR 155:2023 definition (e.g., human-centricity, antifragility, generative value);
- normative or operational compatibility (with reference to the ISO Harmonized Structure, innovation management, and evaluation systems).

4.3. Cross-validation

Finally, a cross-validation of concepts was carried out to:

- verify the degree of convergence between the UNI/PdR 155 definition and European references;
- identify aspects where the practice anticipates or deepens content present in other sources;
- propose the definition as an operational and normative basis for future European standardization of the paradigm.

5. Discussion – Comparative Analysis and Validation of the UNI/PdR 155:2023 Definition

The adoption of the Industry 5.0 definition contained in UNI/PdR 155:2023 represents a structured and normative attempt to formalize a paradigm still in consolidation at the European and international levels. This chapter presents a comparative analysis of the main institutional, normative, and scientific references addressing the Industry 5.0 theme, aiming to verify the coherence, relevance, and enabling capacity of the definition proposed in the practice.

The analysis focuses on three directions:

1. Strategic alignment with the European vision: Starting from the document "Industry 5.0: A Transformative Vision for Europe" (EC, 2021), the conceptual pillars of the paradigm—human-centricity, sustainability, resilience—have been adopted as strategic references in multiple subsequent documents, including the Public Consultation Synopsis Report (2023), Industry 5.0 and the Future of Work (2023), and the BRIDGES 5.0 Policy Brief (2023). These sources converge in calling for an operational, measurable definition compatible with business management.
2. Coherence with European research and innovation programming: The Horizon Europe Strategic Plan 2025–2027 and the ERA Industrial Technologies Roadmap (2024) emphasize the shift from a quantitative growth logic to "prosperity beyond growth," anticipated in the Value Beyond Growth report (ESIR, 2023). UNI/PdR 155:2023 embraces this direction, offering evaluation tools consistent with Horizon's goals and measurable indicators applicable to real industrial contexts.
3. Connection with European industrial policies: The Community of Practice on Industry 5.0 (2024) and the CEPS Report (Renda, 2021; 2024) call for a formalized definition to support policies, programmes, and governance systems. UNI/PdR 155, based on the ISO Harmonized Structure, fills this gap with a structured definition that includes key concepts such as antifragility, well-being, and shared value, essential for the strategic repositioning of European industry.

These introductory elements form the basis for the following paragraphs, where the UNI/PdR 155 definition undergoes cross-validation with key policy, research, and technical standardization sources, including recent European Commission documents, ISO 56000 – 56001– 53001 standards, EESC reports, scientific contributions, and the most relevant European methodological guidelines.

5.1. Coherence with ISO 56000–56001 and ISO HS

ISO 56000:2025 provides the fundamental terminological reference for innovation management. It includes concepts which, though not expressly designed for the Industry 5.0 paradigm, represent a consistent conceptual foundation. These include:

- antifragile: "*ability to gain from stressors, uncertainty and risk*," referring to an entity;
- uncertainty management: "*systematic activities to address uncertainty in internal and external contexts*";
- common good: "*value that benefits a community and its members as a whole*".

These terms provide a useful conceptual base for building innovation systems oriented not only towards efficiency but also towards systemic and collective generativity.

ISO 56001:2024, as a requirement standard, does not directly introduce these value-based concepts but is explicitly based on ISO 56000:2025, which forms its semantic foundation. The Industry 5.0 definition in UNI/PdR 155:2023 is therefore a coherent and practical extension of these foundations. It operationalizes key concepts — *antifragility and the common good* — through a definitional structure compatible with the ISO Harmonized Structure (HS), supported by evaluation tools and transformative criteria.

5.2. Organizational Antifragility, Human Well-being, and Territorial Coherence

The distinctive element of the Industry 5.0 definition proposed in UNI/PdR 155:2023 is the explicit inclusion of antifragility as a strategic and transformative organizational property. Unlike resilience, understood as the

ability to resist shock and return to a previous state, antifragility assumes the capacity to evolve through discontinuities, generating new value. This distinction is conceptually outlined in ISO 56000:2025 defines "*antifragile*" as "*ability to gain from stressors, uncertainty and risk*".

UNI/PdR 155 moves away from abstract or merely adaptive approaches, instead proposing antifragility as a measurable organizational competence, through transformative processes, maturity matrices, and KPIs oriented toward value generation in unstable contexts.

As highlighted in the report *Industry 5.0 and the Future of Work*, "*antifragile organizations are able to construct meaning even in uncertainty, turning change from a threat into a lever*". In this perspective, antifragility is no longer a defensive reaction but a systemic competence, capable of transforming complexity into evolutionary co-creation.

This approach is further consolidated in the volume *Antifragility and Innovation Management Systems* (Casale et al., 2024), which introduces a four-stage evolutionary model (reactive, resilient, transilient, antifragile), offering a useful interpretive framework for designing adaptive innovation roadmaps. The practice embraces this logic operationally, integrating it into the structuring criteria for implementing Industry 5.0.

At the same time, the definition coherently emphasizes human well-being as a structural component of innovation. Empirical evidence from contributions by Casale, Modaffari, and Rinaldi (*Smart Working 5.0 and Territorial Demographic Rebalancing*, 2024) shows that advanced forms of remote work can promote:

- socio-demographic rebalancing of internal areas,
- greater work and territorial inclusion,
- increased workers' psycho-social well-being.

These elements also underpin the new INAIL (2025) methodologies for assessing work-related stress in digital environments, which identify hybrid work as a critical yet transformative area, requiring organizational design oriented toward prevention, participation, and human centrality.

UNI/PdR 155:2023 incorporates this systemic perspective, recognizing that value generation in an organization cannot be separated from people's well-being, relational quality, and territorial coherence.

The same conceptual structure is found in the volume *Paradigm 5.0* (Casale, 2024), which presents an advanced theoretical synthesis of the post-industrial model centred on human well-being, antifragility, systemic innovation, and shared value. The book comprehensively addresses key themes such as:

- the crisis of the linear growth model,
- convergence between Society 5.0 and Industry 5.0,
- governance of complexity,
- integration of sustainability, human-centricity, and Do No Significant Harm (DNSH).

In particular, the chapters on antifragility and the common good reinforce the theoretical framework behind UNI/PdR 155, showing how organizations can become transformative actors through systemic learning, territorial co-evolution, and extended accountability. The formalized definition in the practice thus constitutes a technical translation of a broader cultural paradigm, already outlined in the volume and now ready to be institutionally recognized.

5.3 Circular Economy and Transformative Governance: Integration within the Paradigm

A further element reinforcing the systemic scope and validity of the definition of Industry 5.0 contained in UNI/PdR 155:2023 is its conceptual and operational convergence with the paradigm of the circular economy and with emerging models of adaptive governance. These connections are central to the transition toward a regenerative, inclusive, and sustainable economy, as also delineated in the European industrial strategy and framework programmes for research and innovation (e.g., Horizon Europe, Green Deal Industrial Plan).

The contribution *Industry 5.0 and Circular Economy* (Casale, Cibien, Rinaldi, 2023), published in *Qualità*, highlights that the two paradigms are not alternative but complementary and mutually reinforcing. Circular and antifragile enterprises share several key characteristics:

- modularity and redundancy in organizational structures and production processes;
- systemic optimization beyond linear efficiency;
- the capacity to learn from failure and regenerate value across production, decision-making, and relational cycles.

The definition provided in UNI/PdR 155 explicitly incorporates these principles, presenting a business model capable not only of reducing environmental impacts, but also of generating shared value and actively transforming the conditions of the social and territorial context in which it operates. In this view, circularity is not limited to the ecological domain but extends to relational and cognitive dimensions.

This vision is further supported by the *OECD Framework for Anticipatory Governance of Emerging Technologies* (2024), which advocates for a governance approach to complexity based on:

- foresight methodologies that integrate future scenarios into present-day decision-making;
- systematic stakeholder engagement through deliberative practices, co-design, and transparency;
- dynamic organizational adaptation to socio-technological change.

UNI/PdR 155:2023 implicitly integrates these elements within its architecture, suggesting that enterprises must function as open, reflexive, and generative systems — oriented not solely toward performance, but toward purpose. The proposed governance perspective is thus not only aligned with ISO standards but also compatible with the *anticipatory approaches* necessary to manage uncertainty and position innovation as a *public good*.

5.4 Enabling Technologies as Levers for Systemic Innovation

The definition of Industry 5.0 proposed in UNI/PdR 155:2023 is further consolidated by the full integration of enabling technologies, which are not conceived merely as operational tools but as transformative levers for the systemic evolution of the enterprise. This orientation aligns with the most recent European guidelines, particularly the *Enabling Technologies for Industry 5.0* report (European Commission, 2020), which identifies key technologies — including artificial intelligence, collaborative robotics, neural interfaces, smart materials, cyber-physical systems, and digital twins — whose value lies in their ability to generate impact within complex, interconnected, and dynamic environments.

UNI/PdR 155:2023 reflects this perspective structurally, proposing an innovation model in which the adoption of advanced technologies is governed by criteria of environmental impact, ethical responsibility, and shared value. Technologies are thus not framed as ends in themselves, but as catalysts of generative processes, enabling new forms of organizational learning, workplace well-being, and sustainable transformation.

This approach is compatible with ISO 56000:2025, which, although not explicitly listing technologies, includes *technology-driven* innovation among the recognized approaches — alongside *user-*, *market-*, and *design-driven* methods. This implicit reference underscores the relevance of technology as a determining factor in innovation strategies, particularly when integrated within a value-oriented innovation management system.

The enabling logic set forth in UNI/PdR 155:2023 is translated into a normative and conceptual infrastructure that embeds technologies into processes of transformative innovation, assigning them a systemic and teleological function. In this sense, the practice acts as an operational bridge between ISO standardization and European policy, offering a technical articulation of the Industry 5.0 paradigm that explicitly positions technologies as structural enablers for the transition toward generative and common-good-oriented organizational models.

5.5. Industry 5.0 as a Strategic Reference for European Industrial Policy According to CEPS

In the document “*What ‘North Star’ for Future EU Industrial Policy?*”, published by CEPS in April 2024, Andrea Renda proposes adopting the Industry 5.0 paradigm as a strategic reference for a goal-based European industrial policy. This proposal arises from the need to overcome the limitations of the Industry 4.0 model, considered insufficient to address the interconnected challenges of the current polycrisis (climate, social, geopolitical, technological). From this perspective, industrial policy should integrate elements such as transformative resilience, sustainability, quality of work, territorial co-creation, and human well-being orientation.

This vision aligns with the definition of Industry 5.0 included in UNI/PdR 155:2023, which explicitly acknowledges the role of the organization as a generative actor of sustainable, shared value oriented to the common good, capable of operating adaptively, ethically, and relationally. In particular, the prassi introduces:

- the adoption of integrated KPIs that include environmental, ethical, generational, and social impacts, moving beyond purely economic metrics and enhancing the concept of shared value (Appendix B);
- the centrality of ethical governance based on vision, inclusion, distributed responsibility, and leadership oriented to the common good;
- the recognition of the innovation ecosystem as a lever to meet evolving needs, through systemic and collaborative involvement of internal and external stakeholders, both public and private;
- the promotion of lifelong learning and skills development to ensure the organization's capacity to generate sustainable and transformative innovation.

The CEPS document suggests adopting an industrial governance model based on iterative phases of foresight, co-design, measurement, and adaptation. Although it does not use the term “antifragility”, it shares with UNI/PdR 155:2023 the idea of an organization capable of learning, evolving, and creating value in complex and changing environments. In this context, the UNI/PdR provides an operational normative framework for the concrete implementation of the strategic vision outlined in the CEPS paper, contributing to making the principles of Industry 5.0 measurable and replicable at a managerial level.

5.6. Systemic Framing of UNI/PdR 155:2023 within the 5.0 Paradigm

The definition of Industry 5.0 contained in the current UNI/PdR 155:2023—describing it as an organizational mode capable of reinforcing the role of industry in society, oriented towards human well-being, ethical use of technologies, resilience, and sustainability—finds significant conceptual support in the so-called 5.0 Paradigm.

This paradigm, described in the volume *Il Paradigma 5.0* (Casale, Rinaldi, 2024), does not alter or replace the normative definition but offers a systemic framework useful for guiding its concrete implementation within organizations and territories.

The 5.0 Paradigm is structured around five interconnected elements:

1. *Transformative governance*, oriented toward “*purpose*” and the strategic coherence of industrial action;
2. *Harmonized Structure* (HS) as a common language for the integration of management systems;
3. *Antifragility* as an evolutionary capability beyond resilience, enabling the transformation of crises and stress into learning and innovation;
4. *Common good* as a value horizon and metric for social impact;
5. *Ethics* as the foundation of corporate action and the intangible infrastructure of the paradigm.

This framework makes explicit and connects the three pillars of Industry 5.0 also cited by the European Commission—human centricity, sustainability, and resilience—translating them into levers for action, maturity indicators, and design principles.

It follows that the Industry 5.0 definition found in the UNI/PdR 155 can be effectively interpreted and applied through the lenses of the 5.0 Paradigm, which facilitates its practical understanding and translation into industrial policies, organizational models, innovation strategies, and change governance.

5.7. Recognition of the Industry 5.0 Paradigm in the EESC Opinion

The EESC opinion “*Industry 5.0 – how to make it happen*” describes Industry 5.0 as an industrial paradigm grounded in human centricity, sustainability, and resilience, aiming to promote a profound transformation of the role of industry in European society. However, the EESC notes that the conceptual contours of the paradigm remain under development, requiring a more robust theoretical elaboration to clearly distinguish it from previous approaches or reductive interpretations.

In this perspective, the definition of Industry 5.0 presented in UNI/PdR 155:2023 offers a significant contribution to the conceptual consolidation the EESC calls for. Without substituting European regulatory processes, the prassi proposes a systemic and operational vision of the paradigm, integrating the three pillars identified by the EESC and enriching them with elements consistent with the international normative context.

On the level of *human centricity*, the EESC calls for “*a work environment that values the human role, also through collaborative use of technologies*”. UNI/PdR 155:2023 fully adopts this approach, placing human well-being and the ethical use of technologies at the center of corporate action, going beyond the technocratic model of Industry 4.0 and recognizing the generative value of people within organizational processes.

Regarding *sustainability*, the EESC emphasizes the importance of ecological transition and the need to move beyond the linear production model, promoting regenerative logics aligned with the European Green Deal. The UNI/PdR 155 definition explicitly includes the reference to the “Do No Significant Harm” (DNSH) principle and places business activity within the planetary boundaries and the rights of future generations, fully aligned with the strategic orientations expressed in the opinion.

With regard to *resilience*, the EESC urges the reinforcement of European industry’s capacity to face shocks, instability, and global crises, not only defensively but also transformatively. UNI/PdR 155, consistent with this view, adopts an evolutionary perspective by introducing the concept of *antifragility*, understood as the organizational ability to learn and generate value precisely from adverse conditions. This element constitutes a conceptual extension that is coherent with the direction expressed by the EESC, which calls for a deeper and more proactive vision of resilience.

The opinion also acknowledges that “*Industry 5.0 is not a fixed concept, but an evolving one*”, placing it alongside dynamic approaches such as Society 5.0, oriented towards the integration of digital innovation and social value. The definition in UNI/PdR 155 confirms this view, placing the evolving nature of the paradigm as a methodological premise for an enterprise capable of learning, transforming, and acting in changing environments.

From an operational standpoint, the EESC emphasizes the need to make the paradigm accessible to SMEs as well, through interoperable and integrable tools. The definition included in the prassi addresses this requirement, being structured according to the ISO Harmonized Structure and thus fully compatible with the main management systems already in use (e.g., quality, environment, health and safety, compliance).

Finally, the EESC highlights the need to recognize the transformative potential of industry as a source of *prosperity* and *well-being* beyond mere growth, capable of operating within planetary boundaries and placing workers’ well-being at the center. UNI/PdR 155 fully embraces this concern, introducing in its Industry 5.0 definition an explicit focus on the generation of systemic value, territorial coherence, and intergenerational impact, positioning the enterprise as an active agent of social transformation.

In summary, the Industry 5.0 definition included in UNI/PdR 155:2023—although developed in a national context—emerges as a conceptual and operational foundation consistent with the objectives outlined in the EESC opinion. It can therefore make a concrete contribution to the clarification and harmonization process of

the paradigm at the European level, supporting the evolution of industry toward more inclusive, ethical, and sustainable models.

5.8. Industry 5.0 and Labour Transformations: Convergences with the JRC Report (2023)

The European Commission's report *Industry 5.0 and the Future of Work* (JRC, 2023) explores the Industry 5.0 paradigm from the perspective of labour transformations, human-machine collaboration, and the design of more inclusive and resilient production systems. In line with the vision expressed in the 2021 foundational document, the report proposes an evolution of the institutional framework into a more operational direction, attentive to the organizational and social aspects of the industrial transition.

In particular, the document states that “*Industry 5.0 places human work at the centre of industrial transformation*”, moving beyond the conception of labour as a mere production factor and promoting an approach that acknowledges its social, cultural, and personal significance. This perspective is fully consistent with the definition contained in UNI/PdR 155:2023, which identifies the centrality of the human being as a constitutive dimension of the paradigm, not a secondary one.

The report further emphasises that “*workers should not be passive recipients of technological change, but active participants in shaping it*”, highlighting the need for participatory and socio-technical co-design processes. UNI/PdR 155 reflects this principle through the reference to “*synergistic cooperation between people, intelligent machines, and digital systems*”, promoting complementarity between human and artificial intelligence.

Another element of convergence lies in the shared focus on *transformative resilience*. The JRC (2023) promotes the construction of work environments capable of adapting to change, supporting well-being, lifelong learning, and meaningful participation (“*resilient and adaptive workplaces*”). UNI/PdR 155 extends this perspective by introducing the concept of *antifragility*, which values the capacity of organizations not only to withstand stress but to evolve positively in *complex and uncertain environments*.

Finally, the European document affirms that “*ethical considerations must be embedded into the design and deployment of Industry 5.0 technologies*”, acknowledging the value-based dimension of transformation. The Italian definition explicitly includes the reference to sustainable value for society as a whole, offering an integrated interpretation that combines sustainability, *organizational well-being*, and *social responsibility*.

Overall, the definition proposed in UNI/PdR 155:2023 responds in a structured, coherent manner to the guidelines set out in the JRC report, offering a normative and application-based foundation that could serve as a useful reference for the European governance of the paradigm

5.9. Industry 5.0 and the Challenge of a Shared Definition: Insights from the BRIDGES 5.0 Project

One of the most significant contributions to the European debate on Industry 5.0 is found in *Policy Brief No. 5 of the BRIDGES 5.0* project, published in October 2023 within the Horizon Europe framework. The document clearly and explicitly identifies a central strategic issue:

“The lack of a uniform, widely accepted definition of Industry 5.0 and its three pillars hampers the understanding and uptake of Industry 5.0”.

According to the consortium, the absence of a shared definition constitutes a tangible obstacle to the dissemination and implementation of the paradigm. The project highlights how this gap affects conceptual clarity, policy coherence, the ability of businesses to find orientation, and the effective integration of the paradigm into productive, educational, and institutional contexts.

In response to this shortcoming, BRIDGES 5.0 proposes the development of a *collaborative conceptual framework*, constructed through the engagement of public and private stakeholders, enterprises, trade unions,

universities, and institutions. The stated goal is to make Industry 5.0 more understandable, measurable, and actionable, overcoming the semantic and strategic ambiguity that still surrounds it.

Within this scenario, UNI/PdR 155:2023—already extensively analyzed in previous chapters—emerges as a *concrete and structured response* to this need. The definition it provides, supported by explanatory notes, represents a normative conceptual model capable of offering:

- a formulation consistent with the three foundational pillars of the paradigm (human centricity, sustainability, resilience);
- a structure based on ISO criteria (Harmonized Structure), which strengthens its clarity and methodological usability;
- a technical foundation useful for the development of implementation, evaluation, and standardization tools.

The convergence between the needs expressed by the BRIDGES 5.0 project and the formal content of UNI/PdR 155:2023 further reinforces the validity and relevance of the Italian definition, suggesting its potential role as an operational reference for the future harmonization of the Industry 5.0 paradigm at the European level.

5.10 Industry 5.0 in Horizon Europe Programmes: Strategic and Operational Coherence

The *Horizon Europe Work Programme – Cluster 4 “Digital, Industry and Space” (HORIZON-CL4-2025_V5.07)* represents one of the most advanced and operational policy documents of the European Union regarding industrial transformation. Within this programme, the *Industry 5.0 paradigm* is not merely mentioned but structurally integrated at multiple points, with textual references confirming its human-centric, sustainable, and resilient dimensions, in full alignment with the definition provided in Article of UNI/PdR 155:2023.

The first reference appears on page 25, stating: “*Across industries, the human dimension (including gender differences) will be stressed via the Industry 5.0 paradigm*”. This is a key statement confirming that Industry 5.0 is now recognized as an operational framework for innovation that enhances the centrality of the human being in the design and adoption of technologies, also accounting for gender differences.

On page 52, the Programme further elaborates: “*Improve the capacities of actors to integrate Industry 5.0 (human-centricity, sustainability, and resilience) in the technological development processes...*”. This confirms the operational adoption of the three foundational pillars already present in the standardized definition: human-centricity, sustainability, and systemic resilience. The explicit reference to “technological development processes” indicates that Industry 5.0 is not perceived as a mere theoretical orientation, but as a design principle to be integrated into real industrial processes.

The transformative and generative nature of the paradigm is reinforced on page 53: “*Industry 5.0 recognises the power of industry to achieve societal goals beyond jobs and growth to become a resilient provider of prosperity.*”. This statement aligns with the direction outlined in the UNI/PdR 155 definition, where the enterprise is described as a generator of “*prosperity beyond growth*”, emphasising that innovation must be aimed at collective well-being, systemic stability, and territorial regeneration.

The operational dimension is further articulated in the chapters on systemic design:

- On page 226, among the “Expected Outcomes”, the objective is stated as: “*Demonstrated incentives for systemic transformation towards Industry 5.0 and for adopting organisational and business models...*”. The language used confirms the intent to promote organisational and entrepreneurial models consistent with the Industry 5.0 paradigm, acknowledging its systemic and transformative nature.
- On page 227, the Programme proposes the creation of dedicated infrastructures: “*Proposals should elaborate on initiating a pilot network of Industry 5.0 system innovation hubs...*”. The reference to a network of systemic innovation hubs confirms the need to translate the paradigm into tangible

structures for experimentation, learning, and transformation—coherent with the antifragile and generative approach of UNI/PdR 155.

- Finally, on page 228, the Programme explicitly calls for evolutionary pathways: *“Prototype new transformation journeys and learning ecosystems for industrial ecosystem / value chain players to increase learning capacities of organisations... based on Industry 5.0 paradigm.”*. This passage confirms the systemic and adaptive framework of Industry 5.0, highlighting the urgency for evolutionary models of organizational learning and distributed transformative capabilities—central elements of the UNI/PdR 155 framework.

In summary, the textual analysis of these references confirms that the definition contained in UNI/PdR 155:2023 is not only aligned with the European Commission’s latest strategic orientations, but also anticipates their conceptual and systemic operationalisation, offering a definitional structure ready for standardisation and wide-scale adoption.

5.11 Industry 5.0 in Scientific Literature: Contribution by De Felice and Petrillo

To further confirm the conceptual robustness of the Industry 5.0 definition provided in UNI/PdR 155:2023, it is worth referring to the editorial contribution *Smart Manufacturing Systems for Industry 5.0: Challenges and Opportunities* by Fabio De Felice and Angela Petrillo (2023), which clearly outlines the key features of the emerging paradigm, particularly in the context of *smart manufacturing*.

The analysis of the text identifies ten key elements shaping the transition from Industry 4.0 to Industry 5.0: *human centrality, technological ethics, human-machine symbiosis*, the connection between *sustainability* and *smart manufacturing*, continuous adaptation, transformation of value models, the use of big data for sustainable purposes, reconfigurability of production systems, *organizational learning*, and the recognition that digital transformation is now the present, not merely the future.

These elements are thoroughly and systematically reflected in UNI/PdR 155:2023. The definition in Article 3.14, accompanied by three interpretative notes, incorporates key concepts echoed by De Felice and Petrillo in statements such as: *“The human-centric design of cyber–physical production systems (CPPS) is a very promising field of research”*, *“Technologies enable human–machine symbiosis in the factory of the future”*, and *“A value-oriented and ethical mode of technology engineering in Industry 5.0 is an urgent and sensitive topic”*.

These statements reinforce the positions outlined in UNI/PdR 155:2023 regarding technological ethics, human well-being, and the design of collaborative systems.

The perspective of *organizational antifragility* as an evolutionary capability beyond resilience is fully coherent with the authors’ invitation to *“continuously adapt to a constantly changing environment”*, a central element of the standardized definition, which asserts the need to learn and generate value amid discontinuity. Coherence also extends to the systemic and transformative dimension of technology: De Felice and Petrillo argue that *“Digital transformation implies a redesign of processes and must be accompanied by a change in management process”*, highlighting an integrated approach to structure, culture, and governance—elements developed of the standard.

The statement *“Smart manufacturing and sustainability are increasingly connected”* aligns fully with references in UNI/PdR 155:2023 to the circular economy, the “Do No Significant Harm” (DNSH) principle, and the Sustainable Development Goals (SDGs). Similarly, the extended use of data and digital technologies for environmental purposes - highlighted in the paper as *“Digitalization and the use of big data are seen as key enablers of increased sustainability”* - is reflected in the standard’s sections on digital platforms and open innovation.

Finally, the view of Industry 5.0 as a current and operational paradigm — not merely theoretical or prospective — is reiterated by the authors’ assertion: *“The digital revolution is now our ‘present’, belonging to the future no longer”*.

This reinforces the approach of UNI/PdR 155:2023, which offers concrete tools (maturity matrices, KPIs, transformative criteria) to enable the practical application of the model within existing enterprise systems through seamless integration with the ISO Harmonized Structure.

In summary, the convergence between the scientific elaboration by De Felice and Petrillo and the normative structure of UNI/PdR 155:2023 demonstrates substantial consistency between academic reflection and technical proposal. The standardized definition thus emerges not only as an advanced conceptual synthesis but also as an applicable framework, already aligned with the main trends of European research on Industry 5.0.

5.12. Convergence between UNI/PdR 155:2023 and the World Manufacturing Report 2024 within the Framework of Industry 5.0 and Antifragility

The definition of Industry 5.0 proposed by UNI/PdR 155:2023 identifies a model of enterprise that strengthens the contribution of the industrial sector to society and the environment, placing *human well-being*, the *ethical use of technology*, *prosperity beyond growth*, and the *capacity to evolve through discontinuity* at its core. The accompanying notes clarify that *the paradigm is intrinsically dynamic*, that it benefits from the ISO Harmonized Structure, that it embraces the DNSH principle, and that it *subordinates technology to people and the environment*. Within this framework, antifragility and orientation toward the common good are not optional attributes but foundational criteria linking innovation to an extended system of responsibility.

The *World Manufacturing Report 2024*, published by the World Manufacturing Foundation, provides a global scenario that makes evident why *Industry 5.0 must be conceived as an evolving paradigm*. The Outlook 2030 is an exercise in foresight that analyses geopolitical, economic, social, technological, legal, and environmental forces capable of pushing societies and industries beyond critical tipping points — both positive and negative — showing that technological, social, and environmental change is structural, accelerated, and often irreversible. It portrays an industry required to *learn and redesign itself within a VUCA environment*, characterized by *shorter cycles*, *continuous upskilling*, *pervasive adoption of automation and artificial intelligence*, and a *culture of anticipation rather than reaction*.

Within this framework, the Report places particular emphasis on *governance*. It highlights the *importance of long-term strategic planning even within operational constraints*, proactive risk management and business continuity along the entire value chain, the *use of data and AI for scenario monitoring*, and the need for adaptive decision-making mechanisms. It is precisely in this context that the Report explicitly refers to the notion of *antifragility*, urging organizations to “*build antifragility capabilities against unexpected future events*”, transforming contingency planning into a lever for organizational learning and redesign. UNI/PdR 155 provides the corresponding normative counterpart, defining antifragility as an evolutionary quality of the organization and guiding innovation processes toward *generative outcomes that emerge beyond crises*.

The alignment between the two documents extends to the reference to the Sustainable Development Goals. The World Manufacturing Report includes the SDGs among the major global frameworks that will shape legal and operational tipping points for manufacturing in the coming decade, with a focus on responsible production and consumption, climate action, clean water, and affordable and clean energy. It also anticipates the emergence of a post-2030 framework that reflects new priorities and technological progress. This approach fully mirrors the orientation of UNI/PdR 155, which links sustainable innovation to accountability for social and environmental impacts and to coherence with international standards.

From a technological perspective, both texts converge in viewing AI, automation, and connected platforms as meaningful only when embedded in *renewed value models and governance architectures* that define their purposes and boundaries. The World Manufacturing Report connects technological maturity to the prevention of systemic tipping points and to the *adaptive capacity of industrial ecosystems*, while UNI/PdR 155 embeds technological adoption within ISO-based processes, roles, and responsibilities, connecting innovation to human well-being, sustainability, and transformative resilience. This complementarity shows how the WMF’s scenario mapping explains why the *5.0 paradigm must remain evolutionary and sensitive to social and environmental issues*, while the standardized definition in UNI provides the operational grammar through which this vision can be translated into verifiable governance and innovation practices.

In summary, the dialogue between the World Manufacturing Report 2024 and UNI/PdR 155:2023 *consolidates the image of Industry 5.0 as a living, adaptive, and purpose-driven paradigm*. The ongoing evolution of technologies and social and environmental challenges requires a constant renewal of organizational choices and structures, while governance becomes the hinge connecting foresight and action, *resilience and antifragility*, principle and measurable contribution to the SDGs. In this light, Industry 5.0 is not a static destination but a continuous process of transformation that ties competitiveness to shared prosperity, the common good, and long-term sustainability.

5.13 Conceptual Coherence between Industry 5.0 and the Antifragility and Innovation Management Systems Framework

Although the document *Antifragility and Innovation Management Systems* (Casale et al., 2024) does not explicitly mention the term “Industry 5.0”, it offers a significant contribution in support of the definition adopted in UNI/PdR 155:2023. References to moving beyond resilience toward antifragility, the role of innovation as a tool for navigating uncertainty, and the construction of dynamic, systemic, and regenerative organizations demonstrate conceptual alignment with the three pillars of Industry 5.0: human-centricity, sustainability, and transformative resilience.

The text states: “*Just as a living system is by its nature antifragile, as it has an intrinsic ability to adapt to the environment by learning more and better from it than its elements can learn individually, so an organization [...] can learn, adapt and thrive, if appropriately trained to correctly read the signals coming from an ever-changing environment*”.

This vision of the organization as a complex, learning system fully reflects the concept of a “thriving” enterprise operating in dynamic contexts, as proposed by the Industry 5.0 paradigm. The principles of innovation (Innovation Management Principles - IMP - 4, 5, 6, and 7 of ISO 56000) analyzed in the document — such as culture, intuition, uncertainty management, and adaptability — are interpreted through an antifragile lens that values diversity, experimentation, and generativity. These elements coincide with the systemic approach to *value creation for people, the environment, and society* promoted in the Industry 5.0 definition.

Therefore, the document serves as a valuable reference confirming both the theoretical and practical soundness of the definition proposed in UNI/PdR 155, reinforcing its coherence with an *evolutionary industrial model* aimed at *transformative sustainability*.

5.14 Sustainability of the Industry 5.0 Definition in Light of JRC Evidence

The definition of Industry 5.0 introduced in Article 3.14 of UNI/PdR 155:2023 — “*an evolutionary enterprise model aimed at generating prosperity beyond growth, based on the organizational capacity to learn and create value even under discontinuous conditions, through a dynamic balance between technological ethics, human well-being, sustainability, and transformative resilience*” — is supported by three accompanying notes specifying its foundational pillars: antifragility, compatibility with the ISO Harmonized Structure, and orientation toward ethics, well-being, and territory. A comparative analysis with the JRC report *Supporting the Digital Transformation of Vocational Education and Training* confirms the full sustainability of this framework.

The JRC identifies the enablers of digital transformation in VET, placing emphasis on the ability of training systems to evolve in uncertain environments. It recommends the integration of socio-emotional skills related to resilience and sustainability, explicitly aligning them with the principles of Industry 5.0 and Society 5.0. Furthermore, it promotes flexible accreditation mechanisms — particularly digital micro-credentials — to rapidly update skills and maintain their traceability over time. These operational requirements reflect, on the training side, the same antifragile logic cited in Note 1 of the definition, wherein the organization benefits from shocks and learns from discontinuities.

At the governance level, the report emphasizes the need for an “ecological approach” based on systemic interconnection and stakeholder contextualization, calling for the creation of stable cooperation structures

between VET authorities and industrial representatives for the continuous updating of training offers. This multi-level approach is fully compatible with the ISO Harmonized Structure referenced in Note 2: the management of transformation is thereby framed as a set of planned processes, improvement cycles, and performance metrics — all made interoperable through UNI/PdR with existing standards for quality, environment, safety, and innovation.

Finally, the ethical and territorial dimension of Note 3 is reflected in JRC recommendations that link the digitalization of VET to the twin transition and the promotion of inclusion, environmental sustainability, and “*decent work*”. It emphasizes that technology must reinforce — not replace — human centrality. The focus on vulnerable groups, human-centered approaches, and ESG impact measurement underscores, within the education domain, the necessity of industrial innovations that are territorially grounded and oriented toward the common good.

The convergence of JRC empirical evidence with the three interpretative notes of UNI/PdR 155 demonstrates that the definition of Industry 5.0 is not only theoretically aligned with European policies, but also supported by operational references already applicable within the educational ecosystem. Indeed, the antifragile dimension, the management structure, and the territorial ethics find, in the VET framework, a practical testing ground capable of validating their sustainability and accelerating their diffusion within European industrial governance.

5.15. Definition of Industry 5.0 in UNI/PdR 155 and its Relation to ISO/UNDP 53001, SDGs and the Common Good

The definition of Industry 5.0 contained in UNI/PdR 155 describes an organisational model that strengthens the contribution of industry to society and the environment, placing human well-being and the ethical use of technology at the centre and qualifying prosperity as resilient beyond growth, within planetary boundaries, in reference to future generations and the Common Good. The accompanying notes emphasise the evolutionary nature of the paradigm, its compatibility with the ISO Harmonized Structure, its adherence to the Do No Significant Harm (DNSH) principle, and the subordination of technology to people and the environment. Although the term *community* is not explicitly mentioned, the definition’s references to society, future generations, and the Common Good implicitly articulate a communitarian vision of the enterprise as an actor embedded within and co-responsible for its territorial and social ecosystems.

When read through the lens of future ISO/UNDP 53001, the definition gains a managerial and systemic grammar that makes its commitments measurable and verifiable. ISO 53001 structures management systems around the Sustainable Development Goals (SDGs) and establishes a continuous *plan–do–check–act* cycle (PDCA), integrable with other ISO systems. Within this framework, the key elements of UNI/PdR 155—human well-being, sustainability, antifragility, and extended responsibility—translate into purposes, roles, processes, and performance indicators that can be tracked and reviewed over time. ISO 53001 explicitly recognises the *Common Good* as a foundational concept, in continuity with ISO 56000, and references ISO 56001, thereby reinforcing its linkage with innovation management and embedding the Industry 5.0 paradigm within a coherent system of values and operational requirements.

The alignment extends to the scope of interested parties. ISO 53001 broadens this notion to include the planet, society, the environment, ecosystems, and future generations, connecting such an extension directly to the SDGs as expressions of the Common Good. This broadened inclusivity reflects the same systemic perspective implicit in UNI/PdR 155, where the enterprise is conceived as part of an interconnected social and environmental network. Human centrality thus becomes not a symbolic principle but a design criterion that informs consultation, participation, and decision quality across the entire value chain.

ISO 53001 also introduces a framework of *multi-level governance* and cooperation among institutions, enterprises, social partners, and communities to align organisational objectives with sustainable development strategies at local, national, and global scales. This approach resonates with the vision of Industry 5.0 outlined in UNI/PdR 155, in which the enterprise acts as a learning and generative node within a broader ecosystem of

innovation and shared responsibility. Both texts converge on the idea that *long-term resilience* and *prosperity* depend on *collaborative governance*, *transparency*, and the *continuous renewal* of organisational choices.

The DNSH principle mentioned in UNI/PdR 155 finds direct correspondence in ISO 53001's requirements for identifying actual and potential impacts, clarifying trade-offs, mitigating risks to acceptable levels for affected parties, and reviewing priorities as new evidence emerges. In both frameworks, the avoidance of significant harm becomes a dynamic discipline of decision-making rather than a static declaration, linked to performance measurement and continuous improvement.

In summary, the definition of Industry 5.0 in UNI/PdR 155 finds in ISO 53001 a coherent, SDG-oriented system grammar. The Common Good is acknowledged as a central normative anchor, consistent with ISO 56000; ISO 53001 refers to ISO 56001, strengthening the bridge with innovation management; and the cyclical PDCA architecture enables the progressive alignment between ethical intent and measurable impact. Together, the two texts articulate a unified framework in which Industry 5.0 emerges as both an evolutionary vision and an operational language, connecting competitiveness with shared prosperity through an extended responsibility that encompasses people, society, communities, and the environment.

6. Conclusions and Recommendations for the Industry 5.0 Community of Practice and the European Commission

The analysis across the institutional, normative and scientific corpus supports the validity of the UNI/PdR 155 2023 definition of *Industry 5.0*, which is both conceptually sound and operationally usable. It aligns with the European pillars of *human centricity*, *sustainability* and *transformative resilience*, while integrating the value horizon of the *common good*, the *Do No Significant Harm DNSH* principle and the ethical subordination of technology to people and the environment. The definition treats discontinuity as the normal condition of contemporary industry and frames organisational evolution in *antifragile* terms, turning resilience from a defensive stance into a generative trajectory. In continuity with the ISO ecosystem, the definition is interoperable with the *Harmonized Structure HS*, consistent with the terminology of *ISO 56000*, complementary to the requirements of *ISO 56001* and mutually reinforcing with the *SDG* oriented logic of *ISO 53001*, which broadens the scope of interested parties to include society, environment, ecosystems, the planet and future generations, and translates purpose into auditable processes and indicators within a *PDCA* architecture.

The definition, extensively validated in the preceding chapters, is based on a systemic and generative vision of the organization, viewed as an actor capable of creating value for the *common good* through sustainable, ethical, open, interdisciplinary and *antifragile* innovation processes. The organization is recognised as an entity embedded in both territory and time, engaged in dialogue with present and future generations, and responsible for the impacts it generates on the economic, social and environmental ecosystem. Framed in this way, the UNI/PdR 155 definition aligns with European priorities on *human centricity*, *sustainability* and *transformative resilience*, while remaining interoperable with management architectures and *SDG* oriented governance. It therefore provides a valid and immediately usable reference for policy, programmes and enterprise practice.

Cross validation with European policy confirms this convergence and widens it beyond the standards arena. The *EESC* calls for a clear and actionable conceptualisation, and the definition offers precisely that, while remaining loyal to priorities on decent work, ecological transition and social inclusion. *JRC* evidence on the future of work and skills ecosystems substantiates the centrality of human dignity, participatory co design and adaptive workplaces, which the definition treats as structural conditions rather than decorative aspirations. *Horizon Europe* embeds *Industry 5.0* as a design and evaluation lens, signalling that the paradigm already operates within programme logic and expected outcomes. The *World Manufacturing Report* presents long range scenarios and a governance emphasis that echo the same anticipatory and evolutionary stance, while *CEPS* positions *Industry 5.0* as a credible north star for industrial policy oriented to shared prosperity beyond growth. The *BRIDGES 5.0* project highlights the cost of the current definitional gap, and the UNI/PdR 155 text responds with a coherent formulation capable of immediate uptake by organisations and intermediaries.

On governance and accountability, the definition provides an implementable language that reduces ambiguity for organisations of different sizes, including *SMEs*. Its compatibility with existing systems enables rapid integration without redundant frameworks, while the *DNSH* commitment and the enlarged scope of interested parties support social legitimacy and policy coherence. The *PDCA* logic, together with indicators and review cycles, closes the loop between intention and evidence, and allows progress to be demonstrated and compared over time across value chains and ecosystems.

Recommendations follow directly from this evidence base and rely solely on the UNI/PdR 155 definition as a common reference. The Community of Practice can adopt the UNI/PdR 155 definition to structure dialogues, pilots and capability building across sectors and territories, and to align roadmaps, maturity paths and evaluation practices with the European pillars. The European Commission can reference the UNI/PdR 155 definition in calls, guidance and assessment criteria wherever an operational interpretation of *Industry 5.0* is needed, and can invite feedback from *Horizon* projects, *JRC* studies and consultations with social partners to refine terminology, indicators and audibility. Public administrations clusters and intermediaries can convene institutions enterprises social partners and communities around territorial transition pacts that translate the UNI PdR 155 definition into place based portfolios of projects and learning infrastructures ensuring transparency measurability and interoperability along value chains. In this context, standardization bodies such as ISO, CEN CENELEC, UNI and national counterparts can delineate and publish cross reference documents,

guidelines and operational indications so that the definition of Industry 5.0, or its foundational principles, human centricity, sustainability, antifragility or transformative resilience, ethics and DNSH, orientation to the common good, is taken up, integrated and harmonised both within system standards, HS based and integrated with existing management systems, and within standards and practices for professions and competences. Such deliverables may include mapping matrices with ISO 56000, 56001, 53001, sectoral guides, and competence requirements for professional roles — profiling, learning outcomes, assessment criteria — fostering terminological coherence, interoperability of requirements, and measurability of outcomes along value chains.

Taken together these steps would accelerate convergence on a shared and verifiable language for Industry 5.0 and shorten the distance between principle and practice. The UNI PdR 155 definition proves valid because it is coherent with authoritative European visions and foresight compatible with management architectures and SDG governance comprehensive in its treatment of people society environment and future generations and adaptive to uncertainty and discontinuity. It therefore offers a credible foundation on which the European Union its Member States and the Industry 5.0 Community of Practice can build policies programmes and *organisational transformations* that connect *competitiveness* with *shared prosperity* and the *common good*.

7. Operational Recommendations

In light of the above findings, the following proposals are submitted to the Community of Practice on Industry 5.0 and the European Commission:

1. *Formally adopt the definition of Industry 5.0* contained in UNI/PdR 155:2023, recognizing it as a normative and technical reference model for the future European harmonization of the paradigm.
2. *Enhance the contribution of Italian voluntary standardization* in the consolidation process of the paradigm, promoting its recognition within European policies on innovation, just transition, and sustainable territorial development.
3. *Promote convergence between the European innovation strategy and voluntary standardization*, supporting the adoption of *interoperable, measurable, scalable models* aligned with *ESG principles* and the *2030 Agenda SDGs*.
4. *Support large-scale experimentation* of the *UNI/PdR 155:2023 definition* and its related technical tools (KPIs, governance models, antifragile approaches) within European programmes such as *Horizon Europe, Digital Europe, cohesion policies, and the green transition*.
5. *Define, at the European level, the competencies, knowledge, and responsibilities* of professionals operating within the *Industry 5.0 paradigm*, particularly for *managerial and leadership roles*, including through the development of a *CEN European technical standard* aimed at the *qualification, training, and certification* of the involved professional profiles.

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9. Signatories as of 28 June 2025

- *Oliviero Casale*, Innovation Manager at UniProfessioni, Coordinator of the World Industry 5.0 Forum by Confassociazioni, President of Confassociazioni Emilia Romagna, Board Member at Communia Foundation, Committee Member ISO TC 279.
- *Paola Rinaldi*, Professor at the University of Bologna and Vice-President of Confassociazioni Emilia Romagna.
- *Andrea Minarini*, President of SIGeRiS – Italian Society of Risk Managers in Healthcare.
- *Francesco Castagna*, Vice-President for Digital at Fabbrica Italiana dell’Innovazione and Innovation Manager 11814.
- *Arturo Lavalle*, Head of R&D at Unimarconi and Innovation Manager 11814.
- *Stefano de Falco*, Professor at University Federico II Naples and Board Member of AICQ Reti di Imprese.
- *Rosario Lanzafame*, Full Professor of Mechanical and Energy Systems Engineering at University of Catania and Innovation Manager 11814.
- *Domenico Modaffari*, Public Official, freelance journalist, expert in occupational health and safety and anti-discrimination law.
- *Elisabetta Pieragostini*, CEO and UNI 11814 Innovation Manager at DAMI Srl, President of Confindustria Fermo – Accessories Division.
- *Rick Fernandez*, President of 20-20 Innovation, Inc., Chairman of US TAG TC279 Innovation Management System.
- *Alvaro Reinoso*, Director of PCAinnovation, President of TC279 Guatemala, Member of the Chairman Advisory Group ISO/TC279 Innovation Management.
- *Marco Antonio Imbesi*, President of AICQ Emilia Romagna.
- *Gianfranco Luisi*, President of Technical Scientific Committee for the Third Sector, Conflavoro PMI Association.
- *Marco Sponziello*, Professor at UniSalento, President of Next EU Association, EU Climate Pact Ambassador, Innovation Manager 11814.
- *Giuseppe Bratta*, Managing Director and UNI 11814 Innovation Manager at Plasmapps and Inapulua Srl, President of Puglia Energy Cluster.
- *Pierluigi Rippa*, Associate Professor of Industrial Engineering and Coordinator of the Management Engineering programme at University Federico II Naples, Coordinator of the Advisory Board of Fabbrica Italiana dell’Innovazione.
- *Luca Luigi Manuelli*, Director of the Observatory on Generative Artificial Intelligence, Lecturer at Università degli Studi “Guglielmo Marconi”, President of Editoriale Industria Italiana.
- *Raffaele Zito*, Head of Technical Secretariat for the Volturno River Contract, Province of Caserta, and Circular Economy Advisor.
- *Mario Di Nardo*, Professor at Pegaso Online University.
- *Bruno Siciliano*, Full Professor of Automation and Robotics at University of Naples Federico II, Director of PRISMA Lab, former President of IEEE Robotics and Automation Society.
- *Sebastian Caputo*, CEO of 012factory, MIMIT-certified incubator, and Innovation Manager UNI 11814.
- *Carime Salamone*, RSPP/DPO at CNIT – National Inter-University Consortium for Telecommunications.
- *Tiberio Graziano*, President of Vision & Global Trends – International Institute for Global Analyses, Director of *Geopolitica. Journal of Geopolitics and Related Matters*.
- *Jonny Dotti*, President of Communia Foundation (Permanent Network for the Commons).
- *Tiziana Valerio*, Director General and UNI 11814 Innovation Manager at DHITECH – High-Tech Technology District Foundation.
- *Paolo Cuccia*, President of Artribune Srl, Chairman of Gambero Rosso S.p.A., Board Member of Communia Foundation.
- *Cinzia Rossi*, President of “Siamo Impresa PMI – Gruppo FENAPI” and Board Member of Communia Foundation.
- *Fabio De Felice*, Professor at Parthenope University of Naples and Founder of Protom Spa.
- *Antonio Marco Pantaleo*, Professor at the Department of Soil, Plant and Food Sciences (Di.S.S.P.A.), University of Bari.

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