Report on industrial symbiosis standardisation needs

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Deliverable 4.5

Report on Standardisation Needs

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Executive Summary

This report provides an overview and analysis of EU standards related to the uptake of Industrial Symbiosis and resource efficiency in the industrial process sector, providing recommendations to European regulatory and standardisation bodies on required future focus and action.

This is the result of work carried out in the Work Package 4 Action Plan for Industrial Symbiosis in Europe of the SCALER project, that aims to increase the uptake of industrial symbiosis across Europe. Under the European Union's Horizon 2020 initiative, the project has developed a set of best practices, tools and guidelines, helping businesses and industrial sites and policy makers support the scaling of IS practices across the European territory.

This research was based on all outcomes and activities undertaken within the project, as well as desktop research on the latest EU standards and related material.

This report displays:

- Overview of international standards and of the standardization framework in Europe
- Gaps and Recommendations for the standardization framework
- Conclusions

1. Introduction

According to historical demographers, by 1800 the global population was around 1 billion people, and it has increased to 7.7 billion to date. The rapid growth of population in the last two centuries has come with environmental stress and degradation, a result of increased demand and waste of resources to secure food, clothing, shelter, comfort and recreation. Such damages are reflected in the loss of biodiversity, increase of greenhouse gas emissions, rise of deforestation, stratospheric ozone depletion, acid rain, loss of topsoil, and shortages of water, food, and fuel-wood in many parts of the world (The National Academies of Sciences 1993). Such impact on ecosystems has been intensified by consumption habits and behaviours, technology, and resource management, and the future threats will be even more challenging with an expected population of 9.7 billion by 2050 and even 10.9 billion by 2100.

Together with population growth, industrial activities have rapidly increased in both high and low-income countries, intensifying the consumption rates of finite resources and energy, globally. The concern of some scientists is that "such growth would reach a level that would overwhelm the capacity of the earth and its resources to generate the food and other goods needed for human life" (Peterson 2017). According to the publication in the World Economic Forum, the experience of scarcity on a short- to medium-term basis, is real and often felt directly by businesses and consumers, as it has been faced by electronics and other manufacturing with rare earth minerals and metals, for example (D'Esposito 2012). However, such (risk of) scarcity and depletion of resources and energy for process industries, can be prevented and/or mitigated through sustainable and efficient management of these, supported by consuming a shift to renewable raw materials, recycling and reusing waste streams and energy, and innovating with more sustainable materials and products. In other words, it can be significatively overcome by putting Industrial Symbiosis in practice.

The concept of Industrial Symbiosis is tracked back on to 1940, under the term 'industrial ecosystems' (still used nowadays). However, in 1989 this concept was strongly established as a field of scientific research with the article written by Frosch and Gallopoulos (1989), who defined this concept as "the consumption of energy and materials [that] is optimized and [where] the effluents of one process [...] serve as the raw material for another process". In the same year that this article was published, a self-organized cluster of companies from different industries, originated in 1961, that replicated the industrial ecosystem theory was uncovered in Kalundborg, Denmark (Figure 1) (Frosch and Gallopoulos 1989).

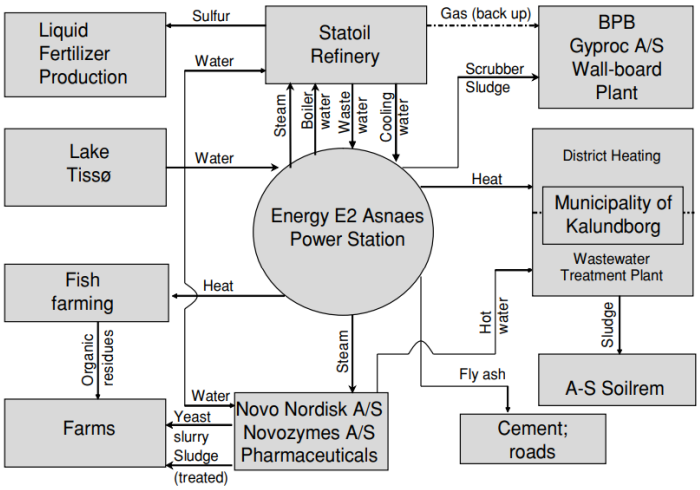

Figure 1. Industrial symbiosis of Kalundborg, Denmark

According to Chertow's (2000) definition, "Industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity". Thus, Industrial Symbiosis creates loops of technical or biological materials, while minimising the leakage and waste in such loops, and leverages underutilised resources. Such transactions may be based on reducing and reusing waste and by-products, finding innovative ways to source inputs and upgrade the value of waste and residuals by providing resource and energy saving alternatives to traditional management or recycling options (Artola et al. 2018). The Sustainable Process Industry through Resources and Energy Efficiency (SPIRE) illustrates, in Figure 2, the concept of a cross-sectorial target driven energy and resource efficiency and competitiveness programme for the process industry.

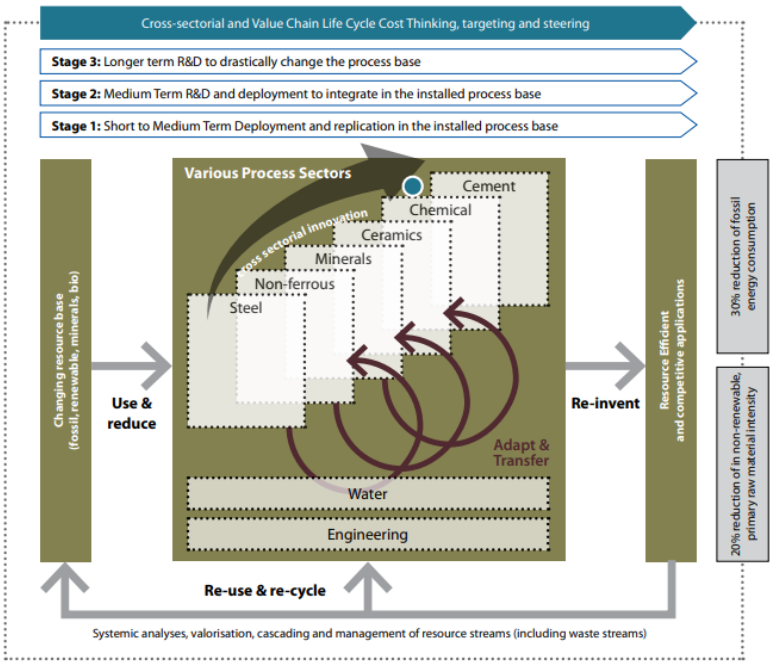

Figure 2 The SPIRE concept - A cross-sectorial target driven resource efficiency and competitiveness programme for the process industry

Based on the report of the European Commission "Cooperation fostering industrial symbiosis: market potential, good practice and policy actions (2018)", there are five drivers to move towards Industrial Symbiosis (IS): economic and business impact, eco-innovation, regional economic development, resource security, energy security and climate change mitigation. Taking all these elements into account, Industrial Symbiosis has been recognised as a key approach to deliver circular economy at a local scale, while reducing waste, emissions, costs and primary resources demand, and promoting collaborative economics. Some of these benefits are captured by the life cycle assessment (LCA), commissioned in 2015 by Kalundborg Symbiosis, which showed that connecting the enterprises saves more than 24 million EUR on the bottom line annually, while the socio-economic benefit amounts to more than 14 million EUR. On the other hand, the symbiosis leads to an emission reduction of about 635,000 tonnes of CO2 equivalents. Such numbers express that interconnected industries leverage their competitive power, while the public sector is able to save money, by reducing investments in waste management, for example (Fundation (n.d.))

Frosch and Gallopoulos (1989), highlighted the importance of changing corporate and public attitudes to favour the ecosystem (or 'symbiosis') approach, and government regulations must promote innovative waste-minimization schemes, focus on the economic incentives for sustainable manufacturing, sound technology and allowance for technological change, encourage (or at least not discourage) the development of alternative processes and innovate methods for dealing with industrial by-products, take advantage of industry's technological know-how so as to avoid counterproductive control measures. Building such

framework, would be possible only if there is a collaboration along government, industry and environmental groups.

The changes required to support IS, mentioned above, are embraced by the European Commission, through the launch of *The European Green Deal* (Figure 3), on December 11, 2019. This strategy aims to "transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. It also aims to protect, conserve and enhance the EU's natural capital, and protect the health and well-being of citizens from environment-related risks and impacts. At the same time, this transition must be just and inclusive." (European Commission, 2019).

Figure 3. The European Green Deal

To deliver *The European Green Deal*, and achieving a climate-neutral and circular economy requires the transformation of the industrial sector and all the value chains. European industry sector remains too dependent on the throughput of new materials extracted, traded and processed into goods, and finally disposed of as waste or emissions. Only 11% of the materials it uses come from recycling (Eurostat, n.d.). Therefore, the Commission adopted on March 10th, 2020, the *New Industrial Strategy for Europe*, that addresses the needs of the industry to become greener, more circular and more digital, while remaining competitive on the global stage. Such transition 'will be supported by a new focus on industrial ecosystems, taking into account all players within a value chain … from the smallest start-ups to the largest companies, from academia to research, service providers to suppliers' (European Commission, 2020a). On addition, the introduction of *A New Circular Economy Action Plan,* will help modernise Europe's economy and draw benefit from the opportunities of the circular economy along all sectors, by ensuring that resources used are kept in the EU economy for as long as possible; stimulating the development of lead markets for climate-neutral and circular products, services and business models, locally and globally; transforming consumption patterns, so that no waste is produced in the first place;

encouraging businesses to offer, and to allow consumers to choose, reusable, durable and repairable products (European Commission, 2020b). The circular economy action plan will include a 'sustainable products' policy to support the circular design of all products, ensure that products placed on the EU market are designed to last longer (through restricting Single-use, tackling premature obsolescence and banning the destruction of unsold durable goods), are easier to reuse, repair and recycle. Also, to strengthen extended producer responsibility, by prioritising reduction and reuse of materials before recycling them, incorporating as much as possible recycled material instead of primary raw material, and supported by a single market for secondary raw materials and by-products. Furthermore, action will focus especially on resource-intensive sectors such as textiles, construction, electronics and plastics, based on plans and initiatives developed with the close involvement of the business and stakeholder community (European Commission, 2019).

Along the objectives of the Green Deal in many different sectors, digital transformation is a key enabler for reaching them. This include technologies such as artificial intelligence, 5G, cloud and edge computing and the internet of things, that would support the acceleration and maximisation of the impact of regulatory and non-regulatory efforts, aimed to adapt and mitigate climate change and protect the environment (European Commission, 2019).

Nevertheless, the success in achieving the ambitious goals of the Green Deal, demands the consistent use of all policy levers: regulation and standardisation, investment and innovation, national reforms, dialogue with social partners and international cooperation. This will be the main challenge, as at the moment "there is no comprehensive set of requirements to ensure that all products placed on the EU market become increasingly sustainable and stand the test of circularity" (European Commission, 2020b). It is demanded a framework that aims to incentivise the industry to revolutionise the way how the sector designs, makes, uses and disposes of things, while reducing environmental impacts, alleviating competition for scarce resources and reducing production costs. Such context would favour the conditions to address system and market failures, eliminating persisting barriers and creating incentives for companies to engage in IS.

It is now evident that Industrial Symbiosis relates to the transformation of the current system of industrial production to a new, low-emission and resource efficient paradigm. This will require a 'systems approach', focusing on many levers around the system that are required for its transformation and are complementary to each other: from new technologies and skills, to citizen participation and behaviour change, to new business models supported by innovative finance, policies, standards and regulatory frameworks.

This report displays:

- Overview of current standards published globally, linked to industrial symbiosis in the process industry
- Standardization framework in Europe
- Gaps and Recommendations for the EU standardization framework
- Benefits of adopting the recommendations
- Conclusions

This proposal can be employed by the various committees of standardization bodies in ISO and CEN-CENELEC, for the development of families of standards under the responsibility of the technical committee of *Circular Economy*, the coordination group on *Smart Manufacturing*, the *EU Green Bond* and the committee of *Sustainable Finance*.

2. Methodology

The methodology pursued for the collection and compilation of the analysis presented in this deliverable is based on desktop research, supported by the use of the British Standards Online Library (BSOL), which gives access to relevant standards including the ones published by EN, BS, CEN, CENELEC, ASTM, IEC and ISO. Other open online databases that include worldwide standards were consulted as well, according to the needs for the proper development of this work.

Additionally, this deliverable builds on the findings identified in SCALER Work Packages 2 & 3, whereby a systematic literature review, case study analysis and stakeholder consultation has been undertaken. Hence, the approach taken for the compilation of the following findings was to seek to complement existing literature reviews and analysis pieces with the findings coming out of SCALER project.

The evolution of this analysis was split into three main consecutive stages. The first stage of this work required the collection and analyses of the global published standards that are relevant to Industrial Symbiosis (approached from the production system, digital technology and sustainable finance) and applicable on the process industry. For the collection of the information, it was used the BSOL tool together with several open access databases, such as SAI Global Infostore, BEUTH publishing DIN, AFNOR store, BSI shop, Chinese Standards shop, Russian Gost, among few others. Based on such data, the standards were analysed according to sector and level of impact, in order to have a first general understanding of the information available.

The second stage was focused on the European standards. Based on the data already collected in the first step, this was filtered on the standards published by the European Standardization Organization CEN-CENELEC. Once this selected information was analysed, a literature review, that included the outcomes of the SCALER deliverables, took place, in order to complement the outcomes found. This stage provided the first hint of gaps approached in this document.

Finally, the third stage consisted of comparing and contrasting the European standardization framework (with a Pan-European impact) with the ones applicable locally and in different geographies. Such analysis was further developed with a more extensive literature review to identify and articulate the gaps and recommendations described in this deliverable.

The importance of standardisation

According to the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC), "standards are agreed definitions or specifications of units, methods, tests products, processes or services. They provide people and organizations a basis for mutual understanding. Standards are everywhere. They make life easier, safer and healthier for businesses and consumers. Standards are useful for optimising performance, ensuring the health and safety of consumers and workers, protecting the environment and enabling companies to comply with relevant laws and regulations... Standardization is identified in Horizon 2020 as one of the innovation-support measures since it bridges the gap between research and the market and facilitates the fast and easy transfer of research results to the European and international market" (CEN, 2014).

Complementing the information above, standards are voluntary by nature to be implemented or not, which proposals may come from any individual, group, association or any stakeholder who believe that a particular standard could help address specific needs, and so the standardization framework is constantly adapted to the needs of industry, users or politics (CIRCE, 2018). Thus, standards support market-based competition and help ensuring the interoperability of complementary products and services, while reducing costs (Sommer, 2020).

Pohle et al. (2018), concludes that standards are a source of knowledge and an option to spread and diffuse knowledge within an innovation system, by providing the next benefits:

- Facilitate market access
- Support the diffusion and transfer of technologies
- Enhance the flexibility of management
- Foster different forms of innovation
- Provide comprehensive scientific and practical knowledge for everyone, at low cost

3. Overview of standards published globally

A collection of 286 national and international published standards that enable the industrial symbiosis in the process industry (related to A.SPIRE sectors) were assembled (Annex 1). The elements considered to make possible the industrial symbiosis, are based on sustainable operations, that include innovative and efficient use of materials and energy, reuse and recycle of waste streams, pioneering design of sustainable products, together with the support of digital transformation technologies (such as artificial intelligence, 5G,

cloud and edge of computing, big data, the internet of things and cyber-physical systems) and sustainable finance instruments.

About half of the standards identified relate to the chemical industry, with substantial focus on plastics, while a quarter is focused on the Engineering sector (mostly electronics). The remaining 30% of the standards analysed apply to the sectors on paper, cement, non-ferrous metals, minerals, water, ceramics and steel (Figure 4).

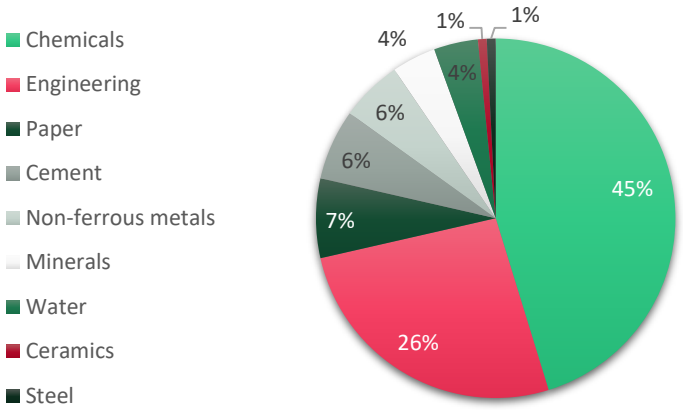

Figure 4. Distribution of Industrial Symbiosis Standards in the Process Industry

The quantitative analysis of the standards collected also shows that 85% of the overall standards have an impact on the firm/industry level ('Micro'), 10% have an impact on the national, European or global level - addressing information that results of private and public interest and application - ('Macro'), and the remaining 5% of the standards processed, focus on opportunities and concerns that impact eco-industrial parks or regional developments ('Meso') (Figure 5).

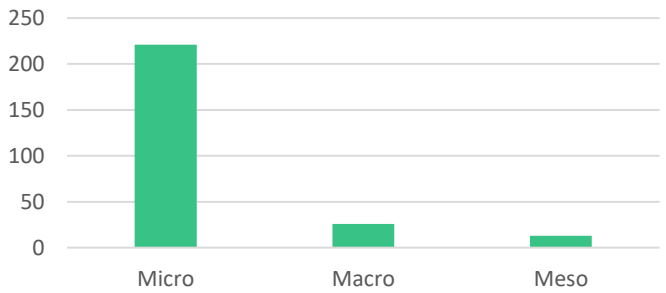

Figure 5. Distribution of Industrial Symbiosis Standards per Impact Level

4. Standardization framework in Europe

Standardization has played a main role in Europe, by creating a single market and defining a path to better regulation and improvement on the competitiveness of the European Industry (Sommer, 2020), by contributing on agility and quality of the products, improving systems reliability towards higher productivity, quality and sustainability of the production system, and helping simplifying business processes between stakeholders in the supply chain (Lu et al., 2016).

The set of standards is in permanent transformation, and most recently with the climate crisis and compromises arranged by all nations at the Paris Agreement, there is a high attention on developing new ones that bring forward the implementation of circular solutions and industrial synergies. Together with these initiatives, there have been created international technical committees focussed on smart manufacturing and sustainable finance, to create the tools and instruments that support the implementation, at both Pan-European and national levels.

The European Standardization Organization *CEN-CENELEC*, has set common standards that are applied across the whole of the European single market. This Pan-European standardization body brings together the national standards agencies of 34 countries, providing a platform for the development of European Standards and other technical specifications across a wide range of sectors. It works closely with the European Commission to guarantee that standards correspond with any relevant EU legislation, together with the International *Organization for Standardization* (ISO) and the International Electrotechnical Commission (IEC), to reach agreements on common standards that can be applied globally (*CEN-CENELEC*, n.d.) (Figure 6).

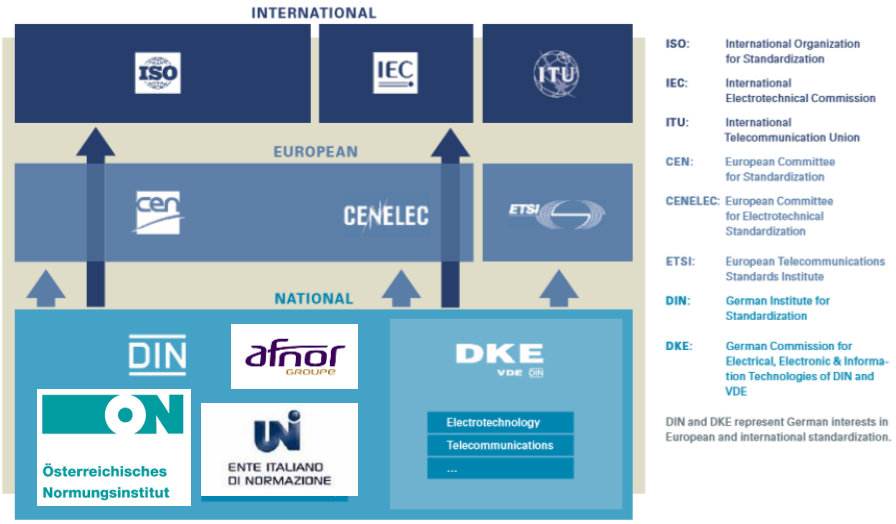

Figure 6. International standards organizations (adapted from (DIN & DKE Deutsche Kommission Elektrotechnik, 2018)

46 current published standards by CEN-CENELC (Annex 2) have been analysed that approach concepts, activities, methodologies, reporting, assessments, among others, embedded in the production system of the process industry for the circular economy, such as reduction (e.g. eco-design), separation, recycling, recover, remanufacture, recondition or refurbish, maintenance and repair, reuse, incineration, landfill. Most of these standards are defined for specific industrial sectors or materials, and about 30% are focused on plastics. On the other hand, there is a minority of standards applicable along all sectors, focused on specific phases of the life cycle of a product. The mapping of the overall standards in the EU is represented in Figure 7.

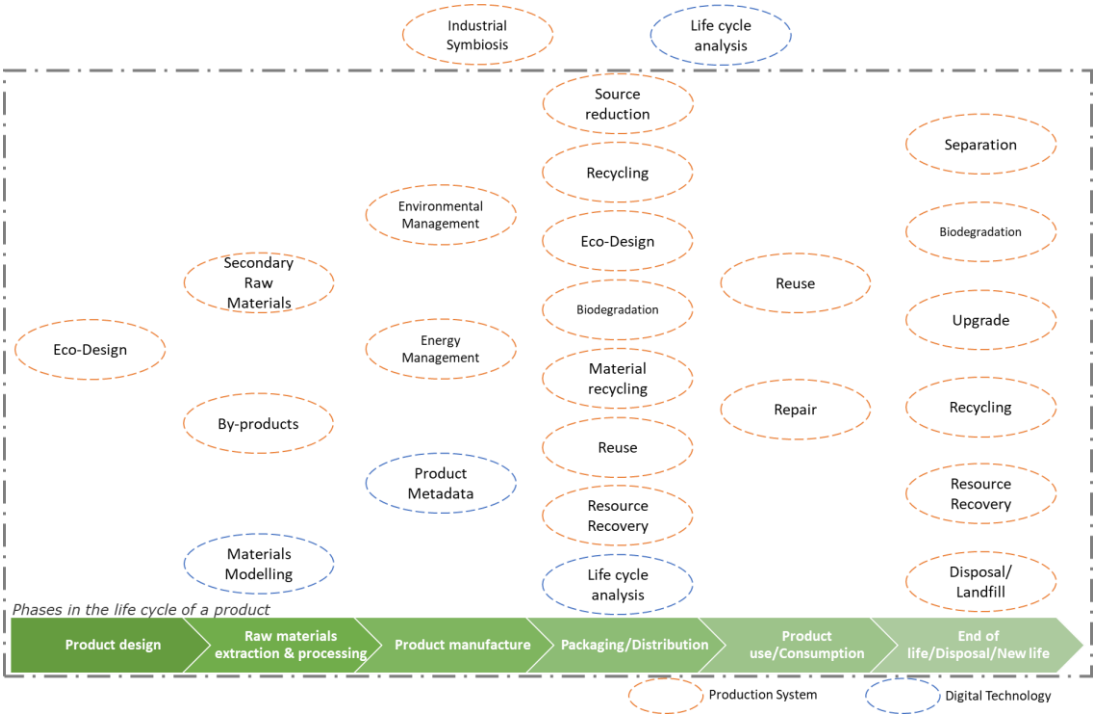

Figure 7. Mapping of EU Standards linked to Industrial Symbiosis

There are a couple of standards that are already published in the form of CEN Workshop Agreements (CWAs), that result of general interest at the overall European level, for the production system and digital technology. Such standards correspond to the CWA 17354:2018 Industrial Symbiosis: Core Elements and Implementation Approaches, and the CWA 17284:2018 Materials modelling - Terminology, classification and metadata.

CWA 17354:2018 Industrial Symbiosis: Core Elements and Implementation Approaches

On 2018, the CEN Workshop Agreement defined the concept of Industrial Symbiosis as the "transactions where organizations acquire underutilized resources (including waste, by-

products, residues, energy, water, logistics, capacity, expertise, equipment and materials that are not the primary output of the production process) from the organization(s) that generates them, and integrates these as inputs of their own production process", with the result of keeping resources in productive use for longer.

The objective of this CEN Workshop Agreement (CWA) is to support the mainstream adoption of good practices proven through implementation, by advancing the mutual understanding of actors (public, private, third sector, and community), who are currently using the term of industrial symbiosis in different ways. This CWA is intended to help the above actors consider and implement industrial symbiosis" (NEN, n.d.).
Thus, this standard contributes to shaping a more sustainable and integrated industrial economy, that identifies business opportunities to improve resource utilization and productivity.

CWA 17284:2018 Materials modelling - Terminology, classification and metadata

"CWA 17284 includes definitions of fundamental terms for the field of materials modelling and simulation. Computational materials models in this CWA are understood to be physics-based models. This CWA does not include data-based models. The definitions enable the classification of materials models. Using the entity and physics equation concepts leads to a relatively small number of distinct materials models replacing the current situation of opacity of materials models and simulations that make the field hard to access for outsiders.

This CWA also provides a systematic description and documentation of simulations including the user case, model, solver and post-processor: the "materials MOdelling DAta" (MODA). This document seeks to organize the information so that even complex simulation workflows can be conveyed more easily and key data about the models, solvers and post-processors and their implementation can be captured" (NEN, n.d.).

Currently, there are different technical committees and expert groups, at ISO and the European Commission, working on creating new standards specifically focussed on Circular Economy, Smart Manufacturing and Green Bonds, which promise to support and incentivise the capabilities and knowledge building around the European industrial sector, required to succeed on the ambitious strategies set by the EU Green Deal. Such work in progress is described below:

ISO/TC 323 CIRCULAR ECONOMY

This technical committee aims to develop frameworks, guidance, supporting tools and requirements for the implementation of circular economy activities, to maximize the contribution to sustainable development (ISO, 2018b). The proposed deliverables can be applied to any organization, or group of organizations, that wish to implement economic projects.

ISO/TC 323 is planning to deliver the first standard by 2021, while specifications of particular aspects of the circular economy are already covered by existing codes, such as eco-design, and LCA in ISO/TC207 Environmental management and sustainable purchasing (ISO 20400:2017). The next set of standards (under development), are in the direct responsibility of this committee:

- ISO/WD 59004 Circular economy — Framework and principles for implementation
- ISO/WD 59010 Circular economy — Guidelines on business models and value chains
- ISO/WD 59020 Circular economy — Measuring circularity framework
- ISO/CD TR 59031 Circular economy – Performance-based approach – Analysis of cases studies

EN-CENELEC-ETSI Coordination Group on Smart Manufacturing

To ensure the best approach and proposal of coherent solutions across the different technologies (Internet of Things, cloud computing, big data and data analytics, robotics or 3D printing), the European Technical Board extended the former CEN-CENELEC Coordination Group 'Smart Manufacturing' to ETSI, and created on 2019 the CEN-CENELEC-ETSI Coordination Group 'Smart manufacturing' (CEN-CLC-ETSI/SMa-CG) (Schoitsch et al., 2019).

EU Green Bond standard

The European Commission is exploring the creation of a "voluntary, non-legislative EU Green Bond Standard, to enhance the effectiveness, transparency, comparability and credibility of the green bond market and to encourage the market participants to issue and invest in EU green bonds" (Plan et al., 2019). This standard encompasses alignment with EU-taxonomy, the publication of a Green Bond framework and mandatory reporting and verification. The EU Green Bond standard also aims to solve diverse barriers in the market, such as reducing uncertainty on what is green, standardising verification and reporting processes, and attaching incentives.

ISO/TC 322 Sustainable finance

The aim of this technical committee is to "integrate sustainability considerations including environmental, social and governance practices in the financing of economic activities" (ISO, 2018a). Thus, the team is developing the standard *ISO/WD 32210 Framework for sustainable finance: Principles and guidance*. The outcomes of such work focus on developing common terminologies and principles for sustainable finance, that help to reduce market confusion and lowering transaction, verification and communication costs, as well as setting out good-practice principles for sustainable finance applicable globally. It also offers a frame for decision making and risk mitigation, methods for assessing benefits and guidance on disclosure (ISO, 2020).

Observations on EU Standardisation Framework

Alongside the collection and analysis of the current standardization framework in Europe, there is a set of observations found by the author that are relevant to share, in order to provide complementary information on the standardization context:

- About half of the overall standards analysed applicable along Europe, are defined at the national level (e.g. AFNOR in France, DIN in Germany, UNI in Italy) but are not yet adopted by the Pan-European standard organization CEN-CENELEC (Figure 8).

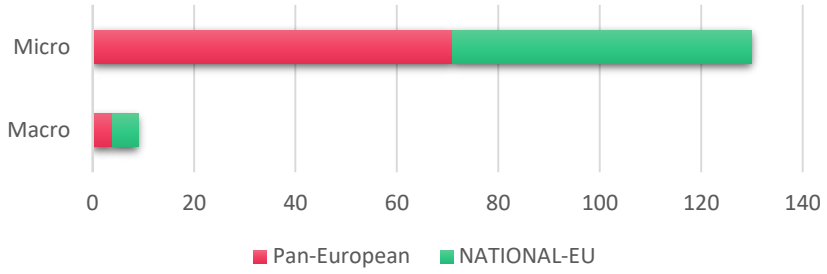

Figure 8. Standards in Europe linked to Industrial Symbiosis

Therefore, the standardization frame is not uniformly implemented across the European Member States, leading to potential duplicates, overlaps or inconsistencies. Such conflicts may create barriers to the internal market, discourage investments and limit the marketing of innovative products (European Commission, 2016)

- Most standards do not address roles, responsibilities, interactions, logistics and dynamics among stakeholders, in the value chain of a product.
- The current standardization framework does not approach, neither deliver, a robust system thinking/innovation approach, as it is demanded by ambitious legislative strategies, such as the EU Green Deal, among others.

The observations described below apply not just to the EU standardization system, but to the overall scheme:

- The overview of standards is not easily accessible
- Updates and evolution of standards are not easy to keep on track
- Changes on the standardization framework (in terms of withdraws and new additions) are very frequent over time, limiting the incentive from organizations to invest if the technology is relatively recent (European Commission, 2016)

5. Gaps and Recommendations for the EU standardization framework

Based on the analysis of the information collected in this study, it has been identified that despite the existing approaches regarding reuse, repair and recycling on the EU agenda for quite some time, there is still a need for a more comprehensive, cost-effective and holistic standardization framework. This would address and deliver a circular value chain to the products placed on the EU market, while becoming increasingly sustainable and supporting the scale-up of the implementation of industrial symbiosis.

According to the report *Cooperation Fostering for Industrial Symbiosis*, published by the European Commission (2018), the success of adopting industrial symbiosis solutions depends on the existence of a suitable regulative framework, which adopts standards to develop knowledge and capacity building along multiple stakeholders (e.g. through clarifying and harmonising vocabulary, promoting best practice facilitation and processes, build on existing knowledge of industrial symbiosis opportunities to facilitate replication), pushes incentives towards waste valorisation (e.g. through well-functioning secondary markets and harmonised criteria for 'by-products' and 'End of Waste' status) and creates favourable condition for symbiotic activities (e.g. by enhancing trust to conduct a transaction with another business counterpart). Moreover, key areas such as planning instruments, finance and strategic investment, support and accelerate the adoption of synergic solutions (Laybourn, 2013).

Thus, it is becoming clear that in order to develop a comprehensive regulative framework, single-point initiatives will not take us far enough, but solutions that tackle different fronts in the surrounding environment (e.g. skills, behaviour, market structures, information flows, organisational governance, and finance), based on a 'System Thinking' approach, will enable it while transforming and reconfiguring our economies and societies.

The specific gaps and challenges, together with the respective recommendations, for each category tackled, corresponding to the production system, digital technology and sustainable finance, are described below.

Production Systems

Gap 1. There is a need for standards that directly approach the concept of circular economy

At present, there is no existence of standards that approach the subject matter of circular economy under the Pan-European scope, leaving a gap on knowledge sharing, capacity

building and cost-efficient guidance to implement and facilitate circular solutions by diverse stakeholders along the supply chain.

Recommendation

To stimulate industrial symbiosis practices, it is important to enrich the current regulatory framework at the Pan-European level, by introducing new standards that harmonise vocabulary, share and promote best practices, tools and processes, and build on existing knowledge on circular economy, facilitating replication and maximizing the contribution to sustainable development.

European standardization bodies have the opportunity to adapt, as part of their regulatory framework, standards that are already published by standardization bodies from other geographies, and which content does not exist in the current Pan-European frame. For example, France and the UK have published, through their national standardization institutions AFNOR and BSI, respectively, standards that directly approach Circular Economy for organizations.

On the other hand, there is an opportunity to create new standards by bringing one step forward relevant work around IS, that is already developed within the EU. Relevant content to explore, could be, for example, work done within the SCALER project, which aims to increase the uptake of industrial symbiosis across Europe by developing a set of best practices, tools and guidelines, helping businesses and industrial sites work together to ensure sustainable resource use (*SCALER*, n.d.).

References

XP X30-901:2018 CIRCULAR ECONOMY - CIRCULAR ECONOMY PROJECT MANAGEMENT SYSTEM - REQUIREMENTS AND GUIDELINES

The voluntary standard XP X30-901 Circular Economy Project Management System was developed by the French Standardisation Association (AFNOR) in 2018, in an effort to guide the planning, evaluation and implementation of truly circular economy projects that help stakeholders reach their circular economy goals (SAI, n.d.). According to the standard, such projects should include the below areas (among them industrial symbiosis):

- Sustainable procurement
- Eco-design
- Industrial Symbiosis
- Functional Economy
- Responsible Consumption
- Extension of Service Life
- Effective Management of materials and products at the End of their Life Cycle

AFNOR proposed a new technical committee to ISO, and it was accepted in 2018, with 26 countries in favour. The ISO/TC 323 stands for standardisation on the topic of Circular Economy scope.

BS 8001:2017 FRAMEWORK FOR IMPLEMENTING THE PRINCIPLES OF THE CIRCULAR ECONOMY IN ORGANIZATIONS - GUIDE

The BS 8001:2017 Framework was proposed by the British Standards Institute (BSI) in the United Kingdom, for the implementation of CE principles in organizations. This describes what the CE is and how an organization can transition and adapt their operations to greater circularity and sustainability, through resource management. In order to support the framework, BS 8001 provides a guide on the specific problems surrounding the transition to a circular model, namely, measurements, liability and insurance, and logistical and material concerns (BSI Group, 2017).

GB/T 34152:2017 GENERAL PRINCIPLE OF CIRCULAR ECONOMY MANAGEMENT FOR INDUSTRIAL ENTERPRISES

This standard defines the general principles on leadership, planning, support, operation, inspection and improvement requirements of circular economy management for industrial enterprises. It applies to enterprises aimed to carry out circular economy management activities, but other enterprises and organizations can also refer to the implementation (*Chinese Standards Shop*, n.d.).

Table 1. Summary Gap 1 and Recommendation

GAP	RECOMMENDATION
Absence of standards that directly approach the concept of circular economy	Introduce new standards that harmonise vocabulary, share and promote best practices, tools and processes, and build on existing knowledge on circular economy • Adapt existent standards: **XP X30-901:2018** Circular economy - Circular economy project management system - Requirements and guidelines **BS 8001:2017** Framework for implementing the principles of the circular economy in organizations - Guide **GB/T 34152:2017** General principle of circular economy management for industrial enterprises

Gap 2. The standardization frame should be more interoperable across sectors, blocking cooperation

IS involves both bilateral (organisation to organisation) and multilateral (multiple organisations involved) transactions, that are in most cases market operations and which may involve different degrees of cooperation, as most opportunities are outside one's own

sector (CEN, 2018). Such collaboration along stakeholders results from opportunities to apply mutually beneficial solutions that surpass the environmental and economic outcomes of acting individually. For example, resources, water and energy may be optimised through such cooperation, which goes hand in hand with reducing the environmental impacts and economic costs of the Industrial Symbiosis participants' activities.

However, the current Pan-European standards are lacking an integrated system approach, by focusing on isolated sectors (e.g. packaging), limiting the applicability across sectors and confusing the concept behind Industrial Symbiosis Cooperation, leading to circular practices across production sectors throughout their life cycle, unapproachable or being left behind.

Recommendation

It is recommended to enrich the current standardization framework at the Pan-European level, by stimulating Industrial Symbiosis facilitation and synergies. To do so, it is required to create new standards that harmonize the concept of Industrial Symbiosis synergy (or Industrial Symbiosis cooperation), as well as provide further guidance on its facilitation. Also, it is required to promote supply chain approaches that recognise the value of Industrial Symbiosis and collective solutions of planned synergies, such as (eco)industrial-parks, as well as the spontaneous ones.

European standardization bodies have the opportunity to adapt as part of their regulatory framework standards that are already published by standardization bodies from other geographies, and which content does not exist in the current Pan-European frame.

China is one of the few countries that have introduced standards for the definition of requirements and development of Industrial Parks, and have demonstrated effectiveness. However, their efforts are complemented with stringent policies and instruments (some of them which would be difficult to replicate in the Western countries), for the promotion of Industrial Symbiosis synergies (The World Bank, 2019).

References

GB/T 33567:2017 SPECIFICATION FOR CIRCULAR ECONOMY EVALUATING OF INDUSTRIAL PARKS

This standard specifies the requirements of circular economy evaluation of industrial parks and the calculation method of a circular economy index. This standard applies to the national economic and technological development zones and provincial industrial parks (or provincial economic development zones) of circular economy performance evaluation, National and provincial high-tech industrial development zones, industrial agglomeration areas such as circular economy performance evaluation can refer to the implementation (*Chinese Standards Shop*, n.d.).

GB/T 31088:2014 GENERAL GUIDELINE OF CIRCULAR ECONOMY MANAGEMENT FOR INDUSTRIAL PARKS

This standard specifies the circular economy industrial park management of general principles, policy, planning, implementation, inspection and improvement requirements. Industrial Park is not limited to state-level economic and technological development zones, high-tech industrial development zone, bonded zone national, national Export Processing Zone and provincial level development zones, including industrial clusters and to large enterprises as the core of the industrial zone. This standard applies to Industrial Park Administrative Committee (hereinafter referred to as "CMC") to carry out recycling economy management to large enterprises as the core Industry clusters can also be implemented by reference (*Chinese Standards Shop*, n.d.).

GB/T 33751:2017 GENERAL GUIDELINE OF STANDARD SYSTEM FOR CIRCULAR ECONOMY OF INDUSTRIAL ENTERPRISES AND PARKS

This standard specifies the principles and requirements of the industrial enterprises and the circular economy standard system of the park, the hierarchical structure, the preparation format. This standard applies to the industrial enterprises and the park system of circular economy standard system, other types of enterprises and parks can refer to the implementation.GB/T 36574-2018 Principles and requirements for the comprehensive utilization of exhaust gases in industrial parks.

This standard specifies the classification, basic principles and requirements for the comprehensive utilization of waste gas in industrial parks. This applies to the planning, design and production operation of comprehensive utilization of waste gas in industrial parks (*Chinese Standards Shop*, n.d.).

T/CSPSTC 2:2017 EVALUATION SYSTEMS FOR INDUSTRIAL PARK INNOVATION INFLUENCE

This standard stipulates the evaluation principles, indicator systems, indicator descriptions and evaluation methods that should be followed in the evaluation of the innovation impact of industrial parks. It is applicable to the evaluation of innovation impact of different types of industrial parks, and provides for the formation, maintenance and improvement of innovation impact of industrial parks (ChinaHaw, n.d.).

HJ 274:2015 STANDARD FOR NATIONAL DEMONSTRATION ECO-INDUSTRIAL PARKS

This standard stipulates the evaluation methods, evaluation indicators, data collection and calculation methods of national eco-industrial demonstration zones. This standard is applicable to the construction and management of the National Eco-Industrial Demonstration Park. It can be used as the basis for the evaluation of national eco-industrial demonstration parks, the technical basis for the construction planning and construction

effectiveness evaluation, and other eco-industrial construction consulting activities (*Chinese Standards Shop*, n.d.).

HJ/T 409:2007 GUIDE FOR ESTABLISHED OF ECO-INDUSTRIAL PARKS PLANNING

This standard specifies the preparation of eco-industrial park construction planning principles, methods, content and requirements. Eco-industrial park construction is not limited to national economic and technological development zones, high-tech industrial development zones, the national free trade zone, export processing zones and provincial state-level development zones, industrial clusters and also to large enterprises the core of the industry gathering area. According to the industrial park and industrial structural features the eco-industrial park is divided into sectors like eco-industrial parks, the integrated eco-industrial park construction planning industry, provincial and other eco-industrial park planning work may also refer to this standard (*Chinese Standards Shop*, n.d.).

Table 2. Summary Gap 2 and Recommendation

GAP	RECOMMENDATION
The standardization frame is not interoperable across sectors	Create standards that stimulate Industrial Symbiosis facilitation and synergies, by harmonizing the concept of Industrial Symbiosis synergy, providing guidance on its facilitation and promoting supply chain approaches that recognise the value of Industrial Symbiosis. • Adapt existent standards: **GB/T 33567:2017** Specification for circular economy evaluating of industrial parks **GB/T 31088:2014** General guideline of circular economy management for industrial parks **GB/T 33751:2017** General guideline of standard system for circular economy of industrial enterprises and parks **T/CSPSTC 2:2017** Evaluation systems for industrial park innovation influence **HJ 274:2015** Standard for National Demonstration Eco-industrial Parks **HJ/T 409:2007** Guide for established of eco-industrial parks planning

Gap 3. Ambiguity and technical barriers prevent transactions of secondary materials and by-products

Ambiguity on the status of secondary materials and by-products has been one of the major issues that discourages the motivation of businesses and institutional investors to engage in Industrial Symbiosis endeavours and creates market barriers to compete against cheap primary resources. In some cases, this is a result of conflictive legislation that pose restrictions to uptake secondary materials, by associating them with risks of cross-

contamination, to mention one example (European Commission, 2018). Additionally, there are no standards focussed on measuring the retention of such materials in the production loop, and the consequent avoidance of emissions. Aside from this, there is a lack of regulation advocating homogeneous waste streams, leading to the current mixed waste and causing that high-quality recycling, represent higher costs for business than the revenues of selling recycled products.

Recommendation

It is recommended to design standards that harmonise the application and define specific minimum requirements, and/or allow flexibility, to use secondary materials and by-product instead of primary raw materials, boosting the optimal use of resources, so that materials extend their end of life, and boost solutions that guarantee their purity (through appropriate waste segregation, collection and pre-treatment of waste streams). Thus, setting up adequate conditions for secondary material and by-product markets, would contribute to advancing the circular economy and allow companies to retain value and materials in Europe (Technopolis Group et al, 2016).

In parallel, homogenisation of the secondary materials and by-products are other key elements in the standardization framework for the success of Industrial Symbiosis transactions, by offering viable alternatives to virgin raw materials and creating confidence in their quality, performance and detail specifications.

European standardization bodies have the opportunity to adapt as part of their regulatory framework standards that are already published by standardization bodies from other geographies, and which content does not exist in the current Pan-European frame.

For instance, Russia, through the local standardization body GOST, has published standards to define the terminology of secondary materials, and best available technologies to obtain safe secondary material resources. UNI, at Italy, has developed a series of standards focussed on plastic raw secondary materials.

References

GOST R 54098:2010 RESOURCES SAVING. SECONDARY MATERIAL RESOURCES. TERMS AND DEFINITIONS

This standard establishes the basic terms and their definitions in the field of waste management as a constantly replenished (conditionally renewable) secondary material resources, using which an economic entity (legal entity or individual entrepreneur) as a raw material seeks for resource and energy saving in business processes simultaneous reduction of anthropogenic load on the environment. This standard applies to secondary material resources resulting from production and consumption waste in business processes. This standard does not apply to waste from defence products, medical, biological and nuclear waste. The terms and definitions set forth in this standard are intended for use in regulatory, regulatory, technical and design documentation, as well as in scientific, technical,

educational and reference literature in relation to the process of involving production and consumption waste as secondary material raw materials and energy resources to ensure environmental protection in the processes of economic activity (RussianGost, n.d.).

GOST R 56828.27:2017 BEST AVAILABLE TECHNIQUES. RESOURCES SAVING. THE METHODOLOGY FOR THE TREATMENT OF WASTE TO PRODUCE MATERIAL RESOURCES

This standard establishes a methodology for applying the best available technologies (BAT) for waste treatment in order to obtain ecologically safe secondary material resources. This standard applies to methods for processing waste from waste oils, solvents, catalysts, activated carbon. This standard does not apply to waste generated at chemical, biological, radioactive and military facilities. The provisions of this standard are intended for enterprises, organizations and associations of enterprises, including unions, associations, concerns, joint-stock companies, inter-sectoral, regional and other associations, regardless of ownership and departmental affiliation, as well as for federal and regional government bodies. The provisions established in this standard are also intended for use in regulatory documents, scientific, technical, educational, reference literature, establishing the procedure for organizing and performing standardization work in the environmentally friendly waste management (RussianGost, n.d.).

UNI 10667 (1-18) PLASTIC RAW-SECONDARY MATERIALS

The UNI 10667 includes a set of technical standards around raw-secondary materials from recovery and recycling of plastic waste and also refers to by-products of plastics (UNI, n.d.).

UNI 10853 (1-4) RECYCLED PLASTIC MATERIALS FROM RECOVERY OF DURABLE GOODS TO END OF LIFE

The set of standards approach different angles on recycled plastic materials from recovery good to end of life. It ranges from the classification, for better use in the manufacture of semi-finished and finished products, to defining the test methods for the characterization of recycled polypropylene (REL PP), polystyrene (REL PS) and ABS, intended for general uses and specific uses (UNI, n.d.).

ÖNORM S 2201:2020 ORGANIC WASTE FOR BIOLOGICAL UTILIZATION - REQUIREMENTS

This ÖNORM defines quality requirements for raw materials for treatment in composting and fermentation plants, whose end products are quality compost, compost, quality sewage sludge compost and liquid and solid fermentation residue. These requirements include description of the raw materials with the necessary evidence of origin, nature, volume and frequency of quality evidence, records and entry control (ÖNORM, n.d.).

BS 6543:1985 GUIDE TO USE OF INDUSTRIAL BY-PRODUCTS AND WASTE MATERIALS IN BUILDING AND CIVIL ENGINEERING

Provides guidance on the use of industrial by-products and waste materials in the construction industry, including roads, building and civil engineering. The materials covered are residues from extractive and processing industries and the standard has been restricted to those residues which are produced in the largest quantities and have some potential for use in the construction industry. Covers the environmental and economic aspects of the utilization of industrial by-products and waste materials. Includes flow diagrams as aids to the decision making process (BSI, n.d.).

Table 3. Summary Gap 3 and Recommendation

GAP	RECOMMENDATION
There is uncertainty and technical barriers to do transactions of secondary materials and by-products	Design standards that set up adequate conditions to use secondary materials and by-product, instead of primary raw materials, by defining specific minimum requirements and allowing flexibility • Adapt existent standards: **GOST R 54098:2010** Resources saving. Secondary material resources. Terms and definitions **GOST R 56828.27:2017** Best available techniques. Resources saving. The methodology for the treatment of waste to produce material resources **UNI 10667 (1-18)** Plastic raw-secondary materials **UNI 10853 (1-4)** Recycled plastic materials from recovery of durable goods to end of life **ÖNORM S 2201:2020** Organic waste for biological utilization – Requirements **BS 6543:1985** Guide to use of industrial by-products and waste materials in building and civil engineering

Gap 4. Most standards focus on “end of pipe” solutions

Authors like Costa et al. (2009) and Paquin and Howard-Grenville (2010), also identify that existing regulation structure focusses more on the “end of pipe” solutions, like treatment and disposal, instead of targeting solutions with the highest possible waste hierarchy and contributing to landfill diversion (Costa et al., 2010; Paquin and Howard-Grenville, 2009). Thus, it is missing a direction and stimulus on actors to choose waste management solutions that prioritise reduction over reuse, reuse over recycling, and recycling over (energy) recovery from disposal.

Recommendation

It is recommended to incorporate new standards that strengthen extended producer responsibility to design circular and sustainable products, prioritizing the reduction of materials and energy at the source, while creating products to last longer (through tackling premature obsolescence and restricting the destruction of durable and single-use goods). Producers also have to make sure that they offer goods that are able to be easily reused, repaired and recycle.

Such framework would aim to revolutionise the way how industry designs, makes, uses and gets rid of things, while reducing environmental impacts, alleviating competition for scarce resources and reducing production costs (European Commission, 2020a).

European standardization bodies have the opportunity to integrate this as part of their regulatory framework standards that are already published by standardization bodies from other geographies, and which content does not exist in the current Pan-European frame. Different national and international standardization organizations have published on environmental impacts and eco-design, together with resource saving.

References

IEC 62430:2019 ENVIRONMENTALLY CONSCIOUS DESIGN (ECD) - PRINCIPLES, REQUIREMENTS AND GUIDANCE

This standard describes principles, specifies requirements and provides guidance for organizations intending to integrate environmental aspects into the design and development in order to minimize the adverse environmental impacts of their products (SAI, n.d.).

ISO/TR 14062:2002 ENVIRONMENTAL MANAGEMENT - INTEGRATING ENVIRONMENTAL ASPECTS INTO PRODUCT DESIGN AND DEVELOPMENT

This Technical Report describes concepts and current practices relating to the integration of environmental aspects into product design and development, where “product” is understood to cover both goods and services. This Technical Report is applicable to the development of sector-specific documents. It is not applicable as a specification for certification and registration purposes (SAI, n.d.).

GOST R 55103:2012 RESOURCE SAVING. EFFICIENT CONTROL OF RESOURCES. BASIC REGULATION

This standard establishes the main provisions on the directions and measures of effective resource management by saving primary and secondary material and energy resources at the stages of the product life cycle and at the stages of the technological cycle of waste. This standard applies to the primary material and raw materials and energy resources used

in the manufacture of products, as well as waste management, to the secondary material and energy resources derived from industrial wastes in the processes of economic activity. This standard does not apply to the infrastructure of enterprises and organizations, to the maintenance and repair of equipment, as well as to medical, biological and nuclear waste (RussianGost, n.d.).

VDI 2243:2002 RECYCLING-ORIENTED PRODUCT DEVELOPMENT

The aim of this guideline is to provide the developer and the designer, in particular, in addition to all those responsible for the product, with information, instructions and decision-making aids for the individual phases of the product development, in order to be able to prepare and select technical and economic possibilities and alternatives for improving the recyclability of technical products (SAI, n.d.).

Table 4. Summary Gap 4 and Recommendation

GAP	RECOMMENDATION
Most standards focus on the "end of pipe" solutions	Incorporate new standards that strength extended producer responsibility towards the design of circular and sustainable products, prioritizing the reduction of materials and energy at the source, while creating products to last longer, able to be easily reused, repaired and recycled. • Adapt existent standards: **IEC 62430:2019** Environmentally conscious design (ECD) - Principles, requirements and guidance **ISO/TR 14062:2002** Environmental management - Integrating environmental aspects into product design and development **GOST R 55103:2012** Resource saving. Efficient control of resources. Basic regulation **VDI 2243:2002** Recycling-oriented product development

Digital Transformation

Gap 5. There is a need for more harmonized metrics on circular economy and IS practices

Despite the developments of the EU in terms of standards that aim to improve the competitiveness of the European industry, and most recently considering sustainable activities (such as reduction, reuse, recycling, recovery, among others) at the core, there is no standardization of the data and there has been no agreed indicator system around the world (Liu et al., 2018b).

Recommendation

It is necessary to integrate indicators (or KPIs) to control the performance and impact around circular economy and industrial symbiosis practices. By standardizing such KPIs, it allows comparative measurements of the of processes and technologies, identify opportunities and needs, set benchmarks and share best practices, that support the deployment of circularity of the value chain to the product, along its life cycle.

European standardization bodies have the opportunity to adapt as part of their regulatory framework standards that are already published by standardization bodies from other geographies, and which content does not exist in the current Pan-European frame. China, for example, has developed Industrial Symbiosis indicators for use in (eco)industrial-parks, that help measure both the flow of materials and impact of activity, and have proved a great success.

References

MEE STANDARD: STANDARD FOR NATIONAL DEMONSTRATION ECO-INDUSTRIAL PARKS

"The MEE standard contains 32 indicators, categorized into 5 groups: economic development; industrial symbiosis; resource saving; environmental protection; and information disclosure. For an IP to be considered a national demonstration EIP, the park is required to meet the requirements of 17 compulsory indicators and a minimum of 6 optional indicators. Requirements on environmental protection and resource saving are the key focus of the MEE standard, including 13 and 9 indicators, respectively. For environmental protection indicators especially, 12 out of 13 are compulsory, covering requirements of pollution emission levels, soundness of environmental management and risk control systems, wastewater and solid waste generation per unit of industrial output, reuse and safe disposal of various kinds of wastes, and the green coverage rate. Detailed description and calculating methods of each indicator are provided as well" (The World Bank, 2019).

NDRC STANDARD: NOTICE ON RECOMMENDING KEY CANDIDATE INDUSTRIAL PARKS FOR CIRCULAR ECONOMY TRANSFORMATION IN 2017

"The Notice provides a guideline for the application, evaluation, and selection of demonstration IPs for circular economy transformation. It specifies 11 basic requirements/qualifications for an IP to be able to apply for becoming a "circular economy" demonstration park, and provides template indicators that measure the performance of IPs. The NDRC standard includes 31 indicators in total, categorized into 8 groups: resource productivity (5); resource consumption (5); comprehensive utilization of resources (5); pollutant emissions (8); other indicators (3); "characteristic indicators" ;55 projects subsidized by central government finance (3); and self-implemented projects (2). The NDRC standard emphasizes the circular economy performance of IPs, leading to a focus on resource productivity, efficiency, and pollutant emissions. Given this specific focus,

economic, social, and managerial performances receive less emphasis than the MEE standard. The NDRC standard also does not set target values for indicators. Instead, it provides an information sheet for IPs' self-assessment against their previous performance and estimated future progress. Rather than providing a general and comprehensive evaluation framework for IPs' performance, the NDRC standard focuses on assessing and promoting circularity" (The World Bank, 2019).

MIIT STANDARD: REQUIREMENT FOR THE EVALUATION OF GREEN INDUSTRIAL PARKS, UNDER THE NOTICE ON THE ESTABLISHMENT OF A GREEN MANUFACTURING SYSTEM

"There are 31 indicators and 8 basic requirements within the MIIT standard. The indicators are divided into 6 categories: energy utilization (3); resource utilization (8); infrastructure (5); industry (4); ecology and environment (8); and management (3). Similar to the MEE standard (with its categories of "resource saving" and "environmental protection"), "resource utilization" and "ecology and environment" indicators are the most numerous, consisting of over half (16/31) of all the indicators of the MIIT Standard. A balance is nonetheless achieved among different categories: managerial, environmental, and economic performance are all assessed through a number of indicators, although social performance indicators are not specifically included. For an IP to qualify as a MIIT-certified green IP, the park needs to meet 17 compulsory requirements and at least 6 optional requirements. In addition, all the 8 basic requirements must be met" (The World Bank, 2019).

Table 5. Summary Gap 5 and Recommendation

GAP	RECOMMENDATION
There is a lack of harmonized metrics on circular economy and is practices	Integrate and standardize indicators (or KPIs) to control the performance and impact around circular economy and industrial symbiosis practices. • Adapt existent standards: **MEE Standard:** Standard for National Demonstration Eco-Industrial Parks **NDRC Standard:** Notice on Recommending Key Candidate Industrial Parks for Circular Economy Transformation in 2017 **MIIT Standard:** Requirement for the Evaluation of Green Industrial Parks, under the Notice on the Establishment of a Green Manufacturing System

Gap 6. Existing manufacturing standards need to be increased to enable smart manufacturing

To enable smart manufacturing systems that follow the principles of Industry 4.0, based on automation and data exchange, and support sustainable manufacturing, it is required to

change the classical manufacturing system architectural paradigm based on a hierarchical control model.

Current manufacturing standards don't always enable a smart manufacturing approach, especially in the areas of cybersecurity, cloud-based manufacturing services, supply chain integration, data analytics (Lu et al., 2016), interoperability, through-life end-to-end connected supply chains – design and service innovation (BSI, 2017). Additionally, current technologies don't meet the specific information needs on classification, contamination, distribution and timing issues, and lack of mainstream uptake to Industrial Symbiosis (CEN, 2018).

Recommendation

There is a need to further developed standards for digital technologies based on distributed manufacturing services to close the resource loop along life cycle stages (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials). To support sustainable manufacturing, new standards on characterizing and assessing manufacturing processes and products are required, that reflect with accurate data the environmental, social and economic impacts of individual activities and processing. Some solutions can be based on solutions such as digital passports, tagging and watermarks (European Commission, 2020b).

The report by Sommer (2020) proposes to establish data and information exchange platforms that are publicly accessible, monitored and maintained, and include data of waste and material flows from key sectors, technologies and re-purposes. Thus, contributing to the identification of Industrial Symbiosis opportunities and barriers, and allowing a broad number of manufacturers to consult the information, regardless the size or location. Such platforms could also contribute to promote solutions that match the available/underutilised resource with the appropriate opportunity, addressing technical, economic and legal requirements (CEN, 2018). Thus, the potential of digital transformation can be articulated with the assessment framework of circular economy and Industrial Symbiosis activities.

European standardization bodies have the opportunity to adapt as part of their regulatory framework standards that are already published by standardization bodies from other geographies, and which content does not exist in the current Pan-European frame. IEC has published some standards in the form of Public Available Specification (PAS), that approach topics on smart manufacturing. Also, China counts with a standard for data on circular economy in eco-industrial parks, that is very interesting due to the specificity and the direct impact it has on industrial symbiosis. Few other organizations have published standards on data guidelines and generation of information.

References

IEC/PAS 63178:2018 SMART MANUFACTURING SERVICE PLATFORM. SERVICE-ORIENTED INTEGRATION REQUIREMENTS OF THE MANUFACTURING RESOURCE/CAPABILITY

IEC PAS 63178:2018(E) provides the requirements of all relevant manufacturing resources integrated to the cloud manufacturing service platform, including integration of hard manufacturing resources, soft manufacturing resources and manufacturing capabilities. This document is used for the integration of the relevant resources to the smart manufacturing service platform (SAI, n.d.).

IEC/PAS 63088:2017 SMART MANUFACTURING. REFERENCE ARCHITECTURE MODEL INDUSTRY 4.0 (RAMI4.0)

IEC PAS 63088:2017(E) describes a reference architecture model in the form of a cubic layer model, which shows technical objects (assets) in the form of layers, and allows them to be described, tracked over their entire lifetime (or "vita") and assigned to technical and/or organizational hierarchies. It also describes the structure and function of Industry 4.0 components as essential parts of the virtual representation of assets (SAI, n.d.).

GB/T 36578:2018 DATA INTERFACE SPECIFICATION FOR CIRCULAR ECONOMY INFORMATIZATION PLATFORM OF INDUSTRIAL PARK

This standard specifies the terms and definitions, data collection and coding format of the data interface specification of the industrial park circular economy information public platform. And information exchange requirements. This standard applies to the design and development of the public platform for circular economy information in industrial parks (*Chinese Standards Shop*, n.d.).

IEEE 1517:2010 INFORMATION TECHNOLOGY - SYSTEM AND SOFTWARE LIFE CYCLE PROCESSES - REUSE PROCESSES

Specifies the relationship of reuse processes to system life cycle processes described in Clause 6 (System Life Cycle Processes) of IEEE Std 12207-2008 and software life cycle processes described in Clause 7 (Software Specific Processes) of IEEE Std 12207-2008 (SAI, n.d.).

IEC/TR 62635:2012 GUIDELINES FOR END OF LIFE INFORMATION PROVIDED BY MANUFACTURERS AND RECYCLERS AND FOR RECYCLABILITY RATE CALCULATION OF ELECTRICAL AND ELECTRONIC EQUIPMENT

This standard provides a methodology for information exchange involving EEE manufacturers and recyclers, and for calculating the recyclability and recoverability rates to provide information to recyclers to enable appropriate and optimized EoL treatment operations, provide sufficient information to characterize activities at EoL treatment facilities in order to enable manufacturers to implement effective ECD, evaluate the

recyclability and recoverability rates based on product attributes and reflecting real end-of-life practices (SAI, n.d.).

DIN PAS 1049:2004 TRANSMISSION OF RECYCLING RELEVANT PRODUCT INFORMATION BETWEEN PRODUCERS AND RECYCLERS - THE RECYCLING PASSPORT (CURRENTLY WITHDRAWN)

This standard describes a recycling passport, helping manufacturers in the electronics industry to share information of the product to recycling companies, and thereby their obligations to comply with the "Law on the placing on the market, the take-back and the environmentally compatible disposal of electrical and electronic devices" (ElektroG). It contributes efficient recycling (Köln, 2005) (SAI, n.d.).

ASTM D 6311:1998 STANDARD GUIDE FOR GENERATION OF ENVIRONMENTAL DATA RELATED TO WASTE MANAGEMENT ACTIVITIES: SELECTION AND OPTIMIZATION OF SAMPLING DESIGN

This document provides practical guidance on the selection and optimization of sample designs in waste management sampling activities, within the context of the requirements established by the data quality objectives or other planning process. This document (1) provides guidance for selection of sampling designs; (2) outlines techniques to optimize candidate designs; and (3) describes the variables that need to be balanced in choosing the final optimized design (SAI, n.d.).

Table 6. Summary Gap 6 and Recommendation

GAP	RECOMMENDATION
Existing manufacturing standards are insufficient to enable smart manufacturing	Developed standards for digital technologies, based on distributed manufacturing services to close the resource loop along life cycle stages and establish platforms to exchange data and information, contributing to the identification of Industrial Symbiosis opportunities and barriers. • Adapt existent standards: **IEC/PAS 63178:2018** Smart manufacturing service platform. Service-oriented integration requirements of the manufacturing resource/capability **IEC/PAS 63088:2017** Smart manufacturing. Reference architecture model industry 4.0 (RAMI4.0) **GB/T 36578:2018** Data interface specification for circular economy informatization platform of industrial park **IEEE 1517:2010** Information Technology - System and Software Life Cycle Processes - Reuse Processes **IEC/TR 62635:2012** Guidelines for end of life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment **DIN PAS 1049:2004** Transmission of recycling relevant product information between producers and recyclers - The recycling passport (currently withdrawn)

	ASTM D 6311:1998 Standard Guide for Generation of Environmental Data Related to Waste Management Activities: Selection and Optimization of Sampling Design

Sustainable Finance

Gap 7. There is a need for more standardisation focused on sustainable finance

The speed at which green bond markets develop and mature hinges on many variables, including policy and regulatory factors, market conditions and financing trends. Additionally, the evolving green bond market faces a range of specific challenges and barriers to its further evolution and growth. These include underdeveloped domestic bond markets, insufficient pipelines of bankable and standardised green projects, a lack of commonly accepted green standards and definitions, issuer's views on costs vs. benefits, and a general scale mismatch between projects, bonds and institutional investors.

Recommendation

Financial markets play a main role in defining how investments are made with private capital. Bonds, for example, can utilize a deep global pool of capital, with a diverse support of investors. Hence, bonds connect investment needs with the latent demand from institutional investors. However, Green bonds differ to regular bonds in the aspect of committing to use the funds raised to finance, or re-finance, "green" projects, assets or business activities. Furthermore, green bonds suit the risk profile of initiatives such as industrial symbiosis or 'circular value chains' projects, overcoming market and failures as well as transactional barriers.

According to the report 'Enhancing China's Regulatory Framework for Eco-Industrial Parks' distributed by the World Bank (2019), "clear standards and better market data, will accelerate the use of green bonds by making them an even more attractive way to invest". By using standards to harmonize terminology and procedures for assessing the "greenness" of bonds, it should help investors and businesses match common interests, under the sustainable umbrella.

European standardization bodies have the opportunity to adapt as part of their regulatory framework standards that are already published by standardization bodies from other geographies, and which content does not exist in the current Pan-European frame. There are already international publications available on sustainable finance and green bonds, as well as new development of standards are under working progress.

References

CLIMATE BOND STANDARDS

"It is an overarching science-based, multi-sector standard overseen by the Climate Bonds Standards Board that allows investors and intermediaries to easily assess the climate credentials and environmental integrity of bonds and other green debt products.
Launched in 2011, with periodic updates, the Climate Bonds Standard is the most detailed climate aligned investment criteria available in the market and provides guidance to issuers, investors, governments and regulators.

Release of Standard V3.0 is part of Climate Bonds Initiative's development programme to improve the Standard, extend underlying Criteria to additional industry sectors, strengthen overarching Adaptation and Resilience (A&R) factors in each Criteria and update the core Climate Bonds Taxonomy. This last version is designed to ensure compatibility with the new EU Green Bond Standard (GBS), the Green Bond Principles, and also the recent guidelines adopted by India, ASEAN and Japan.

The Climate Bonds Standard consists of a Certification process, Pre-Issuance requirements, Post-Issuance requirements and a suite of sector eligibility & guidance documents" (Initiative, 2019)

PAS 7340:2020 FRAMEWORK FOR EMBEDDING THE PRINCIPLES OF SUSTAINABLE FINANCE IN FINANCIAL SERVICES ORGANIZATIONS

"It outlines a framework for, and guidance on, implementing principles and approaches to sustainable finance within financial services organizations. It establishes guiding principles and common terms and definitions related to sustainable finance which can help organizations to:

- Develop their understanding of sustainable finance and determine its relevance within the individual organization;
- Understand what successful sustainable finance practices and activities might look like and how to apply them;
- Develop their own strategies and approaches to embedding sustainable finance in their policies, processes, practices, products, services and value chains.

The PAS aims to facilitate understanding and collaboration within the global financial sector, and ultimately, the alignment of the sector with sustainability objectives. The framework is designed to facilitate global aspirations, by enabling individual organizations to identify, develop and maximize opportunities for addressing sustainability challenges, both in the

short and the long-term, and in a manner that allows the individual organization to adopt sustainable finance practices. It can be applied to all organizational activities" (BSI, n.d.).

ISO 14030-1 (DRAFT) ENVIRONMENTAL PERFORMANCE EVALUATION. GREEN DEBT INSTRUMENTS. PART 1. PROCESS FOR GREEN BONDS

ISO 14030-1 provides principles, requirements and guidance for designating bonds as "green", for eligible projects, assets or activities, for managing proceeds, and for defining, monitoring and reporting on their environmental impacts. It can be applied by any issuer of bonds.

ISO/WD 32210 FRAMEWORK FOR SUSTAINABLE FINANCE: PRINCIPLES AND GUIDANCE (WORK IN PROGRESS) – ISO/TC 322 SUSTAINABLE FINANCE

This standard seeks to "provide guidance on principles, practices and terminology at a framework level to support financial and financial services organisations wanting to integrate sustainability principles into their investment and management practices and/or to facilitate the financing and development of new sustainability assets" (Robinson-Tillett, 2019).

Table 7. Summary Gap 7 and Recommendation

GAP	RECOMMENDATION
There is absence of standards' instruments focussed on sustainable finance	It is demanded a coherent framework in which the entire bond market begins to reflect the transition towards a low-carbon transformation, supported by voluntary and compulsory instruments. • Adapt existent standards: **Climate Bond Standards** **PAS 7340:2020** Framework for embedding the principles of sustainable finance in financial services organizations. Guide **ISO 14030-1 (Draft)** Environmental performance evaluation. Green debt instruments. Part 1. Process for green bonds **ISO/WD 32210 (Work in progress)** Framework for sustainable finance: Principles and guidance – ISO/TC 322 Sustainable Finance

6. Conclusions

Industrial activities have rapidly increased worldwide, intensifying the consumption rates of finite natural resources. The radical increase on the demand of materials and energy link to the current practices of production and consumption that are based on a linear business models, focused on extracting raw materials, manufacturing goods, consuming these and

finally disposing of them. Such patterns cause increased pollution, as well as resource and material scarcity in a short to medium-term, and this reality is becoming more frequently experienced by businesses and consumers. However, the depletion of materials as a result of industrial activities can be significatively overcome by implementing *Industrial Symbiosis*.

Industrial symbiosis synergies are "*transactions where organizations acquires underutilized resources (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials that are not the primary output of the production process) from the organization(s) that generates them, and integrates these as inputs of their own production process"* (CEN, 2018). This approach has been highlighted in the New Industrial Strategy for Europe, which is part of the EU Green Deal, and aim to address the needs of the industry sector to become greener, more circular and more digital, while remaining competitive on the global stage. Nevertheless, the success in achieving **such** ambitious goals requires a coherent use of policy levers (e.g. regulation, standardisation), combined with investment and sustainable finance and supported by the digital transformation.

Standards are a powerful tool, supporting business with standard processes, procedures and knowledge. This helps to unlock innovation within organizations, facilitating market access, diffusion and transfer of technologies and flexibility of management. Standardization has played a main role in Europe, by creating a single market and defining a path to better regulation and improvement on the competitiveness of the European Industry (Sommer, 2020). However, the current standardization content is still lacking a comprehensive, cost-effective framework, that addresses and delivers a circular value chain to the products placed on the EU market, while becoming increasingly sustainable and scaling up the implementation of industrial symbiosis.

The specific gaps identified, together with the respective recommendations in the current Pan-European standardization framework, classified in the categories of production system, digital technology and sustainable finance, are summarised in Table 8.

Table 8. Summary of overall Gaps and Recommendations

GAPS	RECOMMENDATIONS
	PRODUCTION SYSTEM
Absence of standards that directly approach the concept of circular economy	Introduce new standards that harmonise vocabulary, share and promote best practices, tools and processes, and build on existing knowledge on circular economy • Adapt existent standards: **XP X30-901:2018** Circular economy - Circular economy project management system - Requirements and guidelines **BS 8001:2017** Framework for implementing the principles of the circular economy in organizations - Guide **GB/T 34152:2017** General principle of circular economy management for industrial enterprises
The standardization frame is not interoperable across sectors	Create standards that stimulate Industrial Symbiosis facilitation and synergies, by harmonizing the concept of Industrial Symbiosis synergy, providing guidance on its facilitation and promoting supply chain approaches that recognise the value of IS.

	• Adapt existent standards: **GB/T 33567:2017** Specification for circular economy evaluating of industrial parks **GB/T 31088:2014** General guideline of circular economy management for industrial parks **GB/T 33751:2017** General guideline of standard system for circular economy of industrial enterprises and parks **T/CSPSTC 2:2017** Evaluation systems for industrial park innovation influence **HJ 274:2015** Standard for National Demonstration Eco-industrial Parks **HJ/T 409:2007** Guide for established of eco-industrial parks planning
There is uncertainty and technical barriers to do transactions of secondary materials and by-products	Design standards that set up adequate conditions to use secondary materials and by-product, instead of primary raw materials, by defining specific minimum requirements and allowing flexibility • Adapt existent standards: **GOST R 54098:2010** Resources saving. Secondary material resources. Terms and definitions **GOST R 56828.27:2017** Best available techniques. Resources saving. The methodology for the treatment of waste to produce material resources **ÖNORM S 2201:2020** Organic waste for biological utilization – Requirements **UNI 10667 (1-18)** Plastic raw-secondary materials **UNI 10853 (1-4)** Recycled plastic materials from recovery of durable goods to end of life **BS 6543:1985** Guide to use of industrial by-products and waste materials in building and civil engineering
Most standards focus on the "end of pipe" solutions	Incorporate new standards that strength extended producer responsibility towards the design of circular and sustainable products, prioritizing the reduction of materials and energy at the source, while creating products to last longer, able to be easily reused, repaired and recycled. • Adapt existent standards: **IEC 62430:2019** Environmentally conscious design (ECD) - Principles, requirements and guidance **ISO/TR 14062:2002** Environmental management - Integrating environmental aspects into product design and development **GOST R 55103:2012** Resource saving. Efficient control of resources. Basic regulation **VDI 2243:2002** Recycling-oriented product development
	DIGITAL TECHNOLOGY
There is a lack of harmonized metrics on circular economy and is practices	Integrate and standardize indicators (or KPIs) to control the performance and impact around circular economy and industrial symbiosis practices. • Adapt existent standards: **MEE Standard**: Standard for National Demonstration Eco-Industrial Parks **NDRC Standard:** Notice on Recommending Key Candidate Industrial Parks for Circular Economy Transformation in 2017 **MIIT Standard:** Requirement for the Evaluation of Green Industrial Parks, under the Notice on the Establishment of a Green Manufacturing System
Existing manufacturing standards are insufficient to enable smart manufacturing	Developed standards for digital technologies, based on distributed manufacturing services to close the resource loop along life cycle stages and establish platforms to exchange data and information, contributing to the identification of Industrial Symbiosis opportunities and barriers.

	• Adapt existent standards: **IEC/PAS 63178:2018** Smart manufacturing service platform. Service-oriented integration requirements of the manufacturing resource/capability **IEC/PAS 63088:2017** Smart manufacturing. Reference architecture model industry 4.0 (RAMI4.0) **IEC TS 62351 (Series)** Power systems management and associated information exchange - data and communications security **GB/T 36578:2018** Data interface specification for circular economy informatization platform of industrial park **IEEE 1517:2010** Information Technology - System and Software Life Cycle Processes - Reuse Processes **IEC/TR 62635:2012** Guidelines for end of life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment **DIN PAS 1049:2004** Transmission of recycling relevant product information between producers and recyclers - The recycling passport (currently withdrawn) **ASTM D 6311:1998** Standard Guide for Generation of Environmental Data Related to Waste Management Activities: Selection and Optimization of Sampling Design
SUSTAINABLE FINANCE	
There is absence of standards' instruments focussed on sustainable finance	It is demanded a coherent framework in which the entire bond market begins to reflect the transition towards a low-carbon transformation, supported by voluntary and compulsory instruments. • Adapt existent standards: **Climate Bond Standards** **PAS 7340:2020** Framework for embedding the principles of sustainable finance in financial services organizations. Guide **ISO 14030-1 (Draft)** Environmental performance evaluation. Green debt instruments. Part 1. Process for green bonds **ISO/WD 32210 (Work in progress)** Framework for sustainable finance: Principles and guidance – ISO/TC 322 Sustainable Finance

Adopting the recommendations shared in this work would contribute to shaping a more comprehensive and cost-effective Pan-European standardization framework, that stands the test of circularity. Additionally, the multilevel scope explored, based on production systems, digital technology and sustainable finance solutions, offer a systems thinking approach, that considers diverse stakeholders in the production and consumption levels, building-up a more robust and integral framework (Figure 9).

- From the production systems perspective, the recommendations shared may lead to transformations on how industries operate, by revolutionising the way how they design, make, use and dispose of waste, while aiming to become greener, more circular and more digital. Moreover, it would contribute to address system and market failures, eliminating persisting barriers and creating incentives for companies to engage and invest in industrial symbiosis activities.

- The recommendations on digital technologies would help industries moving towards adopting the principles of Industry 4.0, based on automation and data exchange.

- Sustainable finance recommendations aim to provide instruments that fit the risk profile of 'green' initiatives, encouraging the investments of companies and institutional investors that support endeavours on industrial symbiosis.

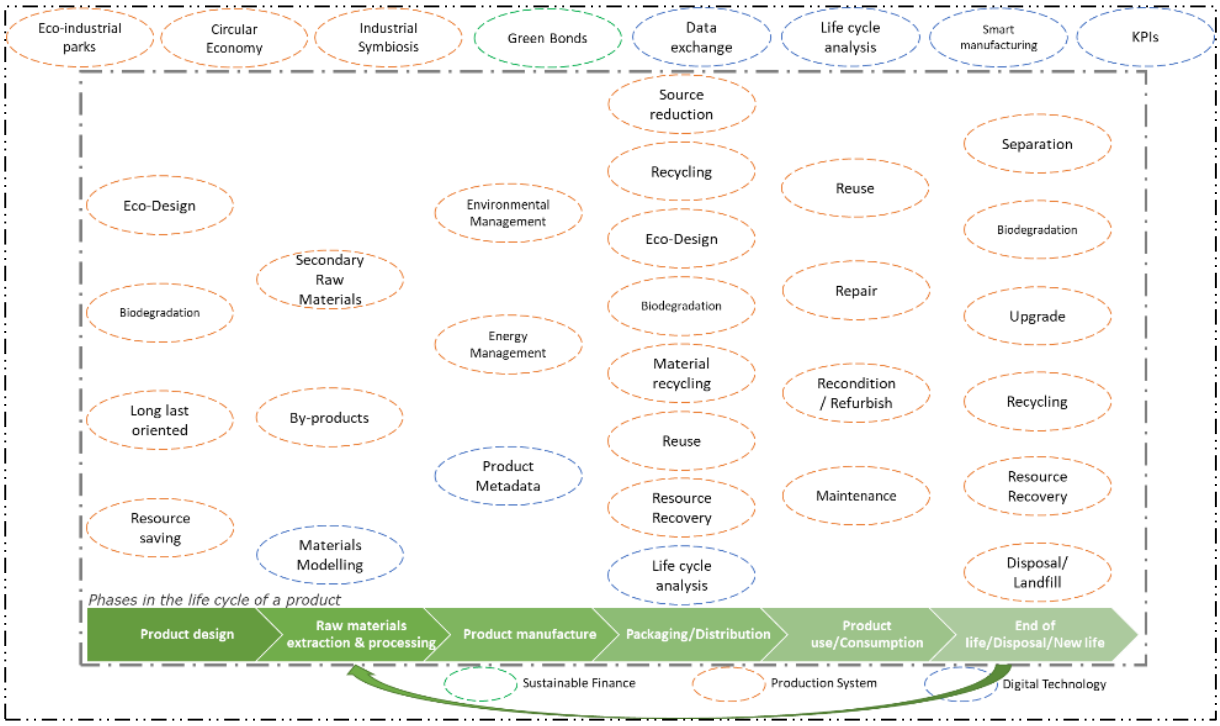

Figure 9. Mapping of Potential EU Standards linked to Industrial Symbiosis

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ANNEX 1. Global Standards linked to Industrial Symbiosis

Document identifier	Title (English)	Issuing body
ABNT NBR 12209	Hydraulic and sanitary engineering design for wastewater treatment plants	ABNT - Brazilian Association of Technical Standards
ABNT NBR 13029	Mining - Elaboration and presentation of a mining waste disposal design	ABNT - Brazilian Association of Technical Standards
ABNT NBR 13230	Recyclable plastic containers and packing	ABNT - Brazilian Association of Technical Standards
ABNT NBR 15114	Construction and demolition wastes - Recycling areas - Lines of direction for project, implantation and operation	ABNT - Brazilian Association of Technical Standards
ABNT NBR 15115	Recycled aggregates of construction and demolition wastes - Construction of pavement layers - Procedures	ABNT - Brazilian Association of Technical Standards
ABNT NBR 15796-2	Implants for surgery - Metallic materials - Nickel-titanium shape memory alloy Part 2: Determination of transformation temperature by bend and free recovery	ABNT - Brazilian Association of Technical Standards
ABNT NBR 15960	Refrigerants - Recovery, recycle and reclaim (3R) - Procedure	ABNT - Brazilian Association of Technical Standards
ABNT NBR 16033	Road vertical signalling - Polymeric poles of recycled materials - Requirements and test methods	ABNT - Brazilian Association of Technical Standards
ABNT NBR 16156	Waste electrical and electronic equipment - Requirements for the activity of reverse manufacturing	ABNT - Brazilian Association of Technical Standards
ABNT NBR 16182	Packaging - Symbology for orientation for selective disposal and materials identification	ABNT - Brazilian Association of Technical Standards
ALZ W 18	Aluminium in the packaging industry - Manufacture, use, recycling	Gesamtverband der Aluminiumindustrie e. V.
ANSI A 138.1	Green Squared (SM): American National Standard Specifications for Sustainable Ceramic Tiles, Glass Tiles, and Tile Installation Materials	American National Standards Institute (ANSI)*American National Standards Institute
ANSI/ASABE S 596	Recycling Plastic Containers from Pesticides and Pesticide-Related Products	American National Standards Institute (ANSI)*American National Standards Institute
ANSI/ASAE EP 403.3	Design of Anaerobic Lagoons for Animal Waste Management	American National Standards Institute (ANSI)*American National Standards Institute
ANSI/IEEE 1517	Standard for Information Technology - System and Software Life Cycle Processes - Reuse Processes	American National Standards Institute (ANSI)*American National Standards Institute
ANSI/NSF 245 (i4)	NSF/ANSI 245 wastewater treatment systems-nitrogen reduction	American National Standards Institute (ANSI)*American National Standards Institute
API PUBL 302	Waste Minimization in the Petroleum Industry Source Reduction Recycle Treatment Disposal a Compendium of Practices	API American Petroleum Institute
ASTM C 890	Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures	American Society for Testing and Materials (ASTM)*American Society for Testing and Materials
ASTM D 5663: 2015	Standard Guide for Validating Recycled Content in Packaging Paper and Paperboard	American Society for Testing and Materials (ASTM)*American Society for Testing and Materials
ASTM D 6311	Standard Guide for Generation of Environmental Data Related to Waste Management Activities: Selection and Optimization of Sampling Design	American Society for Testing and Materials (ASTM)*American Society for Testing and Materials
ASTM D 6842	Standard Guide for Designing Cost-Effective Sampling and Measurement Plans by Use of Estimated Uncertainty and Its Components in Waste Management Decision-Making	American Society for Testing and Materials (ASTM)*American Society for Testing and Materials

ASTM D 7209	Standard Guide for Waste Reduction, Resource Recovery, and Use of Recycled Polymeric Materials and Products	American Society for Testing and Materials (ASTM)*American Society for Testing and Materials
ASTM D8013	Standard Guide for Establishing a Recycle Program for Roof Coverings Roofing Membrane and Shingle Materials	ASTM
ASTM E 2150	Standard Classification for Life Cycle Environmental Work Elements - Environmental Cost Element Structure	American Society for Testing and Materials (ASTM)*American Society for Testing and Materials
ASTM E3027	Standard Guide for Making Sustainability-Related Chemical Selection Decisions in the Life Cycle of Products	ASTM
ASTM F 2576	Standard Terminology Relating to Declarable Substances in Materials	American Society for Testing and Materials (ASTM)*American Society for Testing and Materials
ASTM WK52051	New Guide for Recycling Considerations in Life Cycle Assessment	ASTM
BIP 2102:2006	Environment management report. Focus on Waste Management	British Standards Institution
BNQ 3869-911/2010	Recyclable Plastic Bags - Certification Program	Bureau de normalization du Québec
BNQ 9011-911/2007	Compostable Plastic Bags - Certification Program	Bureau de normalization du Québec
BS 6543:1985	Guide to use of industrial by-products and waste materials in building and civil engineering	British Standards Institution
BS 8001:2017	FRAMEWORK FOR IMPLEMENTING THE PRINCIPLES OF THE CIRCULAR ECONOMY IN ORGANIZATIONS - GUIDE	British Standards Institution
BS 8595:2013	Code of practice for the selection of water reuse systems	British Standards Institution
BS 8905:2011	Framework for the assessment of the sustainable use of materials. Guidance	British Standards Institution
CAN/CGSB-43.125-2003	Design and Manufacture of Packaging for the Transportation of Infectious Substances, Diagnostic Specimens, Biological Products or (Bio) Medical Waste	Canadian General Standards Board
CEN/TR 13688: 2008	Packaging -- Material recycling -- Report on requirements for substances and materials to prevent a sustained impediment to recycling	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CEN/TR 13910: 2010	Packaging - Report on criteria and methodologies for life cycle analysis of packaging	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CEN/TR 14520: 2007	PACKAGING - REUSE - METHODS FOR ASSESSING THE PERFORMANCE OF A REUSE SYSTEM	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CEN/TS 15406:2010	Solid recovered fuels. Determination of bridging properties of bulk material	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CEN/TS 16010:2013	Plastics - Recycled plastics - Sampling procedures for testing plastics waste and recyclates	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CEN/TS 16011:2013	Plastics - Recycled plastics - Sample preparation	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CEN/TS 17307:2019	Materials obtained from End-of-Life Tyres — Granulates and powders — Elastomers identification: Gas-chromatography and mass-spectrometric detection of pyrolysis products in solution	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CEN/TS 17308	Materials obtained from End of Life Tyres — Steel wires – Determination of the non-metallic content	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation

CR 12340:1996	Packaging. Recommendations for conducting life-cycle inventory analysis of packaging systems	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CR 13504:2000	Packaging - Material recovery - Criteria for a minimum content of recycled material	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CR 13686:2001	Packaging - Optimization of energy recovery from packaging waste	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CR 1460:1994	Packaging - Energy recovery from used packaging	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CSA B128.3 : 2012 : R2017	Performance of non-potable water reuse systems	Canadian Standards Association
CWA 17284:2018	MATERIALS MODELLING - TERMINOLOGY, CLASSIFICATION AND METADATA	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
CWA 17354:2018	Industrial Symbiosis: Core Elements and Implementation Approaches	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
DB31/T 949.2-2016	Cultural tourism space service quality requirement. Part 2:Cultural and creative industry park	Shanghai Standard (DB31)
DIN 4226-100	Aggregates for concrete and mortar - Part 100: Recycled aggregates	DIN Deutsches Institut für Normung e. V.*DIN German Institute for Standardization
DIN 4226-101	Recycled aggregates for concrete in accordance with DIN EN 12620 - Part 101: Types and regulated dangerous substances	DIN Deutsches Institut für Normung e. V.*DIN German Institute for Standardization
DIN 4226-102	Recycled aggregates for concrete in accordance with DIN EN 12620 - Part 102: Type testing and factory production control	DIN Deutsches Institut für Normung e. V.*DIN German Institute for Standardization
DIN PAS 1049	Transmission of recycling relevant product information between producers and recyclers - The recycling passport	DIN Deutsches Institut für Normung e. V.*DIN German Institute for Standardization
EIAJ ED-7631	Marking method for recycle of semiconductor device packing magazines	Japan Electronics and Information Technology Industries Association (JEITA)
EN 12574-1	Stationary waste containers - Part 1: Containers with a capacity up to 10000 l with flat or dome lid(s), for trunnion, double trunnion or pocket lifting device - Dimensions and design	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13427:2004	Packaging - Requirements for the use of European Standards in the field of packaging and packaging waste	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13428	Packaging - Requirements specific to manufacturing and composition - Prevention by source reduction	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13429: 2004	PACKAGING - REUSE	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13429:2004	Packaging - Reuse	CEN Europäisches Komitee für Normung*CEN European Committee

		for Standardization*CEN Comité Européen de Normalisation
EN 13430	Packaging - Requirements for packaging recoverable by material recycling	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13431	Packaging - Requirements for packaging recoverable in the form of energy recovery, including specification of minimum inferior calorific value	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13432	Packaging - Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13437	Packaging and material recycling - Criteria for recycling methods - Description of recycling processes and flow chart	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13439:2003	Packaging - Rate of energy recovery - Definition and method of calculation	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13440	Packaging - Rate of recycling - Definition and method of calculation	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13592:2017	Plastics sacks for household waste collection - Types, requirements and test methods	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 13593:2003	Packaging - Paper sacks for household waste collection - Types, requirements and test methods	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 14290 : 2004	ZINC AND ZINC ALLOYS - SECONDARY RAW MATERIAL	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 14995	Plastics - Evaluation of compostability - Test scheme and specifications	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 15342	Plastics - Recycled Plastics - Characterization of polystyrene (PS) recyclates	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 15343	Plastics - Recycled Plastics - Plastics recycling traceability and assessment of conformity and recycled content	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 15344	Plastics - Recycled Plastics - Characterisation of Polyethylene (PE) recyclates	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 15345	Plastics - Recycled Plastics - Characterisation of Polypropylene (PP) recyclates	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 15346	Plastics - Recycled plastics - Characterisation of poly(vinyl chloride) (PVC) recyclates	CEN Europäisches Komitee für Normung*CEN European Committee

		for Standardization*CEN Comité Européen de Normalisation
EN 15347	Plastics - Recycled Plastics - Characterisation of plastics wastes	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 15348	Plastics - Recycled plastics - Characterization of poly(ethylene terephthalate) (PET) recyclates	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 16214-4:2017	Sustainability criteria for the production of biofuels and bioliquids for energy applications - Principles, criteria, indicators and verifiers - Part 4: calculation methods of the greenhouse gas emission balance using a life cycle analysis approach.	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 16760	Bio-based products - Life Cycle Assessment	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 2955	Aerospace series; recycling of titanium and titanium alloy scrap	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 45554:2020	General methods for the assessment of the ability to repair, reuse and upgrade energy-related products	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 570:2007-04	Aluminium and aluminium alloys - Impact extrusion slugs obtained from wrought products - Specification; German version EN 570:2007	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
EN 62309	Dependability of products containing reused parts - Requirements for functionality and test (IEC 62309:2004)	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
GA X30-012:2004	Waste - Recycling terminology	AFNOR
GB / T 36578-2018	Data interface specification for circular economy informatization platform of industrial park	GB Standards (China)
GB/T 31088:2014	General guideline of standard system for circular economy of industrial parks	GB Standards (China)
GB/T 33567:2017	Specification for circular economy evaluating of industrial parks	GB Standards (China)
GB/T 33751:2017	General guideline of standard system for circular economy of industrial enterprises	GB Standards (China)
GB/T 34152 : 2017	General principle of circular economy management for industrial enterprises	GB Standards (China)
GB/T 36574-2018	Principles and requirements for the comprehensive utilization of exhaust gases in industrial park	GB Standards (China)
GB/T 36575-2018	Principles and requirements for water classified using and water recycling in industrial park	GB Standards (China)
GOST 17.0.0.01	System of standards in nature protection and improving utilization of nature resources. General	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST 8407	Reused rubber raw materials. Tyres and inner-tubes. Specifications	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 17.4.3.07	Nature protection. Soils. Requirements for sewage sludge use for fertilization	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 53692	Resources saving. Waste treatment. Stages of technological cycle of waste	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 53740	Resources saving. Packaging. Requirements specific to minimization, composition, manufacturing of package	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 53742	Resources saving. Packaging. Requirements for packaging recoverable by material recycling	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 53744	Resources saving. Packaging. Requirements for the use of European standards in the field of packaging and packaging waste	Federal Agency on Technical Regulating and Metrology (GOST R)

GOST R 53754	Resources saving. Packaging. Definitions and methods of calculation of efficiency of the recycling packaging as a secondary material resource	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 53756	Resources saving. Packaging. Criteria for recycling methods and description of recycling processes with registration flow chart	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 53759	Resources saving. Packaging. Reuse	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 53791	Resources saving. Stages of technological cycle. General principles	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 54193	Resources saving. Energy production. Guidance on implementing the best available techniques for improving energy efficiency in thermal energy generation	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 54199	Resources saving. Energy production. Guidance on implementing the best available techniques for improving energy efficiency in electricity generation	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 54200	Resources saving. Energy production. Guidance on implementing the best available techniques for improving energy efficiency in fuel combustion	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 54259	Resources saving. Waste management. Standard guide for waste reduction, resource recovery, and use of recycled polymeric materials and products	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 54532	Resources saving. Waste treatment. Waste classification and management in footwear manufacturing	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 54533-2011	Resources saving. Waste management. Guidelines and methods for the recovery of plastics waste	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 55100-2012	Resources saving. Best available techniques for the management of tailings and waste-rock in mining activities. Aspects of good practice	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 56828.27-2017	Best available techniques. Resources saving. The methodology for the treatment of waste to produce material resources	Federal Agency on Technical Regulating and Metrology (GOST R)
GOST R 56828.33-2017	Best available techniques. Resource saving. Aspects of good practice for the waste management in the lime industry	Federal Agency on Technical Regulating and Metrology (GOST R)
H60-300	Energy recovery from used packaging	AFNOR
IEC 111/191/CD*CEI 111/191/CD*IEC/TS 62650*CEI/TS 62650	End of life exchange for electrotechnical equipment between manufacturers and recyclers	IEC Internationale Elektrotechnische Kommission*IEC International Electrotechnical Commission*CEI Commission Electrotechnique Internationale
IEC 62430:2019	Environmentally conscious design (ECD) - Principles, requirements and guidance	IEC Internationale Elektrotechnische Kommission*IEC International Electrotechnical Commission*CEI Commission Electrotechnique Internationale
IEC/PAS 62814*CEI/PAS 62814	Dependability of software products containing reusable components - Guidance for functionality and tests	IEC Internationale Elektrotechnische Kommission*IEC International Electrotechnical Commission*CEI Commission Electrotechnique Internationale
IEC/TR 62392*CEI/TR 62392	Suitability of typical electrical insulating material (EIM) for polymer recycling	IEC Internationale Elektrotechnische Kommission*IEC International Electrotechnical Commission*CEI Commission Electrotechnique Internationale
IEC/TR 62635*CEI/TR 62635	Guidelines for end of life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment	IEC Internationale Elektrotechnische Kommission*IEC International Electrotechnical Commission*CEI Commission Electrotechnique Internationale
IEEE 1517	Information technology - System and software life cycle processes - Reuse processes	IEEE The Institute of Electrical and Electronics Engineers, Inc.
ISO 11650	Performance of refrigerant recovery and/or recycling equipment	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO

		Organisation Internationale de Normalisation
ISO 11932	Activity measurements of solid materials considered for recycling, re-use, or disposal as non-radioactive waste	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14001:2015	Environmental management systems - Requirements with guidance for use	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14002-1:2019	Environmental management systems — Guidelines for using ISO 14001 to address environmental aspects and conditions within an environmental topic area — Part 1: General	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14004:2016	Environmental management systems - General guidelines on implementation	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14005:2019	Environmental management systems - Guidelines for a flexible approach to phased implementation	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14006:2020	Environmental management systems - Guidelines for incorporating ecodesign	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14007:2019	Environmental management — Guidelines for determining environmental costs and benefits	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14008:2019	Monetary valuation of environmental impacts and related environmental aspects	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14015:2001	Environmental management - Environmental assessment of sites and organizations (EASO)	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14020:2000	Environmental labels and declarations — General principles	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14021:2016	Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling)	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14024:2018	Environmental labels and declarations — Type I environmental labelling — Principles and procedures	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation

ISO 14025:2006	Environmental labels and declarations — Type III environmental declarations — Principles and procedures	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14026:2017	Environmental labels and declarations — Principles, requirements and guidelines for communication of footprint information	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14031	Environmental management - Environmental performance evaluation - Guidelines	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14033:2019	Environmental management — Quantitative environmental information — Guidelines and examples	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14034:2016	Environmental management — Environmental technology verification (ETV)	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14040:2006	Environmental management - Life cycle assessment - Principles and framework	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14044:2006	Environmental management - Life cycle assessment - Requirements and guidelines	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14045:2012	Environmental management — Eco-efficiency assessment of product systems — Principles, requirements and guidelines	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14046:2014	Environmental management — Water footprint — Principles, requirements and guidelines	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14047:2012	Environmental management — Life cycle assessment — Illustrative examples on how to apply ISO 14044 to impact assessment situations	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14048:2002	Environmental management — Life cycle assessment — Data documentation format	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14049:2012	Environmental management — Life cycle assessment — Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14050:2009	Environmental management - Vocabulary	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO

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ISO 14051:2011	Environmental management — Material flow cost accounting — General framework	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14052:2017	Environmental management — Material flow cost accounting — Guidance for practical implementation in a supply chain	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14055-1:2017	Environmental management — Guidelines for establishing good practices for combatting land degradation and desertification — Part 1: Good practices framework	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14063:2020	Environmental management - Environmental communication - Guidelines and examples	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14064-1:2018	Greenhouse gases — Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14064-2:2019	Greenhouse gases — Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14064-3:2019	Greenhouse gases — Part 3: Specification with guidance for the verification and validation of greenhouse gas statements	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14065:2013	Greenhouse gases — Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14066:2011	Greenhouse gases — Competence requirements for greenhouse gas validation teams and verification teams	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14067:2018	Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14080:2018	Greenhouse gas management and related activities — Framework and principles for methodologies on climate actions	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 14090:2019	Adaptation to climate change — Principles, requirements and guidelines	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation

ISO 15176	Soil quality - Characterization of excavated soil and other soil materials intended for re-use	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 15270	Plastics - Guidelines for the recovery and recycling of plastics waste	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 15663-1:2000	Petroleum and natural gas industries - Life cycle costing - Part 1: Methodology	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 16221:2001	Water quality - Guidance for determination of biodegradability in the marine environment	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 17422	Plastics - Environmental aspects - General guidelines for their inclusion in standards	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 18601	Packaging and the environment - General requirements for the use of ISO standards in the field of packaging and the environment	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 18602	Packaging and the environment - Optimization of the packaging system	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 18603	Packaging and the environment - Reuse	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 18604	Packaging and the environment - Material recycling	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 18605	Packaging and the environment - Energy recovery	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 18606	Packaging and the environment - Organic recycling	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 22628:2002	Road vehicles. Recyclability and recoverability. Calculation method	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO 30003	Ships and marine technology - Ship recycling management systems - Requirements for bodies providing audit and certification of ship recycling management	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO

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ISO 50001	energy management system	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO/TR 14062	Environmental management - Integrating environmental aspects into product design and development	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO/TR 14069:2013	Greenhouse gases — Quantification and reporting of greenhouse gas emissions for organizations — Guidance for the application of ISO 14064-1	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO/TR 14073:2017	Environmental management — Water footprint — Illustrative examples on how to apply ISO 14046	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO/TR 16218	Packaging and the environment - Processes for chemical recovery	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO/TS 14027:2017	Environmental labels and declarations — Development of product category rules	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO/TS 14071:2014	Environmental management — Life cycle assessment — Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ISO/TS 14072:2014	Environmental management — Life cycle assessment — Requirements and guidelines for organizational life cycle assessment	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
ITU-T L.1100	Procedure for recycling rare metals in information and communication technology goods	ITU Internationale Fernmeldeunion*ITU International Telecommunication Union
JEITA ETR-7011	Guide for Reusable and/or Recyclable mark on containers and packaging for electronic components	Japan Electronics and Information Technology Industries Association (JEITA)
JIS A 8706-1	Crawler type recycle machine of construction wastes - Safety - Part 1: Requirements for mobile crushers	Japanisches Institut für Normung (JSA)*Japanese Standards Association (JSA)
JIS A 8706-2	Crawler type recycle machine of construction waste - Safety - Part 2: Requirements for mobile wood crushers with drum type cutter	Japanisches Institut für Normung (JSA)*Japanese Standards Association (JSA)
JIS C 5750-4-1	Dependability management - Part 4-1: Application guide - Dependability of products containing reused parts - Requirements for functionality and test	Japanisches Institut für Normung (JSA)*Japanese Standards Association (JSA)
JIS C 9911	Calculation and display methods of recycled and reuse indicator of electric or electronic equipment	Japanisches Institut für Normung (JSA)*Japanese Standards Association (JSA)
JIS H 2109	Classification standard of copper and copper alloy recycle materials	Japanisches Institut für Normung (JSA)*Japanese Standards Association (JSA)

JIS R 5214	Ecocement	Japanisches Institut für Normung (JSA)*Japanese Standards Association (JSA)
JIS Z 1641	Requirement for steel drum reprocessing	Japanisches Institut für Normung (JSA)*Japanese Standards Association (JSA)
JIS Z 7120	Plastics - Guideline for the application of Mobius loop to plastic products	Japanisches Institut für Normung (JSA)*Japanese Standards Association (JSA)
JIS Z 7121	Methods of life cycle inventory studies on plastics including recycling stages	Japanisches Institut für Normung (JSA)*Japanese Standards Association (JSA)
LES 2021	Guideline of recyclable percentage calculation for small general purpose SI engines	Land Engine Manufacturers Association (Japan) (LES)
NF EN 12258-3	Aluminium and aluminium alloys – Terms and definitions – Part 3: scrap (raw materials for recycling)	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
NF EN 378-4+A1	Refrigerating systems and heat pumps – Safety and environmental requirements – Part 4: operation, maintenance, repair and recovery	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
NF EN 643	Paper and board – European list of standard grades of paper and board for recycling	CEN Europäisches Komitee für Normung*CEN European Committee for Standardization*CEN Comité Européen de Normalisation
NF X31-211:2012	Characterization of waste - Leaching test of a solid waste material initially massive or generated by a solidification process	AFNOR
NF X31-212:2011	Characterization of waste - Determination of the massive solid characteristic	AFNOR
OENORM S 2006	Recycling of waste and existing substances - Definitions and methods	ASI Austrian Standards Institute/Österreichisches Normungsinstitut
OENORM S 2026-1	Recovered fuels from wastes - Part 1: Concepts for solid and liquid fuels	ASI Austrian Standards Institute/Österreichisches Normungsinstitut
OENORM S 2026-2	Recovered fuels from wastes - Part 2: Quality characteristics and analysis methods for solid and liquid fuels	ASI Austrian Standards Institute/Österreichisches Normungsinstitut
OENORM S 2080-1	Quality requirements for secondary raw materials - Part 1: Paper	ASI Austrian Standards Institute/Österreichisches Normungsinstitut
OENORM S 2201:2009-04-01	Organic waste - Quality requirements	ASI Austrian Standards Institute/Österreichisches Normungsinstitut
ONR 2914520	Packaging - Reuse - Methods for assessing the performance of a reuse system (CEN/TR 14520)	ASI Austrian Standards Institute/Österreichisches Normungsinstitut
PAS 101:2003	Recovered container glass. Specification for quality and guidance for good practice in collection	British Standards Institution
PAS 103:2004	Collected waste plastics packaging. Specification for quality and guidance for good practice in collection and preparation for recycling	British Standards Institution
PAS 141:2011	Reuse of used and waste electrical and electronic equipment (UEEE and WEEE). Process management. Specification	British Standards Institution
PAS 402:2013	Waste resource management. Specification for performance reporting	British Standards Institution
RAL-GZ 728	Quality assurance and test specifications for the demanufacture of refrigeration equipment	Deutsches Institut für Gütesicherung und Kennzeichnung e. V.
RAL-UZ 14	Basic Criteria for Award of the Environmental Label - Recycled Paper	Deutsches Institut für Gütesicherung und Kennzeichnung e. V.
RAL-UZ 30a	Basic Criteria for Award of the Environmental Label - Products made from Recycled Plastics	Deutsches Institut für Gütesicherung und Kennzeichnung e. V.

RAL-UZ 35	Basic Criteria for Award of the Environmental Label - Wallpapers and Woodchip Wall Coverings primarily made of Recycled Paper	Deutsches Institut für Gütesicherung und Kennzeichnung e. V.
RAL-UZ 55	Basic Criteria for Award of the Environmental Label - Recycled Printing Modules Refilled with Toner	Deutsches Institut für Gütesicherung und Kennzeichnung e. V.
RAL-UZ 56	Basic Criteria for Award of the Environmental Label - Recycled Cardboard	Deutsches Institut für Gütesicherung und Kennzeichnung e. V.
SAE ARP 1967B	Containers, Shipping and Storage, Reusable	Society of Automotive Engineers, Inc.
SAE AS 22074	Circuit Breaker, Recycling, Trip-Free, Push-Pull, 1/2 Thru 5 Ampere, Type I	Society of Automotive Engineers, Inc.
SAE AS 6055	Drum, Metal Reusable, Shipping and Storage	Society of Automotive Engineers, Inc.
SAE J 1990	Recovery and Recycle Equipment for Mobile Automotive Air-Conditioning Systems	Society of Automotive Engineers, Inc.
SANS 30002:2012	Ships and marine technology - Ship recycling management systems - Guidelines for selection of ship recyclers (and pro forma contract)	SABS STANDARDS DIVISION
SANS 30006:2012	Ship recycling management systems - Diagrams to show the location of hazardous materials onboard ships	SABS STANDARDS DIVISION
SANS 30007:2012	Ships and marine technology - Measures to prevent asbestos emission and exposure during ship recycling	SABS STANDARDS DIVISION
SFS 2691	Pipes for waste water. Reducers	Finnish Standards Association
STN 83 8106	Waste disposal. Sealing of the landfills. Design, construction, control and technical requirements	SUTN - Slovensky ustav technickej normalizacie
T/CSPSTC 2-2017	Evaluation systems for industrial park innovation influence	Group Standards-China Science and
T51-808*AC T51-808	Plastics - Assessment of oxobiodegradability of polyolefinic materials in the form of films - Methodology and requirements.	AFNOR
UL 2778	Products made from recycled plastic	Underwriters Laboratories Inc.
UL 2789	Environmental Claim Validation Procedure for Calculation of Estimated Recyclability Rate	Underwriters Laboratories Inc.
UL 2809	Environmental Claim Validation Procedures for Recycled Content	Underwriters Laboratories Inc.
UNE 156000:1998 EX	PAPER ENVELOPES. ECOLOGICAL CRITERIA.	ASOCIACION ESPAÑOLA DE NORMALIZACION Y CERTIFICACION (AENOR)
UNE 53969:1997 IN	PLASTICS. POLYETHYLENE (PE) WASTE COLLECTION BAGS. LIFE CYCLE ASSESSMENT.	ASOCIACION ESPAÑOLA DE NORMALIZACION Y CERTIFICACION (AENOR)
UNE 7145:1959	HOT EXTRACTION OF ASPHALTIC MATERIALS AND BITUME RECOVERY.	ASOCIACION ESPAÑOLA DE NORMALIZACION Y CERTIFICACION (AENOR)
UNI 10667-1:2010	Plastic raw-secondary materials - Part 1: General	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-10:2011	Plastic raw-secondary materials - Polystyrene for general purposes, from the recycling of industrial residues and/or from pre and/or post-consumer materials - Part 10: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-11:2009	Recycled plastic materials - Polyethylene and ethylene copolymers from agricultural and horticultural films to be used for different purposes - Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-12:2006	Recycled plastic materials - Expanded polystyrene from industrial residues and/or from post-consumer to be used for general purposes - Part 12: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-13:2001	Recycled plastic materials - Fillers obtained from grinding of production reject and/or from post consumer of reinforced thermosetting plastic composite - Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-14:2009	Recycled plastic materials - Mixtures of polymeric materials and of other materials based on cellulose to be used as aggregate into mortar of cement - Part 14: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-15:2008	Recycled plastic materials - Polyethylenterephtalate from post consumer, industrial scraps and residues from mechanical recycling to be used for chemical recycling and depolymerization - Part 15: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-16:2009	Recycled plastic materials - Blends of plastics heterogeneous based polyolefins from industrial residue and/ or from post consumer materials to be used for extrusion processes and / or injection moulding - Part 16: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione

UNI 10667-17:2011	Plastic raw-secondary materials - Blends of heterogeneous plastics based on polyolefins from industrial residue and/or from post consumer materials to be used for reducing processes in blast furnace - Part 17: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-18:2011	Plastic raw-secondary materials - Blends of heterogeneous plastics-based polyolefins from industrial residue and/ or from post consumer materials to be used for conversion into liquid and/or gas fuel - Part 18: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-2:2010	Plastic raw-secondary materials - Polyethylene for general purposes from the recycling of industrial residues and/or from pre and/or post consumer materials - Part 2: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-3:2011	Plastic raw-secondary materials - Polypropylene for general purposes from the recycling of industrial residues and/or from pre and/or post consumer materials - Part 3: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-4:2011	Plastic raw-secondary materials - Polyvinylchloride for general purposes, from the recycling of pre and/or post consumer liquid containers - Part 4: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-5:2012	Plastic raw-secondary materials - Plasticized polyvinylchloride for general purpose, from the recycling of industrial residues and/or from pre and/or post consumer materials - Part 5: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-6:2011	Plastic raw-secondary materials - Unplasticized poly(vinylchloride) for general purposes from the recycling of industrial residues and/or from rigid not plasticized items from pre and/or post consumer - Part 6: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-7:2011	Plastic raw-secondary materials - Polyethylenterephtalate flakes for the production of fibres, from the recycling of post consumer liquid containers - Part 7: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-8:2011	Recycled plastics materials - Polyethylenterephtalate flakes for blow moulding, from the recycling of post- consumer liquid containers - Part 8: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10667-9:2011	Plastic raw-secondary materials - Polyethylenterephtalate flakes for the production of sheets and sheetings, from the recycling of post-consumer liquid containers - Part 9: Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10853-1:2000	Recycled plastic materials from recovery of durable goods to end of life - General.	UNI - Ente Nazionale Italiano di Unificazione
UNI 10853-2:2000	Recycled plastic materials from recovery of durable goods to end of life - Polypropylene - Requirements and test methods.	UNI - Ente Nazionale Italiano di Unificazione
UNI 10853-3:2006	Recycled plastic materials from recovery of durable goods to end of life - Part 3: Polystyrene - Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 10853-4:2006	Recycled plastic materials from recovery of durable goods to end of life - Part 4: Acrylonitrile/Butadiene/ Styrene (ABS) - Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 11183:2006	Plastic materials biodegradable at room temperature - Requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
UNI 11462:2012	Plastic materials biodegradable in soil - Types, requirements and test methods	UNI - Ente Nazionale Italiano di Unificazione
VDI 2074	Recycling in the building services	Verein Deutscher Ingenieure*Association of Engineers
VDI 2243	Recycling-oriented product development	Verein Deutscher Ingenieure*Association of Engineers
VDI 2343 Blatt 1	Recycling of electrical and electronic products - Principles and terminology	Verein Deutscher Ingenieure*Association of Engineers
VDI 2343 Blatt 2	Recycling of electrical and electronical equipment - Logistics	Verein Deutscher Ingenieure*Association of Engineers
VDI 2343 Blatt 3	Recycling of electrical and electronical equipment - Disassembly	Verein Deutscher Ingenieure*Association of Engineers
VDI 2343 Blatt 4	Recycling of electrical and electronic equipment - Preparation techniques	Verein Deutscher Ingenieure*Association of Engineers
VDI 2343 Blatt 5	Recycling of electrical and electronic equipment - Material and thermal recycling and removal	Verein Deutscher Ingenieure*Association of Engineers

VDI 2343 Blatt 7	Recycling of electrical and electronical equipment - Re-use	Verein Deutscher Ingenieure*Association of Engineers
VDI 3397 Blatt 2	Maintenance of metalworking fluids for metalcutting and forming operations - Measures for maintaining quality, process improvement, and for reducing solid and liquid waste	Verein Deutscher Ingenieure*Association of Engineers
VDI 3476 Blatt 3	Waste gas cleaning - Methods of catalytic waste gas cleaning - Selective catalytic reduction	Verein Deutscher Ingenieure*Association of Engineers
VDI 4082	Recycling of cars - Draining and preparation of vehicles for the disassembly	Verein Deutscher Ingenieure*Association of Engineers
VDI 4091	Closed-loop production and material flow management - Methodology - Paper	Verein Deutscher Ingenieure*Association of Engineers
VDI 4431	Life-cycle management in the manufacturing industry	Verein Deutscher Ingenieure*Association of Engineers
VGB M 216 E : 2009	Recommendations for Design and Properties of Waste-fuelled Steam Generators	VGB PowerTech e. V.
XP ISO/PAS 30004	Ships and marine technology – Ship recycling management systems – Guidelines for the implementation of ISO 30000	ISO Internationale Organisation für Normung*ISO International Organization for Standardization*ISO Organisation Internationale de Normalisation
XP T47-751	Non reusable used tyres (NRUT) - Determination of the format of products from primary shredding - Manual method based on the measurement of the largest projected length	AFNOR
XP T47-752	End of Life Tyres (ELF) - Determination of the particle size analysis of granulates issued from End of Life Tyres - Method based on the mechanical sieving of product	AFNOR
XP T47-753	End of life tyres (ELT) - Determination of the format of products from primary shredding - Method based on the automated measurement of the largest projected length	AFNOR
XP T47-754	End-of-life (EOL) tyres - Determination of the ferrous wire content in the granulates stemming from EOL tyres - Method based on the magnetic sorting of products	AFNOR
XP T47-755	End of life tyres (ELT) - Sampling of granulates from grinding process of ELT - Method based on taking a relevant sample from a big-bag from successive different levels	AFNOR
XP T47-756	End of life tyres (ELT) - Sampling of products from primary shredding - Conveyor scenario	AFNOR
XP T47-757	End of life tyres (ELT) - Determination of the format of products from primary shredding - Method of evaluation of filaments	AFNOR
XP T47-758	End of life tyres - Separate determination of free and bound textile contents of granulates from grinding process of End of life tyres - Method based on the manual separation after mechanical sieving of products	AFNOR
XP T47-759	End of life tyres (ELT) - Sampling of products from primary shredding - Scenario pile being moved	AFNOR
XP T47-760	End of life tyres (ELT) - Characterisation of products from primary shredding - Guidance for a testing campaign	AFNOR
XP T47-761-1	End of Life Tyres (ELT) - Determination of residuals impurities content for steel from primary shredding or grinding process of End of Life Tyres - Reference method based on thermal decomposition in inert atmosphere	AFNOR
XP T47-761-2	End of life tyres (ELT) - Determination of residuals impurities content for steel from primary shredding or grinding process of End of Life Tyres - Part 2 : method on manufacturing site	AFNOR
XP T47-762-1	End of Life Tyres (ELT) - Sampling of steel from primary shredding or grinding process of End of Life Tyres - Part 1 : conveyor scenario	AFNOR
XP T47-763-1	End of life tyres (ELT) - Determination of density, porosity and void ratio of shredded tyres - Method(s) of measurement and test protocol(s) - Part 1: method based on water pycnometry (shredded tyres in the abounded state)	AFNOR

XP T47-763-2	End of life tyres (ELT) - Determination of density, porosity and void ratio of shredded tyres - Method(s) of measurement and test protocol(s) - Part 2 : method based on the measure of the compressibility (shredded tyres under stress)	AFNOR
XP T47-765	End of Life Tyres (ELT) - Characterisation of granulates from granulation processes - Guidance for a testing campaign	AFNOR
XP T47-766	End of life tyres (ELT) - Characterization of granulates from granulation processes - Evaluation of the odour intensity	AFNOR
XP X30-901	Circular economy - Circular economy project management system - Requirements and guidelines	AFNOR
ZVEI Entladungslampen, Recyling	Collection and Recycling of Discharge Lamps	Fördergemeinschaft Gutes Licht
MEE 2016	Standard for National Demonstration Eco-industrial Parks	MEE
MIIT 2016b	Notice on the Establishment of a Green Manufacturing System	MIIT
NRDC and MOF 2017b	Notice on Recommending Key Candidate Industrial Parks for Circular Economy Transformation in 2017	NRDC and MOF
CNIS 2017	Specification for Circular Economy Performance Evaluation of Industrial Parks	CNIS

ANNEX 2. EU Standards linked to Industrial Symbiosis

Document identifier	Title (English)	Issuing body
CEN/TR 13688: 2008	Packaging -- Material recycling -- Report on requirements for substances and materials to prevent a sustained impediment to recycling	CEN European Committee for Standardization
CEN/TR 13910: 2010	Packaging - Report on criteria and methodologies for life cycle analysis of packaging	CEN European Committee for Standardization
CEN/TS 15406:2010	Solid recovered fuels. Determination of bridging properties of bulk material	CEN European Committee for Standardization
CEN/TS 16010:2013	Plastics - Recycled plastics - Sampling procedures for testing plastics waste and recyclates	CEN European Committee for Standardization
CEN/TS 16011:2013	Plastics - Recycled plastics - Sample preparation	CEN European Committee for Standardization
CEN/TS 17307:2019	Materials obtained from End-of-Life Tyres — Granulates and powders — Elastomers identification: Gas-chromatography and mass-spectrometric detection of pyrolysis products in solution	CEN European Committee for Standardization
CEN/TS 17308	Materials obtained from End of Life Tyres — Steel wires – Determination of the non-metallic content	CEN European Committee for Standardization
CR 12340:1996	Packaging. Recommendations for conducting life-cycle inventory analysis of packaging systems	CEN European Committee for Standardization
CR 13504:2000	Packaging - Material recovery - Criteria for a minimum content of recycled material	CEN European Committee for Standardization
CR 13686:2001	Packaging - Optimization of energy recovery from packaging waste	CEN European Committee for Standardization
CR 1460:1994	Packaging - Energy recovery from used packaging	CEN European Committee for Standardization
CWA 17284:2018	MATERIALS MODELLING - TERMINOLOGY, CLASSIFICATION AND METADATA	CEN European Committee for Standardization
CWA 17354:2018	Industrial Symbiosis: Core Elements and Implementation Approaches	CEN European Committee for Standardization
EN 12574-1	Stationary waste containers - Part 1: Containers with a capacity up to 10000 l with flat or dome lid(s), for trunnion, double trunnion or pocket lifting device - Dimensions and design	CEN European Committee for Standardization
EN 14290: 2004	ZINC AND ZINC ALLOYS - SECONDARY RAW MATERIAL	CEN European Committee for Standardization
EN 13427:2004	Packaging - Requirements for the use of European Standards in the field of packaging and packaging waste	CEN European Committee for Standardization
EN 13428	Packaging - Requirements specific to manufacturing and composition - Prevention by source reduction	CEN European Committee for Standardization
EN 13429:2004	Packaging - Reuse	CEN European Committee for Standardization
EN 13430	Packaging - Requirements for packaging recoverable by material recycling	CEN European Committee for Standardization
EN 13431	Packaging - Requirements for packaging recoverable in the form of energy recovery, including specification of minimum inferior calorific value	CEN European Committee for Standardization
EN 13432	Packaging - Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging	CEN European Committee for Standardization
EN 13437	Packaging and material recycling - Criteria for recycling methods - Description of recycling processes and flow chart	CEN European Committee for Standardization
EN 13439:2003	Packaging - Rate of energy recovery - Definition and method of calculation	CEN European Committee for Standardization
EN 13440	Packaging - Rate of recycling - Definition and method of calculation	CEN European Committee for Standardization

EN 13592:2017	Plastics sacks for household waste collection - Types, requirements and test methods	CEN European Committee for Standardization
EN 13593:2003	Packaging - Paper sacks for household waste collection - Types, requirements and test methods	CEN European Committee for Standardization
EN 14995	Plastics - Evaluation of compostability - Test scheme and specifications	CEN European Committee for Standardization
EN 15342	Plastics - Recycled Plastics - Characterization of polystyrene (PS) recyclates	CEN European Committee for Standardization
EN 15343	Plastics - Recycled Plastics - Plastics recycling traceability and assessment of conformity and recycled content	CEN European Committee for Standardization
EN 15344	Plastics - Recycled Plastics - Characterisation of Polyethylene (PE) recyclates	CEN European Committee for Standardization
EN 15345	Plastics - Recycled Plastics - Characterisation of Polypropylene (PP) recyclates	CEN European Committee for Standardization
EN 15346	Plastics - Recycled plastics - Characterisation of poly(vinyl chloride) (PVC) recyclates	CEN European Committee for Standardization
EN 15347	Plastics - Recycled Plastics - Characterisation of plastics wastes	CEN European Committee for Standardization
EN 15348	Plastics - Recycled plastics - Characterization of poly(ethylene terephthalate) (PET) recyclates	CEN European Committee for Standardization
EN 16214-4:2017	Sustainability criteria for the production of biofuels and bioliquids for energy applications - Principles, criteria, indicators and verifiers - Part 4: calculation methods of the greenhouse gas emission balance using a life cycle analysis approach.	CEN European Committee for Standardization
EN 16760	Bio-based products - Life Cycle Assessment	CEN European Committee for Standardization
EN 2955	Aerospace series; recycling of titanium and titanium alloy scrap	CEN European Committee for Standardization
EN 570:2007-04	Aluminium and aluminium alloys - Impact extrusion slugs obtained from wrought products - Specification; German version EN 570:2007	CEN European Committee for Standardization
EN 62309	Dependability of products containing reused parts - Requirements for functionality and test (IEC 62309:2004)	CEN European Committee for Standardization
EN 45554:2020	General methods for the assessment of the ability to repair, reuse and upgrade energy-related products	CEN European Committee for Standardization
EN 13429: 2004	PACKAGING - REUSE	CEN European Committee for Standardization
CEN/TR 14520: 2007	PACKAGING - REUSE - METHODS FOR ASSESSING THE PERFORMANCE OF A REUSE SYSTEM	CEN European Committee for Standardization
NF EN 12258-3	Aluminium and aluminium alloys – Terms and definitions – Part 3: scrap (raw materials for recycling)	CEN European Committee for Standardization
NF EN 378-4+A1	Refrigerating systems and heat pumps – Safety and environmental requirements – Part 4: operation, maintenance, repair and recovery	CEN European Committee for Standardization
NF EN 643	Paper and board – European list of standard grades of paper and board for recycling	CEN European Committee for Standardization