Strengthening Circular Economy through Industrial Symbiosis: The *NextGenerationEU* Opportunity

ERIKA DŽAJIĆ URŠIČ [1]

Abstract Adopting the approach of industrial symbiosis, where waste from one company becomes input for another, aligns with global sustainability goals, including the Paris Agreement, UN 2030 Agenda, and European Green Deal. These initiatives promote a development model balancing profitability, social progress, and environmental protection. This chapter examines strategies and policies for sustainable resource management, heightened by COVID-19, and the EU's push for systematic implementation through the European Green Deal and *NextGenerationEU*. The research question addresses whether existing regulations and practices are sufficient for meeting the EU's green and digital commitments.

Keywords: • industrial symbiosis • circular economy • European Green Deal • sustainable development • *NextGenerationEU*

CORRESPONDENCE ADDRESS: Erika Džajić Uršič, Ph.D., Scientific Associate, Rudolfovo - Science and Technology Centre Novo mesto, Podbreznik 15, 8000 Novo mesto; Associate Professor, Faculty of Information Studies, Ljubljanska cesta 31a, 8000 Novo mesto; School of Advanced Social Studies Slovenia, Gregorčičeva 19, 5000 Nova Gorica, Slovenia, e-mail: erika.ursic@fuds.si.

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1 The proposition

We have only one planet-Earth available, but we are consuming resources as if we had many more available, so much so that predicts that at this rate, by 2050, we will consume as if we had three planets available and it is estimated that the consumption of raw materials, fossil fuels, and biomass will double in the next 40 years. The systems' current production processes (especially the extraction and processing phases of raw materials) are responsible for more than 90% of the loss of biodiversity, reduction of water availability, and polluting emissions dispersed in the environment (OECD, 2019). Moreover, without a transformation of the current economic system and with the current trend, it is estimated that the waste produced will increase by 70% by 2050 (Kaza et al., 2018).

Following these facts on our economy's unsustainable patterns, Europe has opted to undertake this plan by concentrating on particular targets to create a sustainable change (Makarovič et al., 2014), (Fric et al., 2023). The goal is to restrict global warming to a maximum of 1.5 degrees Celsius and, as a result, reduce the greenhouse impact by at least 55% by 2030 (Council of European Union, 2023). As many researchers are sceptical about these goals, only the facts and (not only EU but also global) population effort and willingness will show the results.

The United Nations 2030 Agenda for Sustainable Development and the Paris Agreement on climate change, both adopted in 2015, represent two fundamental contributions to guide the transition to an economic development model for the future. They have as a goal not only profitability and profit but also progress in social and environmental protection , ensuring the (realized) dignity of all individuals (Kleindienst & Tomšič, 2022a, 2019;Kleindienst & Tomšič, 2018, 2022). This need is now recognized by all EU countries and has become essential to avoid a future that continues to increase social and environmental problems.

In this context, a crucial aspect is that of the more rational and sustainable management of natural resources, more and more under pressure due to the growing population, the increase of demand for raw materials, and the increase in inequality even in less wealthy countries (Makarovič et al., 2014c).

The theme is characterized by a double dimension. An ambitious, it's about managing resources more efficiently, i.e. increasing productivity in production and consumption processes, reducing waste, and maintaining the value of the products as much as possible. In this regard, we must avoid everything that is still useful in itself and does not end up in a landfill in an illegal way. These types of products must be processed and reintegrated into the economic system. These two aspects (reducing waste, and maintaining value) represent the essence of the Circular Economy (CE) and of course, Industrial Symbiosis (IS), which aims to make economic activities more efficient and less impactful on the

environment through technological innovation and better management (Ministero dell'Ambiente, 2017).

The transition to a resource-efficient, low-carbon, and climate-change-resilient economy represents a fresh global challenge to achieve sustainable and equitable growth.

With a predicted global population of more than 9 billion people by 2050 and strong economic expansion in developing nations, demand for natural resources, particularly primary raw materials, will likely expand tremendously in the coming decades. This tendency will exacerbate environmental and climate problems unless policies and initiatives for more efficient resource usage are implemented.

In this perspective, the growth of a new "circular" and "symbiotic" model of production and consumption is an important strategic element in achieving global environmental goals, as well as a component in relaunching each EU country's competitiveness.

Over the last several years, the notion larger than resource efficiency has been extended into various efforts in sectors such as the OECD, International Resource Panel (UNEP-IRP), and G7/G8/G20 (Ministero dell'Ambiente, 2017). The initiative of the German G7 presidency in 2015 was a continuation of the Japanese G8 presidency in May 2008, which launched the "3R Action Plan - Reduce, Reuse, Recycle." It included a series of actions aimed at improving resource productivity, promoting the "recycling society" and the international market for recycled products, and reducing greenhouse gas emissions (Ministero dell'Ambiente, 2017).

Currently, topics such as procurement of sustainable raw materials, production processes and design ecological, the adoption of distribution and consumption models more sustainable, and the development of commodity markets secondary, have become key elements of the concept of the circular economy. Moving from the current linear economy model to the circular one requires a rethinking of market strategies and models to safeguard the competitiveness of industrial sectors and the heritage of natural resources (Fric and Rončević, 2018). A circular economy model involves consumer habits, acts as a regulator of production and manufacturing processes of large companies, and is able to create new jobs work and at the same time significantly reduces the demand for raw materials first virgins.

In the near future, it will be necessary to design and develop even more efficient systems of regeneration, reuse, and repair of goods, facilitating the maintenance of the products and increasing their life span. Operators, therefore, will have to conceive their products with the awareness that these, once used, are intended to be repaired and reused.

The change must also be made at the level of regulatory review, which simplifies its implementation and improves its coordination; to make cooperation between all actors

more economic, structural, and circular (public administrations, companies, research institutes science, and technology) to foster innovation, transfer of technologies and the competitiveness of industrial sectors (Ministero dell'Ambiente, 2017). The presence of support for (regional) innovativeness creates favourable conditions for the regions to become more competitive (Rončević and Modic, 2011,;Modic and Rončević 2018; Cepoi and Pandiloska Jurak, 2023; Golob and Makarovič, 2023; Pandiloska, 2024). The economic system is located within a wider ecological system and, while taking advantage of its natural resources and its ecosystem services must respect its operating rules e physical, biological, and climatic limits.

An economy where today's products are tomorrow's resources, where the value of the materials comes as much as possible maintained or recovered, in which there is a minimization of waste and impacts on the environment, can be defined as "circular" and in "symbiosis" (Fric and Rončević, 2018, Uršič, Fric, and Rončević, 2024).

In this regard, we can confirm that the analysis of the circular economy and its approach to industrial symbiosis has evolved a lot.

1.1 A new European strategy for sustainable development: Industrial Symbiosis

Industrial symbiosis is intimately connected to sustainability and sustainable development in combatting climate change (Clift & Druckman, 2015) and is regarded as a crucial method for moving to a circular economy (Fraccascia & Giannoccaro, 2020).

On a practical level, industrial symbiosis has been highlighted as a possible strategy for enhancing environmental sustainability while also attaining economic advantages (Plan, 2011), and industrial symbiosis development is part of the EU's sustainable industry policy program (Domenech et al., 2018) and the Green Deal (European Commission, 2022). The circular economy, which includes the notion of industrial symbiosis, is a worldwide megatrend in the last years' (Wadström et al., 2021).

The circular economy is an economic concept that promotes the reuse, recycling, and repurposing of materials in order to establish a sustainable system by decreasing waste, lowering resource consumption, and encouraging the reuse, recycling, and repurposing of resources (Chertow, 2007). Industrial symbiosis is closely related to the circular economy since it includes organizations collaborating and exchanging resources, energy, and waste to create a closed-loop system. Companies in an industrial symbiosis collaborate to use each other's output and by-products as resources rather than discarding them as garbage. This decreases the demand for new materials and energy, as well as trash creation and disposal (Džajić Uršič, 2020). This is consistent with the concepts of the circular economy, which seek to reduce waste and resource consumption. In essence, industrial symbiosis is a practical implementation of circular economy ideas, allowing

businesses to collaborate and share resources to build a more sustainable system. Companies may collaborate to build a more efficient and sustainable industrial ecosystem, lowering environmental impacts and generating economic advantages (Urska Fric et al., 2023). Collaboration can extent to different levels, with promising results from collaboration also between industry and university (Besednjak Valič et. al., 2022).

Industrial symbiosis has been present for decades, but it has grown to become more complex and integrated over time. It may be traced back to the early 1970s when Danish industries began cooperating to trade waste materials and by-products for reuse and recycling. Since then, the notion has expanded and gained traction as a means of reducing waste, conserving resources, and creating economic value. Industrial symbiosis is now a well-established practice that includes not only the interchange of waste materials and by-products, but also the sharing of energy, water, and other resources between businesses. Across the world, there are countless instances of successful industrial symbiosis programs (for example NISP: an International Synergies' most recognized project and was the world's first national industrial symbiosis programme). Individual enterprises partnering on a local scale to huge industrial parks and regions collaborating to form a closed-loop system are examples of this. New technologies, such as improved materials, sensors, and data analytics, have also made industrial symbiosis more complex and efficient. From a simple concept of waste exchange to a sophisticated system of resource sharing and collaboration, industrial symbiosis has grown. It has emerged as a critical component of the circular economy, allowing businesses to lessen their environmental effect while still providing economic value (Fric et al., 2020; Fric et al., 2023; Džajič Uršič and Jelen, 2022; Chertow, 2000; Majetič et al., 2019). But industrial symbiosis is a step up to the approach of the circular economy-is sharing of data and information, development of mutual trust, supportive sustainable consumption, corporate culture, and eventually booster of industrial sustainability, involving proximity, confidentiality, openness, equality, and cooperation amongst sectors that are part of the industrial symbiosis system (Džajić Uršič, 2020). Nevertheless, policy mechanisms, giving experiences from other fields seem to play important role (Besednjak Valič et al., 2023).

In the context of the EU, the concept of industrial symbiosis can be understood through the lens of variation, selection, and retention of EU strategic discourses (Jessop and Oosterlynck, 2008; Sum and Jessop, 2013). Certain discourses may emphasize the EU's role in global governance and diplomacy, while others stress regional cooperation and integration. Similar can be noted in other sectors (Besednjak Valič, 2022a). Nevertheless, EU discourses towards industrial symbiosis may highlight technical innovation and digitization, and prioritize social inclusion and human rights preservation.

As Por (Por, 2019) commented: circularity is a critical component of a broader industrial transition toward industrial symbiosis, carbon neutrality, and long-term competitiveness. It has the potential to produce significant material savings throughout value chains and

industrial processes, as well as generate additional value and unleash economic possibilities.

In line with the objectives outlined in the Industrial Strategy (European Commission, 2020c), the Commission is keen to promote greater circularity in the industry by facilitating industrial symbiosis through the development of an industry-led reporting and certification system, as well as enabling the implementation of industrial symbiosis. To create more effective and efficient cycles, a truly circular economy necessitates increased collaboration among various companies. Industrial symbiotic techniques are therefore the foundation of a circular economy.

The Kalundborg industrial park in Denmark is the most well-known example of this concept. The Park was not constructed with a "symbiotic" aim in mind, but an affiliation of the major companies, together with the involvement and oversight of the regional government, resulted in a successful collaboration between surrounding companies (Por, 2019). Networking appears to be the key component (Rončević and Besednjak Valič, 2022), while interorganisational stability is also important (Besednjak Valič, 2022b).

In theory, there might be many distinct forms of industrial symbiosis, but in fact, it is difficult to identify many examples. The potential for industrial symbiosis between related companies in the value chain (e.g., agricultural and food companies), as well as between companies that are not necessarily neighbours (e.g., seed manufacturers and consumers), or even between companies within the same industry, could be enormous (such as power generation companies). In general, corporate collaborative activities may be crucial in reducing environmental consequences (Bowen et al., 2018). But, in actuality, the majority of extant cases include enterprises that are close to one another and from different industries (similar to the pioneering initiative of Kalundborg). As stated in the Circular Economy Action Plan (European Commission, 2020c), the EU places industrial symbiosis at the heart of resource efficiency strategies and the transition to a circular economy, proposing facilitating and enabling industrial symbiosis as a means of transforming consumption and production patterns for greater circularity and industry (Branca et al., 2021).

In 2019 the new agenda of Europe - The European Green Deal (EGD) - for sustainable growth represents a new strategy for more sustainable management of materials and resources and more rational practices in the waste management and recycling (European Commission, 2019). This comprehensive plan by the EU is to make the economy more sustainable and reduce greenhouse gas emissions to net zero by 2050. It includes a wide range of initiatives, priorities, and policies aimed at transforming the EU into a climate-neutral and resource-efficient society. Some initiatives that reflect European Green Deal are aimed: (1) to improve the energy efficiency of buildings by renovating at least 35 million buildings by 2030 promoting the use of sustainable modes of transport such as walking, cycling, and public transport; (2) Circular Economy Action Plan (includes

measures to promote sustainable production and consumption, reduce waste, and improve recycling); (3) "farm to fork strategy" promoting sustainable food systems by reducing the use of pesticides and fertilizers, promoting organic farming, and reducing food waste and (4) biodiversity strategy to protect and restore biodiversity by conserving 30% of EU land and sea, and by promoting the restoration of degraded ecosystems. In this regards the selection of priorities aims to make the EU climate-neutral by 2050 and promote industrial symbiosis, but also retend to provide funding for various programs and initiatives, regulatory framework, ongoing collaboration, and visions related to the discourses of industrial symbiosis (Sum & Jessop, 2013).

As supported by the European Commission (European Commission, 2011) several countries are committed to introducing industrial symbiosis to their agenda. Undoubtedly, the key motivator for organizations to embrace industrial symbiosis practices is the potential economic rewards. Economic drivers (e.g., reduced raw material and waste costs, revenue generation) can promote and facilitate company cooperation, as can geographical, legislative, political (e.g., regulatory pressure, landfill tax), technical, operational, logistical, market-related, and environmental factors (Branca et al., 2021). The role of EU internal energy market in this context is also worth exploring (Klopčič et al., 2022). As stated by Fraccascia, Magno, and Albino (2016), despite various contributions to industrial symbiosis business models over the last few years, many companies still lack understanding when it comes to incorporating industrial symbiosis-based methods into their business activities. However, strategic actions can overcome such obstacles. Industrial symbiosis implementation can be aided by clear and uniform legislation and procedures, where economic incentives may be another motivator/facilitator that can help companies establish collaboration and organize staff training (Cervo et al., 2020; Jiao & Boons, 2014). At the European level, industrial symbiosis has taken on a strategic role in recent years and has found space in the policies summarized in Table 1.

Table 1: Starting points of the European regulatory initiatives on industrial symbiosis

Institution	**Title**	**Initiative**
European Commission	September 20, 2011 - COM (2011)571 "Table of march toward a Europe efficient in use of resources" (European Commission, 2011).	Industrial symbiosis is suggested as a way to promote more efficient manufacturing by making greater use of raw resources and reusing by-products.
European Commission	December 17, 2012 "European Resource Efficiency Platform (EREP). Manifest for a resource efficiency	European statement declaring that the EU and Member States should stimulate the adoption of industrial symbiosis by promoting pan-European initiatives, scaling up current

	in Europe" (European Commission, 2014a).	industrial symbiosis networks, and creating a knowledge exchange platform.
European Industrial Symbiosis Association (EUR-ISA)	European Industrial Symbiosis Association.	European Industrial Symbiosis Association 's role is to assist the European Commission in program execution in order to create an effective Europe in resource utilization through the adoption of industrial symbiosis.
European Commission	2 July 2014 - COM (2014) 398 "Verse a circular economy: program for a zero waste Europe" (European Commission, 2014b).	It specifically includes symbiotic industry among the techniques to be used to promote resource efficiency and the transition to a circular economy.
G7 (of which they belong France, Germany, Italy, United Kingdom, Canada, United States and Japan)	"Alliance on Resources Efficiency", launched on 2 October 2015 ('G7 Alliance on Resource Efficiency', 2015).	It highlighted industrial symbiosis as one of the foundations of the resource-efficiency approach.
European Commission	2 December 2015 - COM (2015) 614 "The ring missing - Plan of action by the EU for the economy circular" (European Commission, 2015).	The Commission proposes to clarify the standards relating to by-products for facilitate industrial symbiosis e create a level playing field in the EU.
European Parliament and European Council	Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 (European Parliament and Council, 2018).	The industrial symbiosis is defined as a technique for promoting resource reuse and transfer between businesses. Member States shall adopt necessary steps to assist in recognizing as a by-product a substance or an object derived from a manufacturing process whose primary goal is not the creation of that substance or thing.
European Commission	March 11, 2020 - COM/2020/98 final A new Circular Economy Action Plan. For a cleaner and more competitive Europe" (European Commission, 2020a).	Industrial symbiosis is specifically included in the methods to be implemented to increase resource efficiency and the transition to a circular economy.

Source: Circular Economy Network. Rapporto sull'economia circolare in Italia 2021 (Brunori et al., 2021).

1.2 New opportunities for European Union: *NextGenerationEU*

Besides the European Green Deal, a new recovery plan was proposed by the EU in response to the economic crisis caused by the COVID-19 pandemic. The plan called *NextGenerationEU* (NGEU), with a budget of €806.9 billion, will assist repair the immediate economic and social harm caused by the coronavirus epidemic while also preparing the EU for the future. The instrument will contribute to the development of a post-COVID-19 EU that is greener, more digital, more resilient, and better prepared for present and future problems. While the Recovery and Resilience Facility is the centrepiece of *NextGenerationEU*, a €723.8 billion facility instrument to assist reforms and investments in EU Member States (in total, to invest in reforms and projects). Grants will cover a portion of the money (€338.0 billion). Other contributions are for instance: the *EU4Health* project estimated at €9.4 billion will strengthen health security and will be able to cope with future health crises. In addition, with a reinforcement of €2 billion, the RescEU (Civil Protection Mechanism) will be extended and strengthened to prepare the EU to face the possible difficulties of the future. *Horizon Europe* will receive €95.5 billion, (€5,4 billion come from *NextGenerationEU* funds) which will allow him to finance research in the field of health and the green transition, digital, and resilience (Della Valle, 2022). *InvestEU* which will support companies and policies implemented in the EU, for the economic recovery of all Member States. For this, more than €372 billion will be mobilized, through an EU budget guarantee of €26,2 billion, which is reversed by various financial institutions, such as the European Investment Bank, *Just Transition Fund* €10.9 billion, and *Rural Development* €8,1 billion. Loans are estimated at €385 billion (Gundín, 2021).

The European Commission can raise funds through the Facility, a temporary instrument, by borrowing on capital markets to assist Member States in implementing reforms and investments that are in line with the EU's priorities and address the challenges identified in country-specific recommendations under the European Semester framework of economic and social policy coordination. The Facility went into effect in February 2021. From the start of the epidemic in February 2020 through the conclusion of December 2026, it funds Member States' reforms and investments. Member States must submit recovery and resilience plans to the European Commission, outlining the changes and investments they intend to implement by the end of 2026 in order to receive funding up to the agreed-upon amount (European Union, 2023).

Some important initiatives that are part of *NextGeneration EU* are:

(1) investments in energy-efficient renovations of public, social, and private buildings. Renovation of both public and private buildings is a critical activity that has been identified in the European Green Deal as vital endeavour to increase energy efficiency in the sector and meet targets. Building renovations can also play a critical part in European economic recovery following the COVID-19 epidemic, given the labour-intensive character of the construction sector, which is mostly dominated by

local enterprises (European Commission, 2023b). To jump-start and rebound, the European Commission's recovery plan includes additional funding for EU facility improvements. To accomplish this twin goal of energy gains and economic growth, the European Commission launched the policy "A Renovation Wave for Europe - Greening our Buildings, Creating Jobs, Improving Lives" (European Commission, 2020d) in 2020, to encourage renovation throughout the EU. It intends to more than treble yearly energy renovation rates over the following ten years. These improvements will improve the quality of life for individuals who live in and use the buildings, as well as create new green employment in the construction industry. A Renovation Wave strategy for Europe highlights three priority areas: combating energy poverty and underperforming buildings, public structures and social infrastructure, and carbon-free heating and cooling. The strategies' way to support the renovation is mainly by direct expenditures in research and innovation to eliminate market obstacles, as well as offering technical assistance (European Commission, 2023b).

(2) Sustainable transport: where the EU aims to invest in sustainable forms of travel like electric automobiles, public transit, and bicycle infrastructure. Governments and towns have implemented legislation and incentives to speed up the transition to sustainable mobility. Global regulators are setting more rigorous emissions limits. The EU unveiled its "Fit for 55" initiative, which aims to coordinate climate, energy, land use, transportation, and taxation policies in order to cut net greenhouse gas emissions by at least 55% by 2030. In addition to such regulations, most governments are providing electric vehicle subsidies. This is why industry participants are quickening the pace of automotive technology innovation, as they create new notions of electrified, connected, autonomous, and shared mobility. Although the rate and scope of change may vary. Electrification will play an essential part in the transformation of the mobility sector and provide significant potential in all vehicle segments. Launching new electric vehicles on the market is a vital first step in ensuring the rapid, widespread adoption of the electric transportation (McKinsey Center for Future Mobility, 2023).

(3) Investments in clean hydrogen generation and usage as a fuel. This will assist to minimize greenhouse gas emissions from the transportation and manufacturing sectors; In 2022, hydrogen accounted for less than 2% of Europe's energy consumption and was mostly utilized to manufacture chemical goods like plastics and fertilizers. 96% of this hydrogen was created using natural gas, which resulted in large CO2 emissions. The European Commission has suggested that by 2030, 10 million tonnes of renewable hydrogen be produced and 10 million tonnes imported. Since then, the Fit-for-55 package (in July 2021) has proposed a number of legislative recommendations to turn the European hydrogen plan into a specific European hydrogen policy framework. This contains recommendations to set objectives for renewable hydrogen use in industry and transportation by 2030. It also comprises the Hydrogen and decarbonized gas market package (COM/2021/803 final and COM/2021/804 final) (European Parliament and Council,

2021a, 2021b), which makes measures to facilitate the development of optimal and dedicated hydrogen infrastructure, as well as an efficient hydrogen market. Furthermore, the *NextGenerationEU* recovery plan has been made accessible to EU nations in order for them to engage in hydrogen projects across the value chain (European Commission, 2023a).

(4) The Just Transition funds, in which the EU intends to invest in regions that rely heavily on fossil fuels in order to assist them in transitioning to a low-carbon economy. The concept of a fair transition arose in the labor movement, as trade unions sought to combine the demand for excellent work with the need to strengthen environmental safeguards. The notion serves as a shorthand for discussing how to safeguard workers and communities impacted by transitions away from harmful sectors, as well as how to ensure that a new »green economy« delivers fair jobs, enhances human well-being, and tackles growing social and economic inequities (Rosemberg, 2010; Piggot et al., 2019; Kohler, 1998; Golob et al., 2023).The need for a "just transition" to a low-carbon economy - one that minimizes disruption for workers and communities dependent on unsustainable sectors and energy sources — is gaining support in climate policy and political discourse. (UNFCCC 2016; Rosemberg 2010; Piggot et al. 2019; Kohler 1998; UNFCCC 2015; European Commission 2021a) The preamble to the Paris Agreement contained a request for "a fair transition of the workforce", and the United Nations Framework Convention on Climate Change (UNFCCC) secretariat has developed a technical study on transition planning (UNFCCC, 2016). Furthermore, (UNFCCC, 2015) some national and regional administrations, including EU, Canada, Scotland, Spain, and New Zealand have recently launched new transition planning procedures (Rosemberg, 2010).

(5) Resilience and recovery: the EU strategy that aims to invest in climate adaption strategies such as flood protection, forest management, and ecosystem restoration (European Commission, 2021a). Both the European Green Deal and the *NextGenerationEU* are initiatives suggested by the EU to solve various difficulties confronting the EU continent. While the two efforts share some comparable goals, such as encouraging sustainability and generating jobs, their objectives, and priority areas are somewhat different. The European Green Deal is largely concerned with tackling the climate catastrophe and restructuring Europe's economy, while the *NextGenerationEU* is concerned with assisting with economic recovery and reconstruction following the epidemic. These initiatives, however, are inextricably connected since investing in green and sustainable policies may also assist economic development and recovery.

2 *NextGenerationEU* as a tool for Industrial Symbiosis

"*We want NextGenerationEU to kickstart a wave of European renewal and make our Union a leader in the circular economy. But this is not just an environmental or economic project: it must be a new cultural project for Europe*" said Ursula von der Leyen, when in December 2019 the new European Commission launched the European Green Deal (Von der Leyen 2020).

This so-called European "cultural project" aims to make the climate challenge an opportunity for a new development model, with the aim of becoming the first carbon-neutral continent by 2050 through a transition to a socially just ecological and industrial revolution capable of guaranteeing sustainable production but also ensuring trust and cooperation. As the EU moves towards a more sustainable and circular economy, industrial symbiosis can play a crucial role in achieving this goal.

The EU's planned initiative *NextGenerationEU* seeks investments in a sustainable and resilient future for Europe by fostering the transition to a carbon-neutral and circular economy, So, by promoting industrial symbiosis, *NextGenerationEU* can help drive sustainable economic growth, create new jobs, and reduce Europe's environmental footprint. It can also help improve Europe's resilience in the face of global challenges such as climate change and resource scarcity. As outlined before, applications of the concept of industrial symbiosis allow materials to be used in a more sustainable way and contribute to the creation of the core of the circular economy. In this manner, all policies and financial assurances are treated as the same for industrial symbiosis and circular economy. This is why industrial symbiosis as a circular economy approach, has the potential role to play a significant role in *NextGenerationEU*, by promoting collaboration and innovation among businesses, reducing waste and carbon emissions, and creating new economic opportunities.

Undeniably, the European Parliament believes that industrial symbiosis (as a circular economy) is the path that the EU. So, European companies must take in order to remain innovative and competitive in the global market while reducing their environmental footprint. But the COVID-19 pandemic demonstrated the bloody need for an environment conducive to the circular economy approaches (Cerulli, 2023).

Hopefully see, the concept of industrial symbiosis is an important concept of sustainability because allows not only materials to be used in a more sustainable way but contributes to the creation of networks, trust, and collaboration (informal and formal). Albeit individual efforts by particular industries, companies, and sectors must collaborate to scale up the effects of their activities and ensure the flow of recovered and reused materials. So, the approaches as industrial symbiosis, which some European countries are currently implementing in the national strategy, must be generally applied to assure the sustainability of industrial processes in this setting. While this chapter is not discussing

the various concepts of the circular economy approach or industrial symbiosis but it aims to summarize important strategic actions and policies at the European level, concerning the *NextGenerationEU* initiative. But also answering the preliminary question, of whether there is enough effort put into the transition to a circular economy within the initiative. What is certain is that, based on the policies and measures put in place, a favorable environment appears to have formed throughout 2020 for speeding the transition to the industrial symbiosis models (the circular economy approach). The potentials of European technology transfer systems absorbing and delivering the expected results are also worth future exploration (Modic et al., 2022).

2.1 European Union recovery package

In 2020, the EU created the *NextGenerationEU* Plan to cope with the pandemic's emergency and encourage economic recovery in the Member States, with the green transition positioned as a strategic priority. In this context, the new Action Plan for the circular economy was presented in March 2020 and the new European Industrial Strategy was published at the same time. Two different tools but linked by a strong thread, with the common goal of directing development towards four priorities: making our continent carbon neutral, moving from a linear economy to a circular economy, supporting industrial competitiveness, and developing infrastructure digital. The new Industrial Strategy and the Circular Economy Action Plan identify the drivers of Europe's industrial transformation to establish a green, circular, and digital economy.

Later, The Recovery and Resilience Plan (RRP) implemented by the EU to overcome the crisis caused by the pandemic is the key instrument at the heart of *NextGenerationEU* to help the EU emerge stronger and more resilient from the current crisis (European Commission, 2021cb). A strong financial commitment worth €750 billion has been put in place to support the *NextGenerationEU* plan, in addition to the €1.1 trillion foreseen in the Multiannual Financial Framework for the period 2021-2027. Furthermore, in view of a more comprehensive reform of the budget and of its own resources system, the EU has envisaged the issue of bonds (including “green bonds”) as well as some further financing measures consistent with the strategic objectives (Della Valle, 2022). Among the latter, In Table 2, we list some important high points of *NextGenerationEU.*

Table 2: Important assurances towards *NextGenerationEU* package

2015	The first Action Plan for the circular economy defined a series of actions regarding production, consumption, waste management, secondary raw materials, investments, and innovation.	On this basis, new regulations (e.g. Directive on the reduction of the impact of certain plastic products on the environment - 2019/904) (European Parliament and Council, 2019) and changes to existing ones (e.g. Directive 2008/98/EC on waste and repealing certain Directives (European Parliament and Council, 2008) Directive on packaging and packaging waste 94/62/CE (European Parliament and Council, 1994) were introduced.	
March 2020	The European Commission adopted the new Action Plan for the Circular Economy as part of the Green Deal, with the goal of speeding the transition to a circular and regenerative economy.	The new strategy focuses on the creation of sustainable goods and circularity in manufacturing processes, as well as several resource-intensive and high-impact sectors (including plastics, textiles, construction, electronics, food products, batteries, vehicles).	
April 2020	To use European funding, the Member States must define and submit the National Recovery and Resilience Plans by 30 April 2021. Each plan must include reforms and investments to be implemented by 2026.	The guidelines include circular economy reforms and investments, waste reduction and management, and water reuse. The European Commission will review the national	

		plans, and as previously stated, compliance with the objectives of the ecological and digital transition is a crucial requirement for a good evaluation. The European Council will then have to adopt each national plan by a qualified majority. The funds will be disbursed contingent on the effective completion of the intermediate and final project objectives.	
May 2020	On 27 May 2020, the Commission presented its proposal for a recovery plan from the crisis that societies and economies face due to COVID-19		
June, July and November 2020 and by the end of 2021.	The European Parliament finalized the EU Taxonomy Regulation on June 18, 2020, and it went into effect on July 12, 2020. This is a significant piece of legislation that will help to achieve the goals of the Green Deal and the Circular Economy Action Plan. Following that, on 21 July 2020, the European Council agreed on the recovery plan and the EU budget for 2021 to 2027.	With the taxonomy regulation, the world's first system for classifying sustainable economic activities was born, allowing investors to assess the environmental sustainability of projects and economic activities and, as a result, direct investments toward more sustainable and circular technologies and businesses. The regulation outlines six environmental goals. It allows economic activity to be classified as ecologically sustainable if it contributes to at least one of the following goals: (1) mitigation of climate change, (2)	Economic activities must meet the following requirements to be considered environmentally sustainable: substantially contribute to the achievement of at least one of the six environmental objectives; not cause significant harm to any of the environmental objectives; be carried out in accordance with the minimum social protection guarantees; and comply with the "technical screening criteria." The European Commission must issue delegated acts including detailed technical screening criteria in order to incorporate the

		climate change adaption, (3) water and marine resource sustainability and protection, (4) transition to a circular economy, which includes waste reduction and increasing utilization of secondary raw materials, (5)	principles established in the regulation and determine which economic activities may be deemed as contributing to each environmental aim. On November 20, 2020, the first delegated acts relevant to the
		pollution prevention and reduction and (6) biodiversity and ecosystem	categorization of activities contributing to climate change mitigation and
September 2020	The European Commission published guidelines for the preparation of national plans.		
December 2020	On 17 December 2020, the European Council adopted conclusions on "Making the Recovery Circular and Green", which provide political guidance on the measures set out in the new Circular Economy Action Plan.		
January 2021	A plastic tax of 0.80 euro per kilogram will be levied on non-recycled waste in order to compete with the reduction of waste and the increase of recycles.	In order to reduce emissions and achieve climate goals, a carbon tax will be implemented, as well as a change in the system for trading emission rates.	It is also planned to implement an online tax, in addition to a possible tax on financial transactions, to improve overall fiscal equity.
February 2021	The European Parliament voted a resolution on 10 February 2021, favourably reviewing the Commission's new Action Plan, and put up a set of suggestions and ideas aimed at expediting the transition to the circular economy. Among the	The European Parliament also requests that the European Commission present new legislation by 2021 that expands the scope of the Ecodesign Directive (Barkhausen et al., 2022) so that products	The resolution emphasizes two key points in the beginning. To begin with, achieving the Green Deal's objectives will be impossible unless the EU implements a circular economy model, as "the transition to a

	most important aspects is the proposal to the Commission to set certain binding targets for 2030 in terms of reducing the usage of basic raw materials and the environmental effect (European Commission, 2020b).	meet the principles of the circular economy in terms of durability, reusability, reparability, non-toxicity, room for improvement, recyclability, and recycled content (European Parliament and Council, 2009).	circular economy plays a fundamental role in reducing EU greenhouse gas emissions and achieving the 2030 climate target and the net-zero emissions target.
June 2021	The *NextGenerationEU* Recovery Instrument, on the other hand, is funded by money borrowed on international financial markets by the Commission on behalf of the EU (the first borrowing operations began in June 2021).		
July 2021	On 14 July 2021, the Commission presented its "Fit for 55" legislative package. Fit-for-55 is a comprehensive step in overhauling EU legislation to align it with its increased climate ambitions as stated in the European Green Deal.		
2023		The legal obligations on expenditure under the Next Generation EU (€806.9 billion in current prices) must be paid between 2021-2023, whereas payments can be made until the end of 2026. The sum to be utilized under the instrument, will be added to the EU budget as an external designated revenue each year.	

Source: (Cerulli, 2023).

As noted, *NextGenerationEU* has the *green transition* in its core (as one of the three pillars), where is stated that is no time to repair the damage caused by the pandemic but is the time to think about the future, and the future generations, focus on a resilient economy, therefore also be ready to face the great climate and ecological crisis. For this reason, the basis of the Green Deal is the strategy to achieve the goal of net zero greenhouse gas emissions by 2050, which is only possible with the transition to a circular economy.

3 Digital and Sustainability: two steps of the same path to the Industrial Symbiosis

Both, the ecological transition and the digital revolution are global, significant, and irreversible changes in the last three years in the circular economy approach. They must be approached from a unified point of view because although they seem different, they are complementary elements: sustainability (environmental, economic, and social) cannot exist without digital change.

Therefore, the terms digital transformation and digitization should not be used interchangeably. The latter overshadows the economic, psychological, and social components, which are merely by-products of digital development. Digitization refers to the "translation" of processes into digital format in order to automate their management and must be handled with caution. So, what happens when information technology becomes so prevalent that it influences people's behaviour?

After contributing to "polluting" the earth, elements such as artificial intelligence, supercomputing, and quantum computing, ect. can now enable its rescue and redeem its "past". The industry of information technology is responsible for 3% of worldwide CO2 emissions. Additionally, modern equipment necessitates the use of rare minerals and metals, which deplete resources and generate disposal and job security issues. Meanwhile, digital innovation, which is always accelerating, now plays a critical role in constructing a sustainable future. As a result, the notion of digital sustainability was formed, describing how new technologies must be developed in order to contribute to the construction of a better world, both in terms of their nature and their instrumental function in the environment, economy, and society. While in this case, the political interest is much strong (Della Valle, 2022).The introduction of digital technology has also revolutionized public administration, which may simplify procedures and combat corruption, and tailor-made solutions based on citizens' requirements. Not just to simplify, but also to manage smartly: the challenge for institutions is reflected in the development of smart cities, which claim less impactful and more citizen-friendly resource management.

"Digitalizing" individuals and organizations raise the concern of cybersecurity (Della Valle, 2022). So, the concerns with personal data security and protection should not be ignored, as they are becoming increasingly vulnerable as a result of the continual and dynamic interchange of information and may be stolen and misused by unauthorized parties.

Telemedicine, for example, will become increasingly important in the next years, as it will enable regular home monitoring of patients with chronic conditions, eliminating or minimizing access to health facilities, owing to wearable equipment. This context presents potentially critical cybersecurity issues such as the security of the patient's

sensitive health data stored in cloud platforms or the dependability of the patient's electronic medical wearables in terms of the information collected and transmitted through the networks to which they are connected (Della Valle, 2022).

Institutions, organizations, and people are therefore compelled to bear their weight, while the significant link between personal, social, environmental, and digital responsibility has to be clear in this sense. To do all of this, it will be necessary to intercept the direction of change, support it, comprehend its potential benefits, and seize its chances from an innovative standpoint.

Industry digitalization may open up new avenues for achieving industrial symbiosis (Antikainen, et al., 2018; Tseng et al., 2018; Tseng et al., 2018). The availability, quality, and location of material and energy flows across manufacturing processes may be monitored and tracked using information and communication technology (ICT) (Antikainen et al., 2018). Based on this data, for instance, digital platforms can help companies a lot: to identify possible synergies and connect with one another by facilitating the sharing of (real-time) information and matching resource buyers and providers (Benedict, et al., 2018; Kosmol & Leyh, 2020). Notwithstanding the benefits of employing digital platforms to allow industrial symbiosis, their use in the sector has been limited thus far. Current platforms often lack important industrial symbiosis-related services or have not attracted a critical mass of users (Benedict et al., 2018). Yet, there has been little research into how industrial symbiosis platforms might be developed to overcome the present challenges to industrial symbiosis (Benedict et al., 2018; Kosmol, and Leyh, 2020). Despite, companies' commitment to sustainability, existing environmental regulations, (a lack of) community awareness and cooperation between industries located in the same area, information sharing (i.e. the availability of data on waste streams and the material/water/energy requirements of local industries), and the technical and economic feasibility of synergistic transactions are among the seven categories of barriers (and enablers) for industrial symbiosis. As identified by Golev et al. (Golev et al., 2015).This is why industrial symbiosis helps to realize a circular economy by sharing underutilized assets across various enterprises and using leftover products from one sector as waste for the production processes of other industries. While the concept benefits are well understood, quite a lot of times have been hardly implemented in practice. On the other hand, information and communication tools can help a lot in a way of online marketplaces, databases, social networks, applications, and knowledge repositories (Krom et. al., 2022).

4 New opportunities and the sufficiency for Industrial Symbiosis

Inevitably, the EU creates opportunities for policy development in industrial symbiosis but also can help promote this approach and support sustainable economic growth within:

- policies that incentivize industries to collaborate on industrial symbiosis projects, which include financial incentives such as *NextGenerationEU*, regulatory support,

and technical assistance to help companies identify and develop potential synergies. It may help to establish measures and standards, as well as promote their acceptance within the EU and beyond;

- promotions on cross-sectoral collaboration between different industrial sectors. Bringing them together through networking events and seminars in order to uncover new potential for industrial symbiosis and to develop links between firms that would not have worked together otherwise. The EU can encourage increasing awareness among industries and policymakers about the potential benefits, and international collaboration on industrial symbiosis by collaborating with other nations and organizations to create shared regulations and standards;
- encouragements of industrial symbiosis research and development, particularly in developing fields such as digitalization, the circular economy, and green chemistry. This can aid in the identification of new prospects for industrial symbiosis and the creation of novel solutions that benefit numerous industries;
- encouragements for industry information exchange by building a centralized database of best practices, case studies, and other resources relating to industrial symbiosis. This allows businesses to learn from one another and reproduce successful ideas in their operations;
- the creation of a supportive financing environment, while the EU can aid in the creation of financial instruments such as green bonds, sustainability-linked loans, and other novel financing methods that can aid in funding industrial symbiosis projects.

Despite all opportunities, policies, and strategies for industrial symbiosis, for instance, the principles of the circular economy to develop policies that promote industrial symbiosis, digital technologies, the use of green chemistry principles, sustainable finances, and social innovation for projects, and all positive economic, environmental and social impact; the EU has to have in mind "building an EU for the next generations". And this is the historical task to which all European citizens are called. To be all protagonists, and not supporting actors. In recent years, the EU has seen a series of financial crises and recessions. The Eurozone's durability has been severely tested. Economic and employment disparities across Member States and geographical areas have widened, worsening social tensions and increasing political threats. Finally, in 2020, the health catastrophe caused by the COVID-19 pandemic resulted in an unprecedented production stoppage and the implementation of emergency measures with far-reaching societal consequences (Kukovič, 2021).

The difficulties we confront still now, are significant. When confronted with prior crises, the EU failed to develop an effective response owing to an institutional framework and insufficient intervention mechanisms, and the implementation of austerity measures generated a cycle of distrust. During the COVID-19 outbreak, knowledge of shared vulnerability was coupled with a sense of urgency for reform. With the swift acceptance

of measures aimed at combating the crisis and establishing the groundwork for recovery, Europeans have been able to come together.

The decision to fund the *NextGenerationEU* program with €750 billion was a breakpoint moment in European history. The European institutions' decisions demonstrate a keen grasp of the historical change. A European idea of the society of the future is emerging, which will give substance to the project of a "geopolitical Europe" launched by the Von der Leyen (Lehne, 2023), to affirm European strategic autonomy. For the new path, all institutions have been engaged in a coordinated and cohesive effort. The European Central Bank sustained and intensified its unprecedented monetary expansion in the first half of 2020. The European Commission has authorized the flexible use of budgetary resources with the Coronavirus Response Investment Initiative (CRII +), the Stability and Growth Pact's general escape clause, and the Temporary Framework for State Aid Rules. Even before *NextGenerationEU*, unprecedented safety nets were made available to deal with social, economic, and health emergencies: The temporary Support to mitigate Unemployment Risks in an Emergency (SURE), the recapitalization of the European Investment Bank (EIB), as well as a new specific credit line to deal with the pandemic within the European Stability (MES), approved in spring and available for Euro Area Member States.

Ultimately, towards the end of December 2020, the Parliament and the Council of the EU beat an agreement on the new Multiannual Financial Framework for 2021-2027, overriding vetoes in a show of solidarity and putting all available resources for the EU's rebirth into action. We are confronted with a list of a new tangible political will: to reinforce the EU's unitary qualities and internal unity in order to ultimately make Europe greener, more digital, and more resilient as a global player. However, regardless of whether there is enough effort put into the transition to a circular economy within the initiative, is certain, that based on the policies and measures put in place, a favorable environment appears to have formed throughout 2020 for speeding the transition to the industrial symbiosis models. On this note, also question of public opinion should be addressed and questions on the role of journalists (Rončević et al., 2023) and media (Džajić and Pandiloska Jurak, 2023) in delivering information on industrial symbiosis seems relevant. Still remains an open issue in terms of strategies, policies, and recommendations, and how the EU creates opportunities for businesses to build trust in the context of industrial symbiosis investments.

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