ITALIAN NATIONAL AGENCY FOR
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Symbiosis Users Network – SUN

PROCEEDINGS

# Verso un programma nazionale per la Simbiosi Industriale: prospettive e opportunità per l'Italia

# Towards a national industrial symbiosis programme: prospects and opportunities for Italy

## Symbiosis Users Network – SUN

## Proceedings of the seventh SUN Conference

November 8th 2023

Edited by Tiziana Beltrani and Marco La Monica

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# Introduzione

Con la crescente attenzione alle sfide del nostro tempo, che evidenziano la necessità di una conversione ecologica e circolare, la simbiosi industriale (SI) sta emergendo come una strategia promettente e sempre più urgente per ridurre l'impatto ambientale delle attività produttive, promuovendo al contempo la transizione verso un'economia rigenerativa, resiliente e più efficiente. La SI è un approccio che promuove la cooperazione tra organizzazioni per ottimizzare l'uso delle risorse nei territori, trasformando gli scarti di una lavorazione, o – in generale – le risorse sottoutilizzate, in input per altre.

Questo approccio mira a ridurre gli sprechi e a massimizzare l'efficienza, in linea con i principi dell'economia circolare, portando vantaggi ambientali, economici e sociali. Secondo quanto espresso dal Ministero dell'Ambiente e della Sicurezza Energetica, la SI non solo riduce i rifiuti ma crea anche nuovi modelli ispirati ai sistemi naturali, mirando a replicare l'efficienza ecologica attraverso una gestione intelligente dei flussi di materia ed energia.

L'Europa ha identificato la simbiosi industriale come uno degli strumenti chiave per la transizione verso un'economia circolare. Già dal 2011, la Commissione Europea ha incoraggiato gli stati membri a sviluppare politiche che favoriscano la simbiosi industriale, riconoscendo i benefici ambientali, economici e sociali che ne derivano. In Italia, la SI ha guadagnato slancio negli ultimi anni, con diverse iniziative e progetti che ne promuovono l'adozione, sia a livello regionale che nazionale, con l'obiettivo di creare condizioni favorevoli per lo scambio di risorse e la valorizzazione dei sottoprodotti. Tuttavia, manca ancora un programma nazionale organico che possa massimizzare il suo potenziale e accelerare un'integrazione sistemica.

In questo contesto, SUN - Symbiosis Users Network, il CTS di Ecomondo ed ENEA hanno deciso di focalizzare la settima edizione della conferenza della Rete Italiana di Simbiosi Industriale SUN, tenutasi l'8 novembre 2023 a Rimini, sul riconoscimento, avvenuto a giugno 2022 da parte della Strategia Nazionale di Economia Circolare (SNEC), della simbiosi industriale come policy per la transizione verso l'economia circolare. Infatti, nell'ambito delle 63 riforme fondamentali per l'attuazione degli interventi del Piano Nazionale di Ripresa e Resilienza, il Cronoprogramma di attuazione della SNEC prevede alcune misure per sostenere la simbiosi industriale a livello operativo: per esempio, l'approvazione dei Progetti Faro di economia circolare legati al PNRR, lo sviluppo e l'applicazione dello strumento delle reti di impresa e dei distretti circolari e una piattaforma digitale per favorire le sinergie tra le diverse aziende nonché una collaborazione MASE-ENEA per traguardare un programma nazionale di simbiosi industriale coinvolgendo tutte le parti e gli operatori interessati.

Il convegno è stato l'occasione per fare il punto sulle numerose iniziative, pubbliche e private, attivate o previste per la loro potenziale messa a sistema, al fine di fornire una panoramica dei progressi compiuti finora e di ragionare circa le prospettive future che permettano di raggiungere gli obiettivi previsti dalla SNEC e sviluppare un programma nazionale per la simbiosi industriale. Questo dossier ne raccoglie gli atti e offre una restituzione dello stato dell'arte della SI in Italia.

Oltre all'esperienza e ai progetti sviluppati da ENEA già dal 2011, in Italia sono nate negli ultimi anni diverse iniziative private che offrono servizi dedicati alla simbiosi industriale per le imprese presenti sul territorio. Nell'ambito del convegno sono intervenuti alcuni di questi operatori (tra cui Sfridoo, Circularity, e Centrocot con M3P) che hanno illustrato il loro know-how nonché i risultati che hanno raggiunto dal punto di vista operativo. Ne è emerso un quadro molto promettente, dato l'estremo interesse del sistema delle imprese a ricorrere alla simbiosi industriale per la migliore gestione delle loro risorse.

Vista l'importanza crescente dello strumento delle reti di impresa per la simbiosi industriale e dei distretti circolari all'interno del cronoprogramma della Strategia Nazionale per l'Economia Circolare, sono intervenuti specifici stakeholder, quali rappresentanti di associazioni di categoria (RetImpresa), aree industriali (FICEI e Consorzio di Sviluppo Economico Locale Ponterosso Tagliamento) e iniziative private (Simbiosi). Questi hanno condiviso le loro esperienze, evidenziando come tali iniziative possano essere sistematizzate e possano convergere verso un disegno complessivo, capace di guidare importanti realtà del sistema produttivo nazionale verso una giusta transizione all'economia circolare, tenendo conto delle specificità territoriali.

Durante il convegno, infine, sono stati presentati numerosi casi di studio che hanno coperto una vasta gamma di settori, dalle applicazioni industriali alle questioni metodologiche, fino alla standardizzazione e alla diffusione delle buone pratiche. Questi contributi hanno evidenziato come la cooperazione debba estendersi al livello intersettoriale per generare vantaggi competitivi significativi, non solo per le singole aziende, ma anche per l'intero sistema produttivo e territoriale.

Tra i casi studio presentati in questo documento, sono diverse le iniziative che mirano ad attuare i principi dell'ecologia industriale, da cui ha origine la simbiosi industriale. Una tra queste è la piattaforma web APEA del Consorzio di sviluppo economico locale Ponterosso Tagliamento, che integra informazioni ambientali e promuove la collaborazione tra imprese per un uso efficiente delle risorse. Un esempio concreto viene poi dalla filiera del vetro, dove i materiali di scarto vengono trattati e trasformati in nuove materie prime, contribuendo a chiudere il ciclo di vita dei prodotti.

Emerge poi l'esperienza del progetto MARLIC nelle Marche, che ha messo in luce come le imprese della regione abbiano collaborato per ottimizzare l'uso delle risorse attraverso la condivisione di sottoprodotti. Un altro esempio significativo è quello del settore tessile, dove l'applicazione della responsabilità estesa del produttore ha permesso di recuperare e valorizzare i materiali di scarto, trasformandoli in nuove risorse per la produzione.

Un ulteriore caso di successo riguarda il recupero e la valorizzazione dei materassi in poliuretano a fine ciclo di vita. Questo progetto ha dimostrato come sia possibile trasformare un rifiuto problematico in una risorsa preziosa.

In conclusione, il convegno SUN ha confermato il grande potenziale della simbiosi industriale per il nostro Paese e ha mostrato come questa strategia possa essere motore di sviluppo sostenibile, offrendo opportunità per la creazione di valore economico e sociale, riducendo al contempo gli impatti ambientali. L'adozione di politiche e strumenti adeguati, insieme alla collaborazione tra imprese e istituzioni, è fondamentale per realizzare pienamente il potenziale della SI e promuovere una transizione efficace verso l'economia circolare.

Seguendo i principi qui descritti, ogni informazione condivisa può stimolare una maggiore consapevolezza e applicazione sistemica della simbiosi industriale. Ringraziamo quindi tutte le figure esperte che hanno contribuito condividendo le loro esperienze, dalle quali sono emerse le sfide, le necessità e le opportunità del contesto italiano riportate in questo lavoro.


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# Introduction

With growing attention to the challenges of our time, which highlight the need for an ecological and circular conversion, industrial symbiosis (IS) is emerging as a promising and increasingly urgent strategy to reduce the environmental impact of production activities, while promoting the transition to a regenerative, resilient and more efficient economy. IS is an approach that fosters cooperation between organizations to optimize the use of resources in territories, transforming waste from one process, or - in general - underused resources, into inputs for others.

This approach aims to reduce waste and maximize efficiency, according to principles of the circular economy, creating environmental, economic, and social benefits. According to what was expressed by the Ministry of the Environment and Energy Security (MASE), the IS not only reduces waste but also creates new models inspired by natural systems, aiming to replicate ecological efficiency through smart management of resources.

Europe has identified industrial symbiosis as one of the key tools for the transition towards a circular economy. Since 2011, the European Commission has encouraged member states to develop policies that favor industrial symbiosis, recognizing the environmental, economic, and social benefits that derive from it. In Italy, IS has grown in recent years, with several initiatives and projects promoting its adoption (both at regional and national levels) to create favorable conditions for the exchange of resources and the valorization of by-products. However, a comprehensive national program that can maximize its potential and accelerate systemic integration is still missing.

In this context, Symbiosis Users Network - SUN, the Ecomondo STC, and ENEA have decided to focus the seventh edition of the conference of the Italian SUN Industrial Symbiosis Network, held on 8 November 2023 in Rimini, on the recognition of industrial symbiosis as a policy for the transition towards the circular economy (June 2022, National Strategy for the Circular Economy, NSCE). In fact, as part of the 63 fundamental reforms for the realization of the National Recovery and Resilience Plan (NRRP), the NSCE implementation of the schedule provides for some measures to support industrial symbiosis at an operational level: for example, (i) the approval of the “Circular Economy Flagship Projects”, linked to the NRRP; (ii) the development and application of the tool of business networks and circular districts; and (iii) a national digital platform to encourage synergies between different companies as well as a MASE-ENEA collaboration to achieve a national industrial symbiosis program involving all interested parties and operators.

The conference was an opportunity to take stock of the numerous public and private initiatives activated or planned for their potential systemization, to provide an overview of the progress made so far, and to think about prospects that allow achieve the objectives set by the NSCE and develop a national program for industrial symbiosis. This dossier collects the documents and summarizes the state of the art of IS in Italy.

In addition to the experience and projects developed by ENEA since 2011, several private initiatives have been created in Italy in recent years that offer services dedicated to industrial symbiosis for companies. Some of these operators took part in the conference (including Sfridoo, Circularity, and Centrocot with M3P), presenting their know-how and the results they have achieved from an operational point of view. A very promising picture has emerged, given the extreme interest of the business system in resorting to industrial symbiosis for the better management of their resources.

Given the growing importance of business networks for industrial symbiosis and circular districts within the schedule of the National Strategy for the Circular Economy, specific stakeholders intervened, such as representatives of trade associations (RetImpresa), industrial areas (FICEI and Ponterosso Tagliamento Local Economic Development Consortium) and private initiatives (Simbiosi). These shared their experiences, highlighting how these initiatives can be systematized and can converge towards an overall plan, capable of guiding important realities of the national production system towards a right transition to the circular economy, taking into account territorial specificities.

Finally, during the conference, numerous case studies were presented which covered a vast range of sectors, from industrial applications to methodological issues, up to the standardization and diffusion of good practices. These contributions have highlighted how cooperation must extend to the inter-sectoral level to generate significant competitive advantages, not only for individual companies but also for the entire production and territorial system.

Among the case studies presented in this document, several initiatives aim to implement the principles of industrial ecology, from which industrial symbiosis originates. One of these is the APEA web platform of the Ponterosso Tagliamento local economic development consortium, which integrates environmental information and promotes collaboration between companies for the efficient use of resources. A concrete example comes from the glass supply chain, where waste materials are treated and transformed into new raw materials, helping to close the life cycle of the products.

Then the experience of the MARLIC project in the Marche emerged, which highlighted how companies in the region have collaborated to optimize the use of resources through the sharing of by-products. Another significant example is the textile sector, where extended producer responsibility has made it possible to recover and valorize waste materials, transforming them into new resources for production.

A further success story concerns the recovery and valorization of polyurethane mattresses at the end of their life cycle. This project demonstrated how it is possible to transform waste into a valuable resource.

In conclusion, the SUN conference confirmed the great potential of industrial symbiosis for our country and showed how this strategy can be a driver of sustainable development, offering opportunities for the creation of economic and social value, while reducing environmental impacts. The adoption of adequate policies and tools, together with collaboration between businesses and institutions, is fundamental to fully realize the potential of IS and promote an effective transition towards the circular economy.

With the principles described here in mind, any information shared can stimulate greater awareness and systemic application of industrial symbiosis. We therefore thank all the expert figures who contributed by sharing their experiences, from which the challenges, needs, and opportunities of the Italian context reported in this work emerged.


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# INTERVENTI AD INVITO

# Contributo di Silvia Grandi – Ministero dell'Ambiente e della Sicurezza Energetica

**Introduzione**

La simbiosi industriale è generalmente definita come un sistema integrato per condividere risorse secondo un approccio di tipo cooperativo in cui l'output materico di un'impresa può essere utilizzato come input da un'altra nell'ambito del suo processo di produzione (Chertow 2000, Lombardi e Laybourn 2012) ottimizzando i flussi di materia in una logica di azzeramento teorico del rifiuto e dello spreco trasformandoli, quindi, in una risorsa con un valore espresso con un prezzo di scambio o con pratiche implicite collaborative. Richiamando la letteratura geografico-economica e l'economia ambientale, la simbiosi si basa sulla valorizzazione dell'esistenza di economie esterne di localizzazione e nella promozione di vantaggi competitivi attraverso lo scambio di materia, energia, acqua e/o sottoprodotti (Renner,1947; Grandi, 2020) che creano vantaggi per l'agente economico, il territorio e gli ecosistemi.

Per le politiche europee, la simbiosi industriale rappresenta uno degli strumenti più rilevanti per raggiungere un'economia circolare sempre più efficiente e declinata a livello territoriale per abbandonare l'approccio lineare (Commissione Europea, 2011, 2012) ancora prima che un'implicita strategia europea fosse stata adattata (Commissione Europea, 2015). Nell'ambito del linguaggio dei negoziati multilaterali, la simbiosi si riscontra nel principio di efficienza di uso delle risorse (UNEP) ispirato anche a quanto avviene nei sistemi naturali in equilibrio ecologico in contrapposizione ad un metabolismo antropico basato sull'estrazione ed uso della materia prima, solitamente non rinnovabile, che ha caratterizzato il modello dello sviluppo industriale del XIX e XX secolo (Dansero e Bagliani, 2011) creando costi ambientali e sociali, più meno evidenti per le presenti e le future generazioni (i.e. emissioni di gas climalteranti, rischi di gestione di sostanze pericolose, costi di trasporto, dipendenze geopolitiche, inquinamenti, perdita di biodiversità, etc.), nonché un più evidente un costo finanziario per le imprese e i consumatori.

I principi della simbiosi industriale cercano di superare questi limiti attraverso un approccio tecno-manageriale che si sostanzia in profonda analisi funzionale, logistica, fisico-chimica dei flussi in entrata ed uscita nei processi produttivi per evidenziare e trovare punti di incontro tra offerta e domanda come operativizzato in Italia da ENEA (Cutaia *et al*, 2019). L'applicazione può arrivare a ripensare in modo sostanziale le determinanti (*circular rethinking*), riferendosi in modo integrato anche modello pressione-stato-risposte avanzato come lo schema interpretativo DPSIR (EEA, 1995) ed un'integrazione dei modelli di governance territoriale come nel noto caso di studio di Kalundborg in Danimarca.

In questo quadro, la domanda a cui questo breve contributo intende dare risposta è quanto il principio della simbiosi industriale risulta codificato nelle politiche pubbliche italiane e quali sviluppi vi sono nel quadro dei quadri finanziari degli anni ’20.

**La simbiosi industriale nelle politiche pubbliche italiane**

In chiave storico-giuridica, il percorso di codifica normativa può essere fondato sull’articolo 26 del D.lgs. 112/1998, nota come legge Bassanini, che ha introdotto nell’ordinamento nazionale le Aeree Produttive Ecologicamente Attrezzate (APEA), la cui disciplina viene demandata alle Regioni. In questo contesto un’area produttiva per essere APEA ha come condizione l’essere dotata delle infrastrutture e dei sistemi necessari a garantire la tutela della salute, della sicurezza e dell'ambiente e l’avere una concentrazione di aziende e che attivano la gestione unitaria e integrata delle infrastrutture e di servizi centralizzati idonei a garantire gli obiettivi di sostenibilità dello sviluppo a livello locale quali, ad esempio, aree ecologicamente attrezzate, impianti di depurazione delle acque reflue, ecc. Può essere quindi possibile creare processi di simbiosi industriale nella sfera dei servizi ambientali intra-impresa e beneficiare di semplificazioni amministrative nei meccanismi autorizzativi gestiti dalle Regioni. Anche la normativa nell’Autorizzazione Integrata Ambientale (AIA) può, in molti aspetti, presentare alcuni spazi di opportunità per attivare processi di simbiosi industriale (artt. da 29-bis a 29-quattordecies d.Lgs. 152/2006).

La Strategia Nazionale per l’Economia Circolare, inoltre, mette in evidenza nella prospettiva della simbiosi industriale l’istituto di rete di impresa (DL 10 febbraio 2009, n.5 convertito con modificazione della L. 9 aprile 2009), quando questa è finalizzata a motivi ambientali di efficienza delle risorse e nella disciplina relativi ai sottoprodotti (art. 184 bis D.Lgs 152/2006).

Questa breve rassegna, tuttavia, evidenzia che questo corpus normativo che non utilizza il termine “simbiosi industriale” in maniera esplicita, ma lo regola o lo facilita in maniera indiretta ricorrendo ad altri istituti affini di efficienza dei processi, di sottoprodotto, etc.

Il riconoscimento del ruolo della simbiosi industriale come politica pubblica esplicita vede un’esplicitazione quando, tra le azioni eleggibili nei bandi sugli incentivi di ricerca ed innovazione dell’allora Ministero dello Sviluppo Economico, viene richiamata esplicitamente la simbiosi industriale nel Decreto Ministeriale 11 giugno 2020 e poi ripreso nel Decreto Direttoriale del 7 dicembre 2020.

**La simbiosi industriale nel Piano nazionale di ripresa e resilienza: dalla SEC ad una strategia specifica**

Questo processo di codifica esplicita in Italia può essere fatto risalire al 2020, quando la Piattaforma Italiana degli attori per l'Economia Circolare (ICESP) ha definito nel documento "*Priorità ICESP per una ripresa post covid-19*" l'importanza di istituire un Programma Nazionale per le imprese allo scopo di sostenere la creazione di processi di simbiosi industriale e la riconversione eco-industriale delle aree produttive del paese integrato con una serie di incentivi e disincentivi fiscali che possano favorire questi percorsi (ICESP, 2020).

Capitalizzando gli studi, i progetti pilota e le azioni anche dall'ENEA, dall'ICESP e dalla rete SUN, ripresi dal Ministero delle Imprese e del Made in Italy (MIMIT) e da quello dell'Ambiente e della Sicurezza Energetica (MASE), la simbiosi industriale ha trovato uno spazio significativo nel Piano Nazionale di Ripresa e Resilienza (PNRR). Un caso notevole è, nello specifico, quanto previsto nella Missione 2 - Componente 1 - Investimento 1.2 - Linea d'Intervento C. In questo contesto è previsto il finanziamento di proposte volte alla realizzazione di "progetti faro" sull'economia circolare nell'ambito del riciclo dei rifiuti diriciclaggio meccanico, chimico, "Plastic Hubs"), inclusi i Marine Plastic Litter (MPL). Le proposte valorizzeranno, mediante pratiche di simbiosi industriale, l'incremento dell'utilizzo di materia riciclata o di materia prima seconda nel processo industriale.

Fondamentale in questo contesto è la Strategia Nazionale per l'Economia Circolare (SEC), riforma abilitante e milestone del PNRR, che coerentemente con il Piano d'azione europeo per l'economia circolare (Commissione Europea, 2014) e il quadro normativo dell'UE è stata adottata a giugno 2022, integra nelle aree di intervento (ecodesign, ecoprodotti, blue economy, bioeconomia, materie prime critiche, ecc) differenti strumenti, indicatori e sistemi di monitoraggio necessari per valutare i progressi nel raggiungimento degli obiettivi prefissati (Governo Italiano, 2021).

Dopo un processo consultivo svolto tra il 2021 e 2022, la SEC è stata adottata dall'allora Ministero della Transizione Ecologica con DM n. 259 del 24 giugno del 2022. In particolare, in questo documento è contenuto un capitolo totalmente dedicato alla simbiosi industriale dove, tra gli altri, si definiscono i seguenti obiettivi:

*"a) la creazione delle condizioni per un mercato dei "sottoprodotti" in termini di maggiore certezza nel riconoscimento e disponibilità;*

*b) la previsione di punteggi aggiuntivi in sede di partecipazione a procedure di gara per quei soggetti che abbiano sviluppato o si propongano di sviluppare modelli di distretto circolare;*

*c) inserimento dei distretti circolari come esempio virtuoso in linee guida di settore;*

*d) lo sviluppo di una piattaforma digitale che possa favore e facilitare gli scambi di sottoprodotti tra le imprese;*
*e) prevedere bilanci integrati che facciano riferimento all'intero processo sinergico anche se afferente a stabilimenti distinti o nella titolarità di soggetti giuridici diversi;*
*f) prevedere semplificazioni nel rilascio delle autorizzazioni che coinvolgono profili disciplinari diversi che necessitano di essere esaminati in maniera integrata;*
*g) introdurre agevolazioni fiscali in favore di imprese che aderiscono a contratti di rete per l'avvio di processi di economia circolare"* (Ministero della Transizione Ecologica, 2022a).
Gli obiettivi della SEC, inoltre, prevedono un'attuazione nel medio termine descritta nel Cronoprogramma della SEC, adottato con DM del MASE n. 342 del 19 settembre 2022 che definisce i principali output e scadenze per i primi anni di attuazione della SEC " (Ministero della Transizione Ecologica, 2022b). Anche in questo documento viene ripresa esplicitamente la simbiosi nel tema 8, prevedendone il sostegno attraverso strumenti normativi e finanziari, quali:

- *"lo sviluppo di strumenti e/o schemi di incentivazione finanziaria e semplificazione delle reti di impresa con finalità circolari, di rigenerazione di brown areas in eco distretti circolari in ottica di simbiosi industriale (entro il T3 2023);"*
- *"l'implementazione di una piattaforma digitale per favorire l'incontro di domanda e offerta di materie prime seconde in ottica di simbiosi industriale (entro il T2 2024);"*
- *"graduatoria definitiva di approvazione dei «Progetti Faro di economia circolare», inv. 1.2 della M2C1 da 600 milioni di euro: tra i criteri di valutazione premianti inseriti negli avvisi pubblicati è stata inserita la creazione di distretti circolari. Verranno valutate positivamente quelle proposte che prevedono soluzioni di rete finalizzate all'ottimizzazione delle filiere di raccolta, logistica e riciclo/riutilizzo del rifiuto (entro il T4 2022)"* (ibidem).

**L'accordo attuativo tra il Ministero dell'Ambiente e della Sicurezza Energetica (MASE) ed ENEA**

In questo contesto, il MASE e l'Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA) hanno definito un Accordo di collaborazione ex art.15 della legge 241/90 al fine di dare attuazione al tema 8 della SEC "*sostegno ai progetti di simbiosi industriale attraverso strumenti normativi e finanziari, nonché tutte le attività funzionali alla realizzazione di un sistema integrato di strumenti e funzionalità per la implementazione della simbiosi industriale a livello nazionale*" (MASE- EC e ENEA, 2023).

L'accordo prevede lo sviluppo, tra le altre, delle seguenti attività propedeutiche all'attuazione del cronoprogramma della SEC (Ministero della Transizione Ecologica, 2022b): studio sull'applicazione della disciplina del sottoprodotto per la Simbiosi Industriale; rigenerazione di *brown areas* in eco distretti circolari in ottica di SI; rassegna di modelli di piattaforme digitali per favorire l'incontro tra domanda ed offerta di risorse; studio di meccanismi e strumenti di collaborazione studio ed analisi di servizi/processi di facilitazione e trasferimento tecnologico; standardizzazione e certificazione; definizione di strumenti informativi e dataset per il monitoraggio della SI; mappatura delle competenze di tipo amministrativo, tecnico, operativo ed economico per la implementazione nel territorio e tra le imprese. L'obiettivo finale dell'accordo è la realizzazione di un Programma Nazionale per la Simbiosi Industriale (PNSI) dove un ruolo cardine sarà dato alla creazione di strumenti operativi basati sulla capitalizzazione delle metodologie sviluppate in ambito scientifico e tecnologico.

**Conclusioni e prossimi passi**

La breve analisi effettuata sintetizza lo sviluppo e la codifica normativa riconducibile alla simbiosi industriale in Italia cha ha raggiunto un ricco paniere di strumenti di *policy* (es: AEPEA, AIA, incentivi finanziari, reti) così come un'esplicitazione strategica nella SEC. Si delinea un quadro in evoluzione in cui le politiche pubbliche e le scelte delle imprese si devono basare su un approccio sistemico, integrando più fattori dove le parti coinvolte devono considerare attentamente la propria catena del valore del ciclo materico al fine di ottimizzare e conseguire un'implementazione vantaggiosa della simbiosi industriale.
Una delle sfide ed opportunità principali che emerge è relativa alle piccole e medie imprese (PMI). La simbiosi può aiutare a cambiare i propri modelli operativi in termini di ecoinnovazione cercando collaborazioni simbiotiche con altre imprese, al fine di ottimizzare l'uso delle risorse ed i costi aziendali.
Tuttavia, la sfida non riguarda solo la tecnologia o le tecniche, bensì anche la conoscenza, sia essa esplicita che tacita, come il capitale sociale e la fiducia, fattori entrambi essenziali per le interazioni mutualistiche e non di mercato richieste per la simbiosi industriale (Desrochers, 2004). Se infatti le tecnologie dell'informazione e della comunicazione hanno aumentato significativamente il potenziale per facilitare la condivisione della conoscenza, l'importanza della comunicazione umana e delle relazioni basate sulla fiducia non può essere sottovalutata e rappresenta una chiave di volta per facilitare lo sviluppo della simbiosi industriale in Italia.
In questa prospettiva ritorna importante il parallelismo tra l'approccio di Renner (1947) e quello dei distretti industriali marshalliani (Marshall, 1920) dove la collaborazione tra imprese lungo la catena del valore diventa esternalità positiva e quindi soluzione sia ambientale che sociale ed economica.

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# Contributo di Carlo La Rotonda – RetImpresa

**LE RETI D'IMPRESA NEI DISTRETTI CIRCOLARI E NELLE POLITICHE PUBBLICHE PER LA TRANSIZIONE VERDE E DIGITALE**

In una dimensione internazionale ed europea nella quale l'obiettivo di sostenibilità è diventato improrogabile, è prioritario promuovere e validare nuovi modelli e strumenti amministrativi e fiscali a sostegno della doppia transizione, verde e digitale.

La continua situazione di emergenza dovuta, dapprima, alla crisi sanitaria e, successivamente, alle tensioni geopolitiche per il conflitto russo-ucraino, con evidenti ripercussioni sull'approvvigionamento delle fonti energetiche e sui prezzi delle materie prime, ha evidenziato la necessità di riconfigurare le catene del valore, di rafforzare il consolidamento dimensionale delle imprese e i processi di collaborazione imprenditoriale lavorando, quindi, a un nuovo modello italiano di filiera.

Una prima risposta del nostro Paese a queste esigenze del sistema produttivo è rintracciabile nella "Strategia nazionale per l'economia circolare", approvata con il DM 259 del 24 giugno 2022 del Ministero della Transizione Ecologica (oggi Ministero dell'Ambiente e della Sicurezza Energetica): il documento programmatico che, con un orizzonte temporale fissato al 2035, individua le azioni, gli obiettivi e le misure che si intendono perseguire nella definizione delle politiche istituzionali volte ad assicurare un'effettiva transizione verso un'economia di tipo circolare.

La nuova SEC, che fa seguito alla procedura di consultazione pubblica che ha coinvolto diversi *stakeholders* pubblici e privati, tra cui Confindustria e RetImpresa, l'Agenzia confederale per le aggregazioni e le reti di imprese, rappresenta una riforma abilitante per l'economia circolare prevista dal PNRR, insieme al Programma Nazionale di Gestione dei Rifiuti. La riforma si affianca infatti agli altri investimenti attivati dal Legislatore nazionale per l'economia circolare, che mirano a rafforzare l'infrastruttura impiantistica per la gestione dei rifiuti, sia attraverso l'ammodernamento e lo sviluppo di nuovi impianti, sia attraverso la realizzazione di progetti "faro" per le filiere strategiche dei rifiuti (quali apparecchiature elettriche ed elettroniche, industria della carta e cartone, tessile, riciclo chimico e meccanico delle plastiche).

In questo scenario, secondo RetImpresa è fondamentale che l'attenzione dei *policy makers* sia rivolta a favorire misure di politica industriale finalizzate all'applicazione di un modello "circolare" che coinvolga la più vasta platea possibile di piccole e medie imprese, altrimenti escluse dalle principali traiettorie della trasformazione industriale; misure accompagnate da strumenti finanziari, tecnologici e organizzativi che mettano le imprese nella condizione di investire e attuarle.

E le reti d'impresa, introdotte nell'ordinamento da circa 14 anni (art. 3, co. 4-ter e ss. del DL n. 5/2009), appaiono strumento adatto a perseguire tali scopi, dal momento che si basano su un accordo plurilaterale di cooperazione tra imprenditori con finalità e caratteristiche che, specie in termini di trasversalità e flessibilità operativa, lo rendono pienamente compatibile con i *business model* circolari.

Infatti, il contratto di rete permette a più imprenditori, aggregandosi e condividendo idee, iniziative e investimenti, di accrescere, individualmente e collettivamente, la propria capacità innovativa e la propria competitività sul mercato, sulla base di obiettivi strategici definiti e misurabili e di un programma condiviso di attività da attuare nel tempo. Le reti d'impresa rappresentano, quindi, una risposta innovativa dell'ordinamento per aiutare le PMI ad affrontare insieme le sfide della sostenibilità e il cambio di paradigma dal tradizionale approccio lineare di produzione-consumo-smaltimento verso un modello economico circolare, che punta a riutilizzare, recuperare o riciclare i materiali di risulta dei processi produttivi e di consumo, riducendo in tal modo il flusso in uscita di queste importanti "risorse" verso lo smaltimento e il flusso in entrata di nuova materia prima vergine.

Le reti, d'altra parte, si confermano un fenomeno economico, prima ancora che giuridico, di estremo interesse per il mondo produttivo dal momento che, secondo gli ultimi dati aggiornati al 3 novembre 2023 (*dataset* InfoCamere), sono 8.827 i contratti di rete registrati presso il sistema camerale, con quasi 47mila imprese aggregate, per oltre il 90% di micro e piccole dimensioni, e un'ampia diffusione settoriale e sull'intero territorio nazionale (al Nord-est 21%, Nord ovest 19%, 34% al Centro e 26% al Sud e Isole).

Secondo RetImpresa il contratto di rete, per finalità e caratteristiche, è un potente strumento con cui le imprese possono organizzare e gestire progetti finalizzati a sviluppare pratiche di economia circolare e meccanismi di simbiosi industriale.

Questo aspetto è valorizzato anche nella SEC, nell'ambito del paragrafo sulla Simbiosi industriale (par. 2.3 all'interno del capitolo 2 "*Trasformazione dei modelli produttivi*"), laddove lo specifico focus riservato proprio alle "Reti d'Impresa nei distretti circolari", mette in luce le caratteristiche e i vantaggi del contratto di rete ai fini dell'attivazione e del sostegno alle pratiche di economia circolare.

Le reti si caratterizzano, infatti, per: *i)* flessibilità, sul piano organizzativo e gestionale, essendo tali scelte rimesse all'autonomia negoziale dei contraenti; *ii)* strategicità e stabilità, avendo obiettivi di innalzamento della capacità innovativa e della competitività delle imprese basati su programmi d'azione predefiniti e di medio periodo; *iii)* trasversalità e inclusività, dal momento che possono collaborare in rete imprese di qualsiasi dimensione, forma giuridica, area geografica e settore.

In linea con le osservazioni e i suggerimenti proposti da RetImpresa, nella SEC le reti sono indicate come strumento di "innovazione partecipata", moltiplicatore della capacità di investimento e di conoscenza condivisa tra le imprese e potenziale acceleratore dei progetti faro nei distretti circolari, in cui vi è la gestione in maniera unica e integrata dei servizi ambientali connessi con le attività industriali, come anche l'ammodernamento e la realizzazione di nuovi impianti per il miglioramento della raccolta, della logistica e del riciclo dei rifiuti.

La SEC riconosce che attraverso il contratto di rete è possibile dare efficace attuazione al principio di cooperazione tra tutti i soggetti del ciclo di vita di un bene, favorendo meccanismi di coordinamento tra imprese della filiera per la gestione della *supply chain*, modelli di innovazione collaborativa per l'uso efficiente delle risorse e delle materie prime (es. ricerca e sviluppo di nuovi materiali, di nuovi processi per il *packaging* sostenibile), ma anche rapporti di interdipendenza funzionale tra operatori "dissimili" a supporto dei progetti di simbiosi industriale, fornendo in tal modo adeguate garanzie sulla *compliance* aziendale in campo ambientale, da far valere anche in sede di controllo.

Più in particolare, il modello organizzativo della rete di imprese è compatibile con i principali *business model* dell'economia circolare, tra cui quelli che prevedono la condivisione di piattaforme, la servitizzazione di beni, le pratiche di *sharing*, l'allungamento della vita utile dei prodotti tramite *repairing*, *re-manufacturing*, *co-design*, ecc.

Come anticipato, con lo strumento negoziale della rete è possibile gestire - per l'intero o in parte - il percorso che caratterizza il ciclo vita di un prodotto, dalla fornitura della materia prima alle fasi di progettazione e lavorazione, alla commercializzazione, al consumo fino alle successive fasi funzionali al riutilizzo o alla raccolta e gestione finalizzata al riciclo e recupero.

Il coordinamento in rete può poi agevolare l'integrazione orizzontale e/o verticale tra imprese della filiera, attivando concretamente pratiche di simbiosi industriale. Si pensi alla condivisione di infrastrutture e *utilities* per la gestione e l'utilizzo congiunto di risorse, quali vapore, acque e reflui, energia; alla fornitura congiunta di servizi per soddisfare bisogni di sicurezza, igiene, trasporti, ecc., comuni, ad esempio, ad un'intera area industriale o distretto.

Altro esempio è rappresentato dalla materia dei sottoprodotti, cioè i materiali di risulta dei processi produttivi, che da scarto di lavorazione del processo produttivo di un'impresa possono diventare un prezioso *input* di materia per le linee di lavoro di altre imprese, che possono organizzarsi in reti di filiera per impiegarli a fini commerciali.

Infatti, il meccanismo normativo di pubblicità legale dei contratti di rete assicura evidenza del *network* verso i terzi e certezza giuridica in ordine ai soggetti aderenti alla rete, coinvolti nella realizzazione degli obiettivi e del programma comune di attività, e quindi anche rispetto agli impegni che la compagine aggregata ha assunto o intende assumere nei confronti di enti terzi, pubblici o privati, per l'attuazione di piani di investimento e progetti imprenditoriali o per beneficiare di agevolazioni.

Altra caratteristica del contratto di rete funzionale ai principi della circolarità è l'obbligo imposto alle imprese in rete di prevedere espressamente nel contratto criteri per la misurazione dell'avanzamento verso gli obiettivi strategici condivisi. Si tratta di un aspetto spesso considerato solo per i suoi risvolti obbligatori e formali, e non già per gli effettivi benefici che esso comporta, potendo agevolare la diffusione di virtuose pratiche di monitoraggio, analisi (es. *life cycle assessment*, relazione sui criteri ambientali minimi, ecc.) e misurazione delle *performance* ambientali da parte delle imprese e, quindi, il conseguimento concreto di obiettivi e risultati.

In questa medesima prospettiva, le reti ambientali possono altresì accompagnare la formazione e la crescita professionale del capitale umano dedicato all'innovazione tecnologica e alla sostenibilità presso le imprese retiste, nonché l'inserimento nelle stesse di profili altamente qualificati e necessari per lo sviluppo delle relative attività. Si pensi, sul punto, alle opportunità derivanti dall'utilizzo della codatorialità in rete, vale a dire l'innovativo strumento lavoristico - reso operativo nel 2022 grazie anche al contributo di RetImpresa - che consente esclusivamente alle imprese aderenti a contratti di rete di assumere congiuntamente uno o più dipendenti per svolgere compiti tecnici o manageriali e realizzare le attività previste dal programma comune (es. *manager* per la comunicazione, per la gestione degli appalti, per la sostenibilità, ecc.).

Ulteriore aspetto degno di nota della SEC è il richiamo espresso alla *best practice* della piattaforma Registry di RetImpresa, che utilizza l'*open innovation* e la *blockchain* per favorire l'aggregazione e la nascita di reti e filiere digitali tra PMI e *startup*, agevolando l'incontro tra domanda e offerta di beni e servizi ambientali, l'eco progettazione e l'*ecodesign* in piena sicurezza e tracciabilità. RetImpresa Registry rappresenta, in altre parole, uno strumento operativo a disposizione delle imprese di qualsiasi dimensione e settore per sperimentare sul campo l'economia circolare, un ecosistema digitale partecipato da oltre 600 imprese che condividono idee e proposte alla ricerca di *partner* e di collaborazioni per realizzare insieme innovazioni sostenibili e progetti simbiotici.

Infine, guardando alle prospettive future e alle possibili misure per dare slancio al cronoprogramma di attuazione della SEC, a giudizio di RetImpresa è fondamentale valorizzare strumenti adeguati di incentivazione delle forme di organizzazione e coordinamento delle reti di filiera per superare gli attuali limiti, non solo territoriali e dimensionali, connessi all'utilizzo delle risorse – regionali, nazionali, europee - proprio come si sta facendo con la promozione dei "distretti circolari".

Bisogna, in altri termini, sostenere la capacità di investimento delle imprese che decidono di collaborare in maniera stabile e organizzata, attraverso i contratti di rete e le altre forme "leggere" di aggregazione, anche con l'ausilio di piattaforme collaborative digitali come RetImpresa Registry, per perseguire obiettivi di formazione, sostenibilità e di economia circolare, introducendo *policy* e misure per:

- ✓ incentivare la partecipazione in rete delle PMI nei progetti di economia circolare attraverso la previsione di criteri premiali, quali ad esempio, punteggi aggiuntivi, riserva di quote di risorse, preferenza in graduatoria, cumulo dei requisiti di accesso/investimento;
- ✓ agevolare, ad esempio con l'incentivo automatico del credito d'imposta, la realizzazione di investimenti in forma aggregata per finalità strategiche di innovazione tecnologica e di simbiosi industriale;
- ✓ stimolare la creazione di reti tra PMI nelle comunità energetiche rinnovabili, nell'ambito del dibattito aperto sulla nuova disciplina di incentivazione delle CER;
- ✓ rifinanziare il regime agevolativo della sospensione temporanea della tassazione degli utili di azienda reinvestiti nel programma di rete, laddove diretti ad accrescere la capacità di raggiungimento degli obiettivi di economia circolare e di simbiosi industriale;
- ✓ assegnare *voucher* per sostenere le imprese in rete che acquisiscono competenze specializzate o manageriali allo scopo di realizzare programmi comuni orientati all'adozione di pratiche circolari.

# Contributo di Antonio Visconti - FICEI

E' con piacere che partecipo in qualità di Presidente della FICEI, federazione fondata nel 1963 che riunisce e coordina circa 30 Consorzi ed Enti industriali che operano e gestiscono le aree strategiche del Paese: dal quadrante di Verona, al petrolchimico Sardo; dal polo siderurgico di Taranto alle aree industriali del cratere Campano e Lucano, passando per Bari, Cagliari, Pordenone e Udine.

I consorzi e gli Enti Industriali sono, come previsto dall'Art.36 della Legge 317 del 1991, Enti pubblici economici impegnati nel creare le condizioni ottimali per favorire gli insediamenti produttivo di agglomerati d'imprese in determinate aree idonee.

Gli interventi dello Stato e delle Regioni hanno realizzato in 60 anni dalla nascita della prima area industriale (Verona 1963), un sistema infrastrutturale degli insediamenti industriali che si può definire imponente.

Può essere utile specificare che le maggiori industrie italiane presenti al sud sono localizzate in agglomerati facenti parte dei Consorzi per le aree di sviluppo industriale (ASI).

Oggi il Green Deal europeo, il Next Generation EU e il nostro PNRR, gettano le basi per un'economia resiliente e sostenibile.

Le aree industriali possono essere un importante riferimento, dove realizzare interventi in grado di generare nuovi posti di lavoro e contribuire nel contempo alla riqualificazione in ambito energetico, ambientale e digitale, favorendo processi di competitività e attrazione delle aree industriali. All'interno delle componenti del PNRR troviamo gli interventi sull'economia circolare e gestione dei rifiuti, la transizione energetica con le produzioni di fonti rinnovabili, l'utilizzo di idrogeno per il settore "hard to abate", la produzione in aree industriali dismesse, lo sviluppo di infrastrutture di ricarica elettrica, la riqualificazione e bonifica dei siti orfani, l'investimenti per i porti verdi ed investimenti in depurazione e fognature.

Le industrie e le imprese sono sollecitate in maniera crescente a ridurre il loro impatto ambientale sono chiamate ad investire in tecnologie efficienti su vasta scala, per rendere i loro processi produttivi e le loro catene del valore più sostenibili riducendo le emissioni dannose in atmosfera.

Il processo di riqualificare le aree industriali attraverso il miglioramento del contesto in cui esse vivono e operano, migliorando anche i servizi e le infrastrutture dal punto di vista energetico, ha lo scopo di favorire sia una riduzione dei costi e dei consumi energetici, che favorire la riduzione delle emissioni di $CO_2$ nonché ridurre gli impatti delle industrie sull'ambiente, creando una responsabilità sociale e una capacità collaborativa delle imprese all'interno dei Consorzi industriali.

La crescente consapevolezza da parte delle imprese sulla opportunità di produrre energia da fonti rinnovabili, riducendo i consumi e i costi energetici, configurando l'impresa come *autoconsumatore* delle energia prodotta, anche attraverso la aggregazione di più imprese che condividono l'energia prodotta dagli impianti messi in condivisione, ricorrendo anche a impianti condivisi di stoccaggio dell'energia, aprendo a nuovi scenari dove le *Comunità Energetiche* diventano una preziosa opportunità per il sistema produttivo. Queste comunità rappresentano uno spazio in cui le imprese collaborano per un obiettivo comune: produrre, condividere e consumare energia in modo efficiente e sostenibile.

La partecipazione attiva delle imprese consente di condividere esperienze, competenze e risorse, contribuendo a costruire un futuro energetico più sostenibile per l'intera comunità.

Le opportunità di sviluppo di un'impresa sono legate alla sua capacità di dotarsi di fonti di energia sostenibili ed economicamente vantaggiose svolgendo le proprie attività in modo efficiente grazie alla riduzione ed ottimizzazione del consumo di energia per unità di prodotto. Tale opportunità dipende evidentemente dal contesto industriale in cui essa opera e risulta essere localizzata, con impatti ambientali controllati e quindi eco-sostenibili. In tal senso, i Consorzi industriali possono svolgere un ruolo decisivo in tale ambito ponendo in essere programmi per il risparmio energetico, per l'utilizzo di fonti di energia rinnovabile e per la relativa riduzione dell'inquinamento derivante dai processi industriali.

Le direttive comunitarie sulle fonti energetiche rinnovabili, le cosiddette "RED II e RED III", offrono alle aree e consorzi industriali una possibilità di sviluppo e riconversione in quanto si stabilisce che, ogni Stato membro definisca una disciplina per l'individuazione delle superfici e delle aree idonee per l'installazione di impianti per la produzione di energia da fonti rinnovabili, "*chiamate aree di accelerazione"*, dove rendere possibile il rilascio delle autorizzazioni più brevi e un'esenzione dall'obbligo di effettuare le valutazioni d'impatto ambientale a protezione del patrimonio culturale, storico e ambientale.

L'utilizzo di superfici e strutture industriali avrà il vantaggio duplice sia di evitare il consumo di nuovo suolo a valenza paesaggistica o culturale, che di produrre energia sul posto rispetto a dove verrà consumata, configurando la generazione di energia per autoconsumo da parte delle singole imprese. Si potrebbe configurare una produzione di energia dove le imprese che agiscono collettivamente rappresentino i membri della *comunità di consumatori* di energia rinnovabile, creando delle comunità di energia rinnovabile dove le aree industriali e le imprese condividono tra loro l'energia prodotta dagli impianti di cui sono comproprietari.

Il maggiore ricorso all'energia da fonti rinnovabili oltre ad offrire vantaggi ambientali, sociali e sanitari, rappresenta una occasione per le imprese per partecipare al mercato favorendo il loro sviluppo tecnologico e innovazione, attraverso un loro posizionamento industriale nel settore della produzione d'impianti e della loro componentistica (inverter, pompe di calore, ecc), creando nuovi posti di lavoro qualificati per la loro specializzazione.

La FICEI può aiutare le imprese a promuovere ed attivare Comunità Energetiche Rinnovabili, offrendo servizi specialistici finalizzati ad individuare le soluzioni migliori per realizzare gli impianti, coinvolgendo anche investitori privati realizzatori d'impianti per la produzione di Energie rinnovabili. Con le competenze disponibili, e il sostegno del Governo, si potrà affrontare la sfida della transizione energetica con fiducia, creando un futuro sostenibile e prospero per i nostri Consorzi Industriali.

# Contributo di Piero Manzoni – Simbiosi

**The territory**

From Agri Desert rural territory to a fertile Human-Nature alliance: the Environment Producer

**Figura 1. Agricultural desert**

**From agricultural desert to an exclusive "anno mille" rewild area**

Nature is regenerated, biodiversity goes back a thousand years, improving living and health conditions for the eight neighboring municipalities that can benefit from the area with bike paths, high $CO_2$ storage in the soil, reduced presence of insects, incredible increase in underground and aboveground biodiversity, cooler temperatures, and water quality incomparable to nearby areas.

On this site, boasting the presence of Sites of Community Interest, Simbiosi continues to extract data for its technologies and for the development of new ones, facilitated by the presence of an Innovation Center (INNOVATION CENTER GIULIO NATTA). Here, start-ups, university spin-offs, research centers, and companies are incubated and financed to bring their technologies to market.

The area thus becomes a research and development center where Simbiosi, inspired by nature's behavior, creates technologies capable of replicating natural processes in industrial chains, community utilities, and on the territory. This 450-hectare area, once a "agricultural desert" until 1996, has been transformed through the execution of Smart Land, supporting numerous interventions for renaturalization and environmental regeneration, including the formation of over 107 hectares of wetlands, 78 hectares of forests, 65 hectares of timber reforestation, 50 hectares of meadows, and 110 kilometers of hedges and field rows.

**Figura 2. Smart Land**

## Exclusive "Anno mille" rewild area

Many other works are still in progress. The term "neorurale" is used because it refers to a place once inhabited by farmers but is now lived in by people who are not farmers but bring innovative, sustainable, and circular activities. These individuals define themselves as "neorurale," as they are highly educated people extracting an income many times higher than agricultural income from these places and their sustainability.

In the Neorurale territory, environmental services, or "ecosystem services," add to existing agricultural activities. These services are a heritage for all and support the concept of a sustainable future.

In the Neorurale perspective, even agricultural buildings, combined with surrounding land, form a unique and indivisible complex, as in ancient farmsteads. This allows the hosting of urban working activities without increasing or reducing the built-up area, integrating new constructions perfectly with the historical agricultural and natural landscape.

**COMPRENSORIO NEORURALE**
EVOLUTION OF BIODIVERSITY AND SOIL FERTILITY IN OVER 20 YEARS

| N° OF SPECIES | 1996 | 2021 | VARIATION |
|---|---|---|---|
| Birds | 80 | 217 | + 171% |
| Nesting Birds | 25 | 65 | + 160% |
| Mammals | 16 | 29 | + 81% |
| Butterflies | 21 | 45 | + 114% |
| Dragonflies | 13 | 32 | + 146% |
| Grasshoppers | 10 | 19 | + 90% |
| Mushrooms | 5 | 14 | + 180% |
| Plants and Flowers | | 255 | |
| **SOIL FERTILITY** | | | |
| C.E.C. meq/100g | 7 | 17,7 | + 153% |

**Figure 1. Evolution of biodiversity and soil fertility in over 20 years**

## THE NATURAL SYSTEM

### *Cross Resources Efficiency*

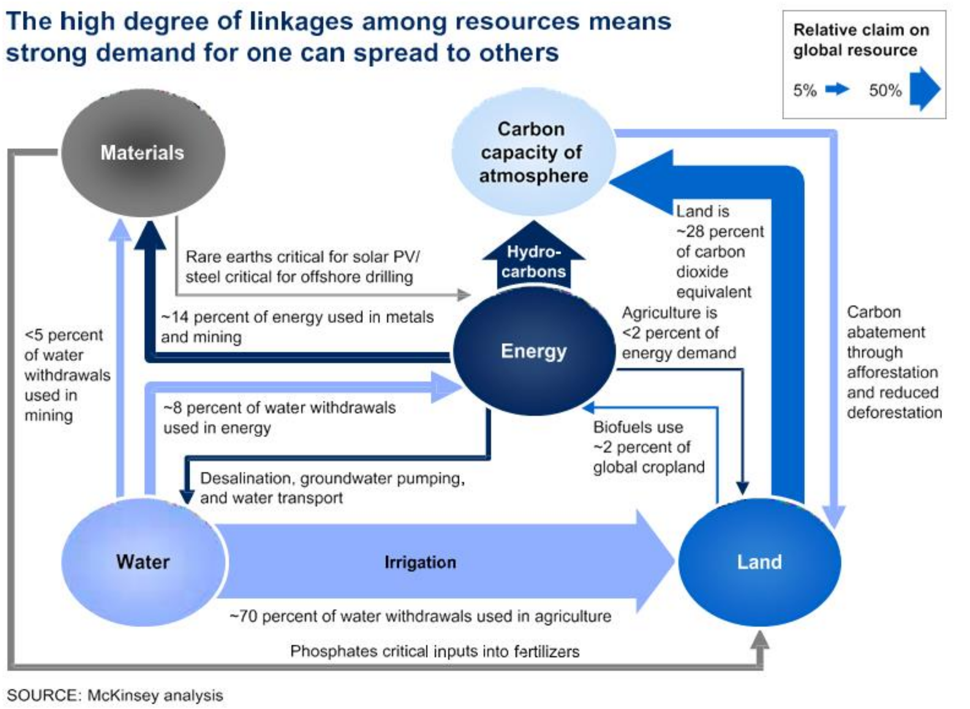


**Figura 3. Cros Resources efficiency**

**FROM *"ANNO MILLE"* TO THE FIRST SMART LAND**

- The concept of "sustainable territories" bring us to the first SMART LAND;
- A set of innovative technologies, intelligent agricultural practices, and agro-environmental inventions capable of to reactivate territory circularity to make resources necessary for human life simultaneously available, convenient, and sustainable.

Through the SMART LAND concept, the territory comes alive and develops in a surprising landscape enhancement logic, thanks to environmental recovery activities and resources possible only through technology application.


**Figura 4. The smart Land**

**SIMBIOSI'S RESPONSE FOR:**

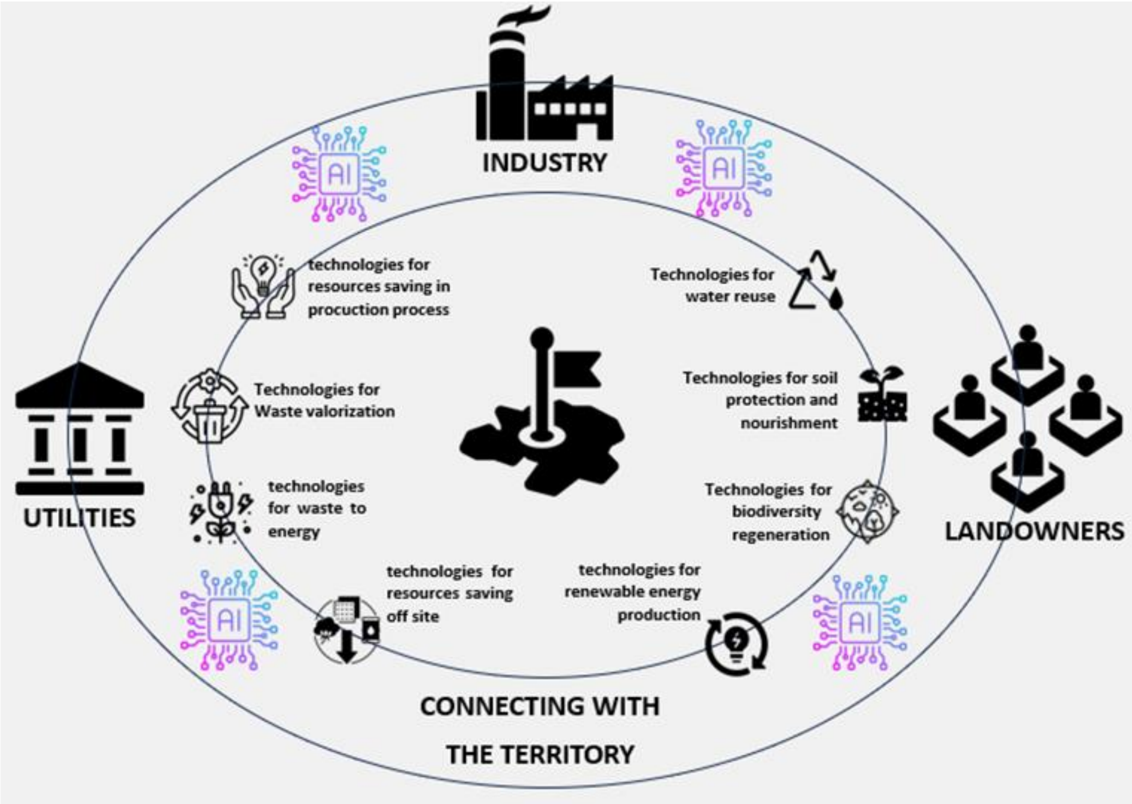


**Figura 5. The first smart land**

## SIMBIOSI - THE FIRST ENVIRONMENT PRODUCER

*THE NEW CONCEPT OF TERRITORY AND RESOURCES*

The connection with the territory is no longer a choice, but a responsibility that becomes reality. Technology guides us towards a sustainable future, in which the territory becomes our most precious ally.

# Contributo di Sergio Barel – Consorzio di sviluppo economico locale Ponterosso Tagliamento

Il Consorzio di Sviluppo Economico – Locale del Ponte Rosso - Tagliamento, si distingue per il suo impegno deciso verso la sostenibilità e la promozione attiva della simbiosi industriale. Attualmente il Consorzio gestisce tre aree di competenza: la zona industriale Ponte Rosso sita a San Vito al Tagliamento (ZIPR), la zona artigianale "ex Eridania" di San Vito al Tagliamento (Za Ex Eridania) e la zona industriale Nord di Spilimbergo (ZIN). Inoltre ha instaurato convenzioni specifiche con il Comune di Valvasone Arzene e Cordovado per fornire una serie di servizi alle rispettive zone artigianali e con il Comune di Spilimbergo per la Zona Industriale del Cosa. Complessivamente nelle aree gestite e convenzionate con il Consorzio sono insediate 261 aziende per un totale di 5.147 occupati e 602 ettari gestiti. Oltre al numero degli occupati diretti dalle aziende insediate si stima che le attività economiche presenti generino un indotto pari ad un ulteriore 30% che porta i soggetti interessati dalle attività economiche presenti ad oltre 6.700 unità. La forza di queste aree produttive risiede nell'eterogeneità dei settori rappresentati, contribuendo a garantire produzioni di qualità e standard elevati. La strategia del Consorzio si articola attorno a quattro pilastri fondamentali: Governance, Servizi per le imprese, Sostegno al territorio e Ambiente e sostenibilità. Per quanto riguarda la Governance, il Consorzio gestisce direttamente le aree industriali, concentrando le attività sulla gestione di nuovi insediamenti e sull'acquisizione di terreni da convertire in lotti industriali. Si occupa anche della gestione diretta delle infrastrutture, inclusi impianti di trasporto e reti viarie e logistiche, e ha una politica attiva di recupero del patrimonio industriale dismesso, adottando criteri di sostenibilità nella selezione e nella gestione delle aree. Nei Servizi per le imprese, Il Consorzio fornisce una gamma completa di servizi alle aziende e ai loro dipendenti, tra cui asili nido, mensa, centro di alta formazione, centro servizi, e sale riunioni e auditorium. L'obiettivo è offrire servizi che agevolino la quotidianità di occupati e aziende. La presenza di tali servizi all'interno dell'area industriale contribuisce a ridurre l'utilizzo dei trasporti, le emissioni di $CO_2$ e il tempo impiegato nei percorsi casalavoro-servizi, migliorando così la qualità della vita. La promozione di iniziative volte a rendere più sostenibili le attività delle imprese è un elemento chiave di questa strategia. Il Sostegno al territorio vede il Consorzio impegnato nella collaborazione con enti locali, regionali e nazionali, partecipando a progetti formativi e occupazionali che integrano principi di sostenibilità. La promozione di sinergie tra le imprese e il territorio rappresenta un elemento fondamentale, favorendo una crescita equilibrata e sostenibile. Nel 2023 è inoltre nato il Progetto Search Italia, promosso da Consorzio, Cooperativa Sociale Futura, ASFO (Azienda Sanitaria Friuli Occidentale) e con il sostegno della Regione FVG, LEF e IAL FVG. Cons. Zona Sviluppo Industriale Ponterosso prot. partenza n. 0000238 del 15-01-2024 Tale progetto, inedito in Italia e tra i pochissimi in Europa, ha come obiettivo di cambiare la prospettiva sull'inserimento lavorativo di persone disabili e far conoscere un approccio innovativo che parte dalle esigenze dell'azienda per costruire percorsi lavorativi ad hoc, che prevedono l'intervento di specialisti quali terapisti occupazionali, psicologi ed educatori in stretta collaborazione con i referenti aziendali e con i colleghi di lavoro. L'Ambiente e la sostenibilità sono al centro della strategia del Consorzio, il cui approccio si basa su una visione olistica che riconosce il valore cruciale dell'ambiente e si propone di integrare la crescita economica con la tutela del territorio circostante. Tale impegno è ancorato nella consapevolezza che un'economia prospera e sostenibile deve necessariamente evolvere in armonia con l'ecosistema circostante. La strategia di sviluppo industriale del Consorzio è infatti saldamente ancorata al concetto di "sviluppo sostenibile". Questo implica il riconoscimento dell'ambiente naturale come una risorsa fondamentale per la valorizzazione sociale e culturale del territorio. L'obiettivo prioritario è quello di sostenere la nascita e lo sviluppo delle attività produttive in modo compatibile con la valorizzazione e il rafforzamento delle ricadute positive sull'ambiente. Fin dai primi anni della sua attività, il Consorzio ha implementato una serie di presidi ambientali all'interno delle aree industriali gestite. La gestione responsabile delle acque con il monitoraggio continuo di numerosi "pozzi spia", la cura del verde e delle piantumazioni nell'area (110 ettari a verde gestiti e 1.464 piantumazioni dal 2003) e un approccio prontamente attivo alle situazioni di emergenza ambientale rappresentano pilastri essenziali di questa iniziativa. Dal 2022 il Consorzio si è inoltre concentrato ulteriormente sullo sviluppo di un sistema di monitoraggio della qualità dell'aria. Diverse postazioni di monitoraggio degli inquinanti, in tempo reale e continuativo, sono state istallate all'interno dell'area industriale Ponte Rosso. Questa iniziativa riflette la volontà del Consorzio di ottenere una comprensione approfondita degli impatti ambientali delle attività industriali e di implementare misure preventive e correttive mirate. Il Consorzio ha messo a punto un progetto ambizioso denominato "Area Produttiva Ecologicamente Attrezzata" (APEA). Avviato nel 2017, il progetto APEA mira a trasformare l'area consortile Ponte Rosso nel comune di San Vito al Tagliamento in una zona altamente attrezzata dal punto di vista ecologico. L'obiettivo è ottenere una fotografia dettagliata dello stato di salute dell'ambiente, prevedere potenziali impatti e implementare soluzioni in grado di rafforzare le infrastrutture e i servizi esistenti, oltre a introdurne di nuovi. Il progetto APEA è pensato non solo come un investimento nell'ambiente, ma anche come un contributo significativo alla competitività del territorio e al benessere delle aziende insediate e futuri investitori. All'interno di tale progetto si inserisce lo sviluppo della piattaforma web APEA, strumento innovativo concepito con l'obiettivo di svolgere un ruolo cruciale nell'integrazione e nella gestione efficiente delle informazioni provenienti da varie fonti. La sua funzionalità chiave Cons. Zona Sviluppo Industriale Ponterosso prot. partenza n. 0000238 del 15-01-2024 sarà quella di integrare le informazioni provenienti dal database del Consorzio con i dati provenienti dai sensori di monitoraggio ambientale installati nell'area industriale Ponte Rosso. In questo modo, la piattaforma creerà un quadro dettagliato e in tempo reale delle condizioni ambientali, contribuendo alla gestione proattiva e alla valutazione delle prestazioni ambientali. Inoltre, il Consorzio promuove attivamente la simbiosi industriale all'interno delle aree consortili. La collaborazione tra le imprese insediate è incoraggiata per sviluppare filiere interne che contribuiscano a un utilizzo più efficiente delle risorse e a una riduzione degli sprechi. Ad esempio, il ciclo del vetro vede la presenza di aziende che si occupano del trattamento del materiale di scarto del vetro, trasformandolo in materia prima di alta qualità, destinata alle aziende del settore presenti nella stessa area industriale e nel triveneto in generale. Tale pratica non solo riduce gli sprechi ma contribuisce anche a chiudere il ciclo di vita del prodotto all'interno dell'area, sostenendo l'idea di un'economia circolare. In quest'ottica, anche l'attività di ritiro, riparazione e vendita di pallets usati rappresenta un altro esempio non solo di riciclo di materiale, ma ha anche di positivo impatto sulla riduzione delle emissioni di carbonio, promuovendo un approccio sostenibile verso la gestione dei rifiuti industriali. In conclusione, l'impegno del Consorzio Ponte Rosso – Tagliamento verso la sostenibilità e la simbiosi industriale non solo si riflette nei progetti e nelle pratiche attuate, ma rappresenta un impegno concreto per un futuro in cui lo sviluppo economico si coniughi in armonia con la preservazione dell'ambiente. Il Consorzio si pone come modello esemplare, ispirando non solo le realtà regionali ma anche a livello nazionale, dimostrando che la prosperità economica può coesistere con una gestione responsabile e sostenibile delle risorse e dell'ecosistema.

# Contributo di Marco Battaglia - Sfridoo

Sfridoo è stata fondata nel 2017 come startup innovativa inserita nel Registro Speciale delle imprese italiane, con l'obiettivo principale di aiutare le aziende a massimizzare il valore dei loro rifiuti di produzione.

Il termine "sfrido", incluso nel vocabolario Treccani, si riferisce ai residui o agli scarti derivanti dalla lavorazione di varie materie, come legno, metalli, marmo, carta e fibre tessili. Sfridoo è nata con la visione di trasformare il concetto di rifiuto in risorsa, creando una piattaforma digitale per lo scambio di residui di produzione, sottoprodotti, materie seconde e avanzi di magazzino aziendali.

Con un team di 10 persone di età media 31 anni, Sfridoo coinvolge un network di più di 2.500 aziende con risparmi totali che ammontano ad oltre 6 milioni di euro. Oggi sulla piattaforma sono presenti +120 milioni di kg di risorse suddivise in Carta e Cartone, Plastica, Metalli, … (ndr oggi ammontano a +310 milioni di kg) e grazie all'expertise maturato, i tecnici Sfridoo hanno individuato ed istituito +40 nuovi sottoprodotti.

Sfridoo offre un sistema di matchmaking online e di supporto tecnico-normativo su base italiana per mettere in collegamento aziende con esigenze diverse e materiali comuni d'interesse.

L'azienda si rivolge alle realtà industriali di tutti i settori in quanto è stato verificato che la valorizzazione dello sfrido e, più in generale, degli scarti aziendali di qualsiasi natura, per essere più vantaggiosa debba coinvolgere tutti, proprio perché gli scarti di un settore possono rivelarsi utili a un altro e le aziende di settori diversi possono aver bisogno l'una dell'altra. In un movimento win-win come prevede proprio l'Economia Circolare.

Tra le numerose difficoltà incontrate durante i 6 anni di attività di Sfridoo si evidenzia la mancanza di percorsi professionali nell'ambito. Proprio per questo Sfridoo supporta e forma giovani studenti e studentesse iscritte al primo corso JECE – Junior Expert in Circular Economy – il primo corso di Istruzione e Formazione Tecnica Superiore (IFTS) organizzato da Centoform e ART-ER con il supporto di Regione Emilia-Romagna e della EIT Raw Material Academy.

Per affrontare questa sfida, inoltre, Sfridoo promuove la creazione di nuovi ruoli aziendali, come i/le "Matcher" e i/le "Seeker", che facilitano l'integrazione dei processi simbiotici tra le imprese.

Altre sfide incontrate includono quelle di natura normativa, come la mancanza di una solida giurisprudenza sull'istituto del sottoprodotto. Per affrontare queste sfide e promuovere la simbiosi industriale a livello nazionale, Sfridoo si impegna ad aumentare la diffusione di argomenti non solo tra gli addetti ai lavori ma anche tra il pubblico generalista, utilizzando strumenti digitali e promuovendo la formazione dedicata al settore.

Inoltre, l'uso di strumenti digitali come veicolo di moltiplicazione dei risultati è essenziale per la crescita del settore. In Sfridoo riteniamo anche strategico, come si accennava poco fa, investire nella formazione, creando nuovi posti di lavoro per le giovani generazioni e incentivando lo sviluppo di competenze nel settore.

- Aumentare la diffusione di argomenti verso i non addetti ai lavori
- Incrementare l'utilizzo di strumenti digitali come vettore di moltiplicazione dei risultati
- Promuovere la formazione dedicata al settore e incentivazione sulle competenze per le giovani generazioni creando nuovi posti di lavoro
- Condividere esperienze e creare tavoli congiunti per la messa in comune di ostacoli con l'obiettivo di contribuire alla riduzione degli sprechi.

L'azienda è pronta a giocare un ruolo attivo nel programma nazionale, contribuendo con KPI e risultati attraverso un sistema centralizzato sulla Simbiosi Industriale e condividendo le proprie esperienze e migliori pratiche attraverso tavoli di lavoro congiunti. Sfridoo si vede anche coinvolta nel sensibilizzare le parti interessate, portando valore nelle analisi di mercato e promuovendo la riduzione degli sprechi. Contribuire con KPI e risultati raggiunti attraverso un sistema Webhook o API definiti con un sistema centrale, all'Osservatorio sulla SI:

- Portare la propria esperienza su tavoli di lavoro congiunti di Best Practice
- Avere un ruolo attivo nel coinvolgere e sensibilizzare le parti interessate (e.g. aziende)
- Portare valore nelle analisi del mercato

# Contributo di Camilla Colucci - Circularity

L'economia circolare, intesa come un nuovo modello di produzione e consumo volto all'uso efficiente delle risorse, costituisce una sfida epocale che punta all'eco-progettazione di prodotti durevoli e riparabili per prevenire la produzione di rifiuti e massimizzarne il recupero, il riutilizzo e il riciclo per la creazione di nuove catene di approvvigionamento di materie prime seconde, in sostituzione delle materie prime vergini.

Circularity è una piattaforma pensata per le aziende che raggruppa in un unico luogo tutti gli strumenti utili ad integrare la sostenibilità ambientale nel proprio business: grazie al suo team di professionisti esperti di tematiche di sostenibilità e di ingegneria dei materiali, offre percorsi di formazione, sviluppa tool di misurazione e gestisce progetti di consulenza tecnico-strategica per accompagnare le aziende nel percorso di integrazione della sostenibilità e della circolarità all'interno del proprio modello di business.

Fondata a giugno 2018, e guidata da Camilla Colucci, CEO della società, Circularity è una società benefit, integra cioè nel proprio oggetto sociale, oltre agli obiettivi di profitto, lo scopo di avere un impatto positivo sulla società e sull'ambiente. In linea con quanto definito dalla "Strategia nazionale per l'economia circolare", l'innovazione di Circularity sta nell'aver sviluppato la prima e unica piattaforma di simbiosi industriale in Italia in grado di mettere in rete gli attori del processo di produzione, trasformazione e gestione degli scarti e dei materiali, lungo tutta la filiera, per avviare percorsi di economia circolare.

La Circularity Platform, online dal 2019, nasce infatti come network digitale che permette alle aziende di entrare in contatto con potenziali partner in grado di riciclare i propri scarti di produzione, consentendo l'implementazione di modelli di business circolari e fornendo valutazioni quantitative in termini di emissioni di $CO_2$. Infatti, attraverso la piattaforma, le imprese che hanno scarti di produzione possono conoscere ed entrare in contatto con chi li raccoglie e trasporta, chi li recupera e trasforma e chi li reintroduce in un nuovo ciclo produttivo. Logiche di rating che classificano gli operatori in base ad aspetti ambientali ed economici garantiscono che i materiali di scarto (intesi come rifiuti, sottoprodotti o End of Waste) vengano gestiti con le migliori tecnologie disponibili, facilitandone il reimpiego da parte di altre imprese.

Al fine di promuovere e facilitare la simbiosi industriale tra le imprese italiane, nel 2022 è stato avviato un rinnovamento delle funzionalità della piattaforma: a partire dalle logiche di base, non più solamente fondate sulla caratterizzazione degli scarti quali rifiuti, ma sulla natura del materiale che li compone, le imprese hanno la possibilità di accedere a un network di aziende al fine di individuare soluzioni “circolari” per la valorizzazione dei loro scarti, acquisendo consapevolezza sul loro fine vita, sul tipo di impiantistica e su quale sia l'effettiva percentuale di recupero con cui i materiali sono stati lavorati per poi poter essere reimpiegati come materia prima seconda. Le funzionalità della Circularity Platform non si fermano alla struttura logica di ricerca di possibili partner ma includono anche la gestione dei contatti e la possibilità di creare una vera e propria rete di partner con la quale dialogare online, misurando l’impatto ambientale della propria filiera.

L’ambiente, in costante aggiornamento e in linea alle normative in materia ambientale, vedrà inoltre lo sviluppo di una nuova funzionalità che permetterà di generare annunci di materiali circolari derivanti dal recupero di materia oltre che di tecnologie e macchinari per l’economia circolare. Un unico luogo, adatto ad ogni realtà di ogni dimensione, dalle piccole imprese fino ai più grandi player del tessuto industriale.

Al fine di guidare le imprese lungo un percorso di integrazione della circolarità nella propria strategia di business, la Circularity Platform è pensata per offrire un unico strumento in grado di digitalizzare le attività di misurazione delle proprie performance di sostenibilità, di economia circolare e di impatto ambientale, all’interno della Circularity Platform sono presenti diversi strumenti integrati. Nell’ambiente digitale è presente anche una sezione dedicata ai corsi di formazione incentrati sulle tematiche ESG che un’impresa può erogare a tutta la popolazione aziendale.

# Contributo di Claudio D. Brugnoni - Centrocot

Centro Tessile Cotoniero e Abbigliamento SpA (di seguito abbreviato come Centrocot) è un Centro di testing di laboratorio e ricerca sul territorio di Busto Arsizio (VA), dove ha le due sedi principali, quella di Piazza Sant'Anna dove sono presenti tutti i laboratori di prova e la direzione, e la sede presso Malpensafiere dove è situato il Multi-Lab, di recente installazione.

Le aree di azione di Centrocot ruotano intorno al settore tessile, spaziando tra vari ambiti, senza porsi limiti di sorta. In verbi, le attività si pongono l'obiettivo di sperimentare, misurare le prestazioni, certificare e formare. Ciascuna di queste aree contribuisce allo sviluppo di una conoscenza di settore sempre più approfondita, senza tralasciare gli aspetti di innovazione tecnologica.

Presso la sede di Sant'Anna (circa 4000 mq) sono dislocati i laboratori di analisi, prova e certificazione, che coprono oltre 2000 test di laboratorio a listino, di cui 774 accreditate da Accredia. I laboratori di prova di Centrocot si pongono al fianco delle aziende per poter rispondere alle richieste di certificazione e analisi dei loro prodotto, per garantire la sicurezza e la conformità alle normative vigenti. I laboratori rilasciano oltre 1500 certificati per DPI all'anno. Inoltre, Centrocot è l'ente italiano autorizzato a rilasciare la certificazione Oeko-tex®, che contribuisce a garantire una sicurezza di prodotto elevata ed efficace dal punto di vista del consumatore.

Da sempre viene posta una grande attenzione alla Ricerca & Innovazione. Presso MalpensaFiere, è stato installato il Multi-Lab con i suoi strumenti in un'area di oltre 1000 mq. Il laboratorio sperimentale multisettoriale si pone a supporto delle imprese che vogliono affrontare i nuovi trend di innovazione legati alla Sostenibilità e all'Economia Circolare. I focus dell'attività sono: (i) materiali innovativi per lo sviluppo di nuovi materiali eco-sostenibili e bio-degradabili, (ii) nuovi processi produttivi per lo sviluppo di nuovi metodi di processo per la sostenibilità, (iii) nuovi processi produttivi per la ricerca, sviluppo e sperimentazione di nuovi prodotti e applicazioni per il riciclo.

Le attività del Multi-Lab si concentrano intorno al recupero, riutilizzo e riciclo di materiali di scarto pre- e post-consumo attraverso differenti tecnologie:

- Riciclo meccanico: adatto a differenti composizioni fibrose (pure e miste) e tipologia di prodotto (pezza, prodotto finito). Le macchine di lavorazione a disposizione sono una sfilacciatrice e una carda apri-fibra per la lavorazione di tessili per le fasi successive, e una sminuzzatrice per materiali di imbottitura tipo schiume espanse.
- Riciclo termo-meccanico: adatto a fibre sintetiche termoplastiche (preparate mediante processo meccanico preliminare) o materiali termoplastici più in

generale. Le strumentazioni a disposizione sono: estrusori bivite, monovite e melt spinning (lab scale) per la lavorazione dei materiali, mulino macinatore e deumidificatore per la preparazione dei materiali.

- Sistema di sorting avanzato: due strumenti per il riconoscimento della composizione tessile tramite spettroscopia NIR accoppiata alla chemiometria, con annesso sviluppo di modelli per la determinazione delle componenti chimiche di superficie (trattamenti di finissaggio, contaminazioni).
- Misura della biodegradabilità: attraverso un respirometro a 12 canali è possibile eseguire una valutazione della capacità di biodegradazione di un materiale in un determinato comparto ambientale (condizioni di compostaggio, in acqua di mare o acqua dolce).
- Stampanti 3D per sviluppare prove di concetto di produzione di prototipi tramite tecnologia a fusione di filamento.


**Figura 6. Multi-lab by Centrocot**

All'interno delle attività di Multi-Lab, e per aiutare le aziende nello sviluppare attività di recupero dei propri scarti, è stata implementata la piattaforma digitale M3P, acronimo di Material Match Making Platform (www.m3plife.com). La piattaforma M3P è uno strumento per le aziende che vogliono valorizzare i loro scarti di produzione e rifiuti: si propone di creare dei match tra gli scarti di produzione, gli invenduti o i rifiuti che le aziende possono inserire e le tecnologie per il riciclo disponibili sul mercato, tenendo in considerazione anche le vigenti normative e le possibili certificazioni applicabili in ambito di Economia Circolare. Consiste quindi in un database di materiali, tecnologie, competenze e servizi che permette di dare risposta ad ogni esigenza creativa e dare una seconda vita agli scarti e rifiuti industriali.

Tale piattaforma si pone come obiettivo l'essere un collettore tra la domanda e l'offerta in ambito di Economia Circolare e Simbiosi Industriale, erogare servizi a favore delle PMI

in tale ambito e diffondere tecnologie innovative offerte da imprese, risultati di progetti, start-up.
La piattaforma è multisettoriale, e copre vari settori quali, ad esempio, quello tessile, delle materie plastiche e imballaggi di varia natura.
Concretamente, la piattaforma M3P si rivolge alle aziende e consente di fare ricerche per verificare materiali analoghi ai propri, creare un portafoglio dei propri scarti e/o materiali da offrire o ricercare, ottenere, per ogni scarto o materiale inserito, un elenco delle tecnologie di riciclo adatte, un elenco dei servizi necessari per realizzare un processo di riciclo industrialmente completo, e un elenco delle certificazioni di prodotto o processo necessarie per lo scarto o per il materiale riciclato.
Un esempio di caso di successo di applicazione della piattaforma M3P è legato al progetto europeo Digiprime, di cui Centrocot è partner. Tale progetto si propone come obiettivo di promuovere l'economia circolare nel settore automotive e quello tessile attraverso l'integrazione della piattaforma M3P e una piattaforma sviluppata ad hoc per il progetto. Considerando che nel 2022 sono state prodotte nel mondo 79,4 milioni di auto, e che in ciascuna auto si stima che ci siano circa 35 kg di tessuti, il quantitativo di materiale tessile da riciclare nel momento in cui viene rottamata un'auto è notevole. In particolar modo, come caso pilota si è focalizzato l'ambito delle cinture di sicurezza, che dei 35 kg di tessile rappresentano circa 1,5 kg per auto, e costituiscono circa 1650 tonnellate di cinture di sicurezza da smaltire ogni anno.
Andando ad inserire le caratteristiche del materiale in oggetto, la piattaforma è in grado di restituire un set di tecnologie per la lavorazione del materiale di scarto, e anche di servizi e certificazioni (come, ad esempio, l'analisi del ciclo di vita LCA) e assistenza normativa per tali lavorazioni. Tra le tecnologie che la piattaforma propone c'è la lavorazione mediante riciclo termo-meccanico; successivamente, una volta ottenuto il granulo plastico, è possibile lavorarlo mediante estrusione di filamento (melt-spinning) per formare un filo di poliestere, pronto per tornare nel settore tessile.

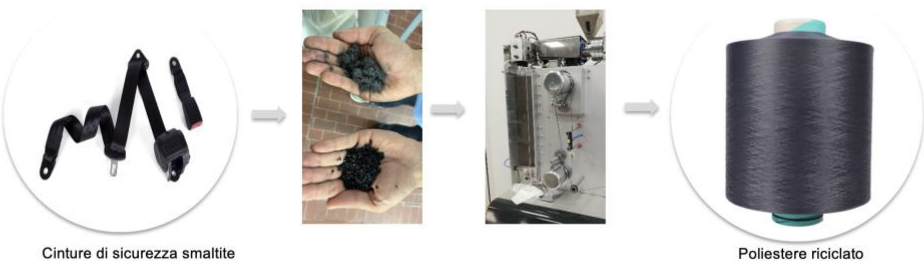


**Figure 7.** Tecnologie proposte dalla piattaforma

Un altro esempio di caso di successo in cui la piattaforma M3P ha dato riscontro positivo per il riciclo dei materiali, e inserito all'interno del progetto React coordinato da Centrocot, riguarda il riciclo dei tessuti acrilici utilizzati per l'arredamento da esterno, e in particolar modo i tendaggi parasole. Ogni anno, infatti, vengono prodotte circa 11 mila tonnellate di tessuti acrilici, che solo in Europa vanno a formare circa 2,5 milioni di tende da sole che vengono installate. Tutto ciò corrisponde ad un quantitativo di circa 7700 ton/anno di tessuti che vengono conferiti in discarica.

Tuttavia, è stato dimostrato che tali tessili sono riciclabili: attraverso lo sviluppo di un metodo per rimuovere le sostanze indesiderabili, quali trattamenti superficiali idrorepellenti, resine melaminiche e acriliche e agenti antimuffa, è stato proposto un processo ecologico per migliorarne il riciclaggio, aumentare la sostenibilità e ridurre i rischi per l'ambiente e la salute. È stata così sviluppata una nuova collezione di tessuti acrilici riciclati, pronti a prendere nuova vita come tendaggi parasole, avendo dimostrato la possibilità di ridurre sensibilmente il rischio di trattenere sostanze pericolose nei materiali riciclati.

La piattaforma M3P favorisce la possibilità di ampliare nuove opportunità di mercato per il settore tessile e dei riciclati, restando al passo con le tecnologie e le normative europee che negli anni verranno proposte per far fronte allo smaltimento dei rifiuti tessili.

# INTERVENTI DA CALL FOR PAPER

# Advanced design for circularity and sustainability: digital solutions to foster the transition of made in Italy

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## Abstract

In recent years, numerous reflections have emerged on how design practices offer possible solutions to respond to the ecological transition. In this context, Advanced Design, considered as an anticipatory and multidimensional design approach, intersects with Transition Design, which focuses on the theory of change and the study of possible futures, to come up with a new profile of "Transitional Industrial Designer", capable of incorporating the practices of mediation and anticipation in the sustainable and circular transition of industrial processes. This reflection currently finds a space for practical experimentation and theoretical exchange within an NRP-funded research program (MICS) and specifically in projects under one of its lines of intervention (Spoke 1), with the aim of creating new design models that consider the diversity of disciplinary approaches, the complexity of production chains and the heterogeneity of the actors involved, in order to arrive at affirming a principle of "Design Endless Responsibility", where digital tools are agents of mediation and interaction.

Keywords: *Advanced Design; Ecological Transition; Transitional Industrial Design; Digital Solutions; Made in Italy.*

## Towards the definition of a transitional industrial designer

In recent years, numerous theoretical reflections have emerged on how design practices and approaches offer different perspectives and possible solutions to respond to current crises [1], with the aim of supporting change and transition towards more responsible and sustainable forms of innovation, capable of taking into account both the environment and the different actors in it [2, 3]. In this context, Advanced Design, within the framework of Process Design, is a systemic, anticipatory, multidisciplinary and multidimensional approach, based on collaborative practices capable of driving transformative change within the realities in which it operates.

Advanced Design explores and investigates the role of design cultures in academic, business, institutional and social contexts to innovate not only products and services but also socio-technical systems [4, 5]. It intervenes within value chain enhancement and transformation processes, connecting multiple actors and disciplines, and promotes collaboration, collective intelligence and adaptivity as key factors to support new forms of knowledge [6] and more sustainable production and consumption patterns that reduce social, environmental and economic impacts. In this perspective, the designer assumes a role as a mediator of knowledge [7] and needs of different stakeholders [8, 9], becoming a protagonist of these changes. Advanced Design also puts the concept of anticipation and future studies at the centre of its work [10, 11, 12] as drivers supporting an 'advanced design approach' capable of responding to the complexity of changing contexts [13, 4] conditioned by environmental, social and resource constraints, in line with the Sustainable Development Goals (SDGs) of the UN 2030 Agenda and with the European Commission's Green Deal to outline transformational policy interventions on energy, climate and circularity. Working in anticipation is a key concept in transition processes. In addition to Advanced Design, Transition Design [14, 15] works at the intersection of the theory of change and the study of possible futures to define appropriate strategies for designing responsible innovation paths, interconnecting technological and economic systems with socio-cultural and natural systems. This approach focuses, in fact, on ecological and social transition [16, 17] and is inspired by the Transition Town movement, initiated by Rob Hopkins [18], which starts from community projects to go and solve local and global problems. Transition Design aims to address the wicked problems of the 21st century such as climate change, loss of biodiversity, depletion of natural resources and the growing gap between rich and poor to support the design-led transition of society towards more sustainable futures [15]. The long-term goal is a design of and for radically new paradigms that challenge the status quo and are based on equity and quality of life [19].

From the intersection of these two approaches, new ways of designing and a new profile of designer emerge, which can be referred to as the “Transitional Industrial Designer”, capable of bringing practices of mediation and anticipation into the sustainable and circular transition of industrial processes, an active agent of change who moves between the micro and macro scales and is able to imagine, starting from past and present situations, possible medium- and long-term futures that can be modified over time through the creation of scenarios.

## Digital advanced design for the transition of Made in Italy

The theoretical reflection around the integration of mediation and anticipation in transition processes, as well as around the definition of the Transitional Industrial Designer’s profile, was set down from the point of view of practical experimentation within the “MICS - Made in Italy Circolare e Sostenibile” (Circular and Sustainable Made in Italy) research programme, financed by the Italian Ministry of Universities and

Research (MUR) thanks to funds made available by the European Union under the NextGenerationEU programme and representing one of the projects relating to Mission 4 (Education and Research) of the PNRR. MICS is carried out by an Extended Partnership composed of 25 partners, of which 12 of them are public (including universities and research centers) and 13 industrial, engaged in multiple joint basic and industrial research activities, with the aim of promoting circularity and sustainability in the design and production of Made in Italy, within three of the sectors that most characterize the Italian industrial scenario: Fashion, Furniture and Automation. MICS involves the development of about 80 projects geared toward responding to current challenges affecting current design, production and consumption patterns, as well as end-of-life management of products, to facilitate the processes necessary for the ecological transition of Made in Italy.

In order to achieve its objectives, MICS has defined eight research areas, called Spokes, which are oriented towards specific lines of intervention, transversal to industrial sectors, and characterizing the current challenges of Italian manufacturing: from the ecological transition to overcoming the energy crisis, from recovering waste materials within production processes to move towards more circular models to improving relations between the players in the various supply chains, to name but a few examples. Among these eight MICS research areas, Spoke 1, which involves 13 MICS partners and is coordinated by the University of Bologna, is dedicated to the topic "Digital Advanced Design: Technologies, Processes, and Tools" and aims at investigating digital solutions (innovative technologies methods and tools) to foster circular and sustainable innovation processes, expanding the capabilities of industrial designers – the above mentioned "Transitional Advanced Designers" – along the entire production process, according to a systemic model focused on continuous dialogue with the multiple actors involved in the process (the so-called "Open Innovation" approach).

Material elements such as advanced manufacturing, innovative materials, circular processes and systems for measuring impacts (of an environmental, social and economic nature), are placed at the centre of the Spoke 1 line of intervention, which are combined with intangible elements such as gender equity, citizenship involvement, ethics, etc., and human factors such as ergonomics and bio-psychosocial well-being, according to a "Responsible Advanced Design" approach [20, 21]. Circularity and sustainability are in fact not only prerogatives of the scientific-technological sphere, but also of the social-humanistic one. In this dialectical relationship, Advanced Design fits in as a mediator of knowledge and skills and activator of multi-stakeholder collaborative practices. The aim of Spoke 1 is therefore to create new design models that take into account the variety of disciplinary approaches, the complexity of the production chains and the heterogeneity of the actors involved, in order to affirm a principle of "Design Endless

Responsibility" (DER), according to which the designer is called upon not only to connect areas and actors (mediation), but also to take into account the entire value chain and its future impacts (anticipation), putting into play knowledge and practices that allow for responsible solutions.

In this scenario, digitization becomes the guiding thread of research activities: design-led enabling technologies facilitate and monitor information flows, tracking and anticipating the consequences of design choices made. Digital tools are not merely a medium, but agents of mediation and interaction. In this sense, among the expected results of the Spoke 1 research activity is the creation of a portfolio of advanced digital solutions at the service of the Transitional Industrial Designer.

## Digital solutions to improve packaging as a platform for collaboration and exchange

Among the projects developed within Spoke 1, some of them are oriented toward knowledge-sharing processes and specifically the role of design as a mediator between the actors involved within different supply chains, including with a view to industrial symbiosis. One of the projects going in this direction, involving Università di Bologna (project leader), Politecnico di Torino and Università di Firenze, is dedicated to the theme "FuturE-Pack. Digital Advanced Design for the Enhancement of Packaging as a 'Broadcaster' in the Made in Italy Supply Chain".

The project goal is to explore the application of digital solutions to packaging to enhance its significant role as a communication channel for information exchange [22, 23]. In particular, the role of packaging in recording, storing, translating, and communicating relevant information about packaged products and their impacts throughout the supply chain is investigated in order to: on the one hand, facilitate information sharing among supply chain actors to facilitate the safe and efficient movement of goods; and promote the emergence of "green logistics"; on the other hand, improve the end-user experience through transparent, understandable, accessible, and inclusive information to encourage more informed and sustainable purchasing and consumption choices.

FuturE-Pack is thus exploring the potential of so-called "Advanced Design" and pushed digitization to improve the role of packaging as a "communication device," as a digital platform that facilitates the monitoring and traceability of packaged goods and their impacts throughout their lifecycle, and the exchange of information both among supply chain actors and between them and end users. The study focuses, as an application case, on the E-Commerce sector of the Fashion System, but the goal is then to test it in other strategic sectors of Made in Italy.

## Conclusions

From the intersection of Advanced Design with Transition Design it is possible to define new ways of designing. A new figure emerges, the Transitional Industrial Designer, capable of lowering practices of mediation and anticipation into the transition of industrial processes towards sustainability and circularity. Such a figure integrates advanced and systemic skills, enabling design and production processes to be managed more quickly and flexibly, responding more appropriately to contemporary challenges and adapting more easily to changing social, environmental and economic contexts. Taking into account the contextual variables of complexity and uncertainty, the Transitional Industrial Designer considers in an integrated way all the material and immaterial elements involved in the project and manages, in collaboration with stakeholders and experts, the entire design process, including the redefinition of relationship patterns, as well as those of production and consumption [24, 25]. The theoretical reflection around the integration of mediation and anticipation in transition processes, as well as around the construction of the figure of Transitional Industrial Designer, has been dropped in different contexts to those of MICS for example in training and third mission activities related to the world of research and will also be tested in international cooperation contexts, despite that Spoke 1, remains the 'privileged area of observation. In fact, thanks to its territorially widespread structure and the variety of actors involved, it allows the exploration on several dimensions of different application areas for the principle of the so-called DER, according to which the planner operates both at the level of mediation between disciplines, actors and skills and at the level of anticipation of impacts. In addition, the organization of MICS and the configuration of Spoke 1, and its lines of work, mark an important milestone with respect to the recognition of the role, within production processes, of design theories and practices, which are officially accorded a central role in solving complex problems, in the transition to circularity and sustainability.

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# Wastudy: The Italian observatory of the special waste market

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## Abstract

The WaStudy project aims to provide an annual market analysis relating to the industrial waste management sector, with a section dedicated to the collection of average tariffs applied by specialised companies for the main collection and management activities. The Italian and territorial market for environmental solutions for industry was analysed and qualitative and quantitative information was collected relating to the characteristics of supply, demand and the indication of the average prices applied for the management of industrial waste. The study of average market prices was carried out by telephone interview with a questionnaire addressed to the main operators in the sector, specialised in the management of industrial waste. The end of the first year of the project, a dedicated website was created to allow the consultation of the results updated annually.

Keywords: *Circular Economy; industrial waste; price analysis; waste management.*

## Introduction

For several years, Italy has been facing a shortage of waste treatment plants that places operators in the environmental services market in serious difficulty, facing high volatility in waste management prices and difficulties in finding appropriate recovery and disposal solutions [1]. A situation that favours the export of special waste, especially those from waste and wastewater treatment plants that make up 67% of total exports. Compared to 2019, special hazardous waste exported in 2020 increased by around 40,000 tonnes (over 3%)[2]. From these assumptions, the Wastudy project was born with the aim, pending the intervention of national operators for the modernisation and construction of new plants to support the circular economy and the sector, of creating a sharing tool between industries that favours transparency on the main market variables and at the same time supports producers of special waste to evaluate and meet new specialised suppliers.

The research has now reached its third year, doubling the number of respondents, and can be freely visited at Osservatorio Rifiuti Marazzato (gruppomarazzato.com) [3]. Over 200 companies in the environmental sector, mainly belonging to the Ateco 38 code relating to the collection, treatment and disposal of waste, responded to the telephone interview carried out by Cerved Group Spa that allowed the main characteristics of the market offer of environmental services to be collected and analysed, such as the types of waste treated, the territorial scope, R&D and the prices applied.

## Methods

The Wastudy project began with the morphological analysis of companies in the environmental sector, from which it emerged that of about 10,000 companies in the sector, belonging to the Ateco codes 37, 38 and 39 relating to waste management, half have at least an ANGA (National Register of Environmental Operators) registration and about 350 companies have at least an SOA certification, a mandatory certificate for participation in public body tenders.

The project followed the following phases:

- Ex-novo analysis crossing the information on the ANGA certifications and the results of the previous analyses (2021 and 2022 edition) from which a universe of 5,297 companies that meet all the established criteria has emerged;
- Extraction of a list of about 1,000 companies with telephone contact that were more representative of the market based on the area, size and activity of the company;
- Administration of the questionnaire through CATI (telephone) interviews, from which a sample of 202 complete interviews emerged;
- Weighting of the sample by regional distribution in order to return the sample to the original universe and allow a solid and statistically representative reading of the universe of the companies analysed.

## Results

The universe taken into consideration consists mainly of companies operating in the sectors of collection, treatment, disposal of waste (Ateco Code 38 - activities of collection, treatment and disposal of waste; recovery of materials) and management of sewerage networks (Ateco code 37 - management of sewerage networks). The Ateco classification was also crossed with the most relevant entries in the National Register of Environmental Operators. Thus, 936 companies emerged, compared to 606 in 2022 and 482 in 2021, attributable to the selected universe.

In the contact phase, from May to July 2023, 26% of the respondents responded, equal to 221 companies (156 in 2022 and 95 in 2021), of which 202 were targeted (112 in 2022 and 69 in 2021) [Tab.1].

**Table 1**. Sample involved in the investigations from 2021 to 2023

| | 2021 | 2022 | 2023 |
|---|---|---|---|
| **Positive result at contact** | 95 | 156 | 221 |
| **Off-target companies** | 34% | 28% | 9% |
| **Target companies** | 66% | 72% | 91% |

## Results

Regarding the average prices applied, the situation in terms of price range per ton applied to the industry that produces the waste has been deepened. Four types of waste were examined: sludge, liquid, solid and assimilable. From the data, it emerges that already in 2021 in each macrocategory it is hazardous waste that requires a higher disposal price, a figure consistent with the previously detected market criticalities that is also confirmed in the 2022 surveys [Tab.2 -Tab.3].

In the 2023 surveys, we can attest to average prices that tend to be in line with previous years. On the other hand, the disposal prices of urban waste for all categories: mixed, paper, plastic, glass and wood are substantially increasing. [Tab.2] [Tab.3].

**Table 2.** Average price bands detected in the last 3 years for the categories of sludge and liquid waste. Highlight in red the categories for which the price classes are merely descriptive, in relation to the contained size of the sample base.

| TREND VS 2022 | | | 2023 | 2022 | 2021 |
|---|---|---|---|---|---|
| | | | **AVERAGE PRICE (€/t)** | **AVERAGE PRICE (€/t)** | **AVERAGE PRICE (€/t)** |
| **SLUDGE** | Agricultural sludge | < | <75 | 75-90 | 75-90 |
| | Non-hazardous sludge from landfill | < | <180 | 180-200 | <180 |
| | Non-hazardous sludge from inertization | = | <300 | <300 | <300 |
| | Non-hazardous sludge from landfill | > | 285-320 | 250-285 | 320-335 |
| | Non-hazardous sludge from inertization | < | 275-310 | 345-380 | 310-380 |
| **LIQUIDS** | Base leachate from landfill | < | 15-25 | 45-55 | 15-25 |
| | Compost leachate | < | 40-55 | 85-100 | <25 |
| | Light waters | = | 45-55 | 45-55 | 35-45 |
| | Heavy waters | > | 110-130 | 90-110 | 70-130 |
| | Waters with sediments | > | 90-110 | 70-90 | 90-110 |
| | Lean emulsions (up to 5 percent oil) | > | 65-75 | 55-65 | >55 |
| | Fat emulsions (over 5 percent oil) | = | 105-120 | 105-120 | 75-145 |
| | Waters from thermodis. low calorific value | < | 320-360 | 400-440 | 320-360 |
| | Waters from thermodis. high calorific value | < | 280-320 | 360-400 | 260-290 |

**Table 3.** Average price bands detected in the last 3 years for the categories of solid and assimilable waste In red the categories for which the price classes are merely descriptive, in relation to the contained size of the sample base.

| | | TREND VS 2022 | 2023 | 2022 | 2021 |
|---|---|---|---|---|---|
| | | | AVERAGE PRICE (€/t) | AVERAGE PRICE (€/t) | AVERAGE PRICE (€/t) |
| SOLIDS | Non-hazardous solids from Waste to Energy systems | = | <450 | <450 | 530-770 |
| | Hazardous solids from Waste to Energy systems | < | 720-790 | 790-860 | 720-790 |
| | Compact asbestos | = | 260-280 | 260-280 | 240-260 |
| | Crumbly asbestos | > | 850-900 | 800-850 | 800-850 |
| | Earth and rubble for recovery | = | 10-25 | 10-25 | 10-25 |
| | Earth and inert rubble | = | 15-30 | 15-30 | 15-30 |
| | Earth and rubble Non-hazardous landfill | = | 120-150 | 120-150 | <120 |
| | Earth and rubble Dangerous landfill | < | 180-210 | 210-240 | 150-180 |
| ASSIMILABLE | Mixed | > | 220-240 | 200-220 | <200 |
| | Paper | > | 20-30 | 10-20 | 10-20 |
| | Plastic | > | 50-75 | 25-50 | 50-75 |
| | Glass | > | 50-75 | 25-50 | 25-50 |
| | Wood | > | 70-80 | 60-70 | 60-70 |

Unlike previous surveys, in 2023 the forecasts of changes in average prices for the following 6 months significantly decrease. Only 32% of the companies surveyed expect changes in the short term, while in 2022 it was over 70%.

The expected changes are related to urban waste and solid waste from waste-to-energy.

## Discussion and conclusion

The Wastudy analysis, repeated annually from 2021 to 2023, has allowed us to analyse in detail the most critical aspects of the environmental services market and in particular the management of special waste. The free use (after registration on the website) and the methods of digital interaction, make it a tool available to the industry as a whole to ensure transparency to the end customer and collaboration between companies in the sector. The continuous improvements in the selection of the sample and in the sharing of the report have allowed us to obtain statistically relevant results in the 2023 edition involving an increasing number of companies [3].

The portal offers a database of companies operating in the sector that can be filtered and sorted by revenue, geographical area, size and SOA and ANGA classes. A map allows you to select individual provinces to visualise the operating companies, while the dynamic graphs illustrate the subdivisions by sectors of activity, by territorial areas and for R&D activities. Finally, the prices were represented in radar graphs that allow you to visualise the comparison of the forecasts of price changes compared to previous years [3]. To date, over 5,000 users have visited the online observatory and about 130 have registered on the portal. Registration to the portal allows you to unlock some data and view in detail the average price applied to the individual category of waste, and also allows you to enter comments and participate in discussions, thus facilitating opportunities for contact with other operators in the sector [3].

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# Textile industry towards circularity: the role of the extended producer responsability

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## Abstract

Circular Economy (CE) has progressively established itself as a reference paradigm for the transition towards more sustainable socio-economic systems. Textile industry is now one of the industrial industries on which attention is most focused. For this industry the European Union drafted the s. c. European Union Strategy for Sustainable and Circular textile products. This decision makes it necessary a complete review of the production methods and life cycle management, along the whole supply chain, towards a full implementation of eco-design and environmental assessment approaches and tools. This article proposes a historical-evolutionary analysis of the most recent regulatory provisions on Extended Producer Responsibility and Circularity in the textile industry, highlighting potential synergies and critical issues of their prospective application.

Keywords: *Textile Industry; Circular Economy; Extended Producer Responsibility.*

## Introduction

The textile industry includes manufacturing activities devoted to the production and processing of textile fiber, inputs of the clothing and textile products industry, and technical materials used in different industries, ranging from fashion to furniture. Europe is the second largest exporter in the world; in recent years, commercial performance has increased, making the textile-clothing industry the second most export-intensive industry of the entire European economy. The main production, in the overall textile industry, is that of clothing and accessories, with a share of 31%, followed by textile products for technical and industrial use (17%), fabrics (15%), and home textiles (14%) [1]. However, foreign dependence (import and export) has made the textile supply chain one of the most vulnerable [2].

The textile industry consists of a series of sectors which, overall, define highly branched and globalized supply chains at the moment. The production processes start from the production of the fiber to be used, which can be of natural origin (e.g. animal fiber, such as wool and silk, or vegetable fiber, such as cotton and linen) and/or artificial (e.g. synthetic fibers or seeds -synthetic such as nylon and rayon). The long and complex value chain continues with the following phases: i) production of fabrics and finishing (aimed at giving the fabrics visual, physical, functional and aesthetic properties); ii) transformation of fabrics into finished products through manufacturing processes (clothing, home textiles or technical textiles), and finally iii) retail sales activities (Figure 1).

Environmental and social sustainability represents a critical aspect in the textile industry. From a life cycle perspective, the main problems of the production phase are highlighted: i) in the fiber production phase, where different production techniques are applied with a massive use of resources, water, energy and chemical substances; ii) in the use of land for the cultivation of natural fiber (an emblematic example is the cultivation of cotton); iii) in the textile processing, which generates a significant amount of solid waste and wastewater; iv) in the use of energy, common to all phases of the life cycle [3]. The impacts relating to the use phase are also considered to be responsible for the problem of microplastics released into the oceans, mainly due to clothing made of synthetic fiber, such as nylon, polyester, acrylic, released during washing [4]. As regards the end-of-life phase, the supply chain model for textile products is currently still predominantly linear at a global level: according to the Ellen MacArthur Foundation [5], only 13% of garments that reach the end of their life are recycled, of this, less than 1% of material, is reused to produce other clothing [6]. A large part of them (between 50 and 75%) is intended for reuse, the largest share of the rest is recycled into lower quality products (e.g. the production of insulating material in the construction industry, or padding for mattresses), suffering a loss of value. The remaining two-thirds of textile waste generated is expected to end up in mixed municipal waste streams for incineration or landfill [7].

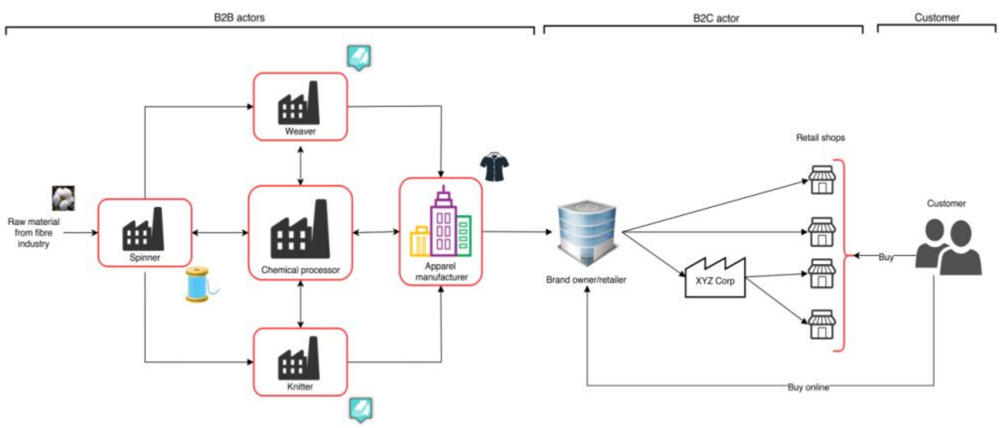


**Figure 1.** Textile Supply Chain Network [8]

More recently, the environmental and social sustainability of the textile supply chain has been further and strongly threatened by the spread of the 'fast fashion' phenomenon, which has radically transformed the dynamics of production and sales.

## Circularity and Extended Producer Responsability in the textile EU regulation

The attention to the environmental and human health impacts deriving from the production and consumption of textile products has played an important role in the EU legislation, especially in recent years. In general, EU Regulation no. 1007/2011 [9] concerning the labeling of textiles and the transparency of information and the Directive 2008/98/EC [10] concerning waste, which obliges Member States to adopt a system for the separate collection of textile waste by 2025, can be pointed out. In particular, this last Directive, amended in 2018 by EU Directive 2018/851 [11], has been integrated by the addition of article 8 bis regarding the minimum general requirements on "Extended Producer Responsibility" (EPR), a fundamental principle to guarantee the reorganization of the supply chain in a "circular" perspective [1]. The European Green Deal, the Action Plan for the Circular Economy and the 2020 Industrial Strategy have also assessed the high circularity potential of the textile industry [12].

On the basis of these measures, on 30 May 2022 the European Commission adopted the Strategy for Sustainable and Circular Textile Products which provides a reference framework aimed at making, by 2030, textile products placed on the European market "durable and recyclable, largely made up of recycled fiber, free of dangerous substances and produced in compliance with social rights and the environment..." [4]. Specific measures include: i) Introduction of binding ecodesign requirements; ii) End the destruction of unsold or returned fabrics; iii) Fight against microplastic pollution; iv) Introduction of information obligations and a digital product passport; v) Environmental self-declarations for truly sustainable textile products; vi) Extended producer responsibility and promotion of reuse and recycling of textile waste. Despite the considerable efforts that the EU and the Member States are putting in place, the production of textile waste tends to increase [13]. In this regard, the European Commission intends to propose a new directive that aims to eliminate regulatory barriers and address market failures by making provisions clearer, more specific and harmonized [14].

In particular, the principle of EPR was introduced for the first time in 1990 [15] and describes an environmental protection strategy aimed at reducing the environmental impact of a product, making the producer responsible of the entire life cycle of the same, including the so-called take back phases, i.e. collection, recovery and final disposal. The strategy underlying the EPR principle is achieved through the use of administrative, economic and information tools; their synergistic implementation determines their effectiveness. Table 1 summarizes the progress of the implementation of the EPR for textiles in some European countries.

**Table 1.** Progress of EPR in some European countries

| | Italy | France | Germany | Sweden | Netherland |
|---|---|---|---|---|---|
| **National Legislation** | NO<br>Draft decree under evaluation | YES<br>Code de l'environnement | NO<br>Position Paper | YES<br>SOU 2020:72-Statute in force since 01/01/2022 | YES<br>Decree 14/04/2023 132 – in force since 01/07/2023 |
| **EPR operating system** | NO | YES | NO | NO<br>Collection systems authorized starting from 01/01/2024 | YES |
| **Textile categories included** | Clothing, footwear, accessories, leather goods and home textiles (draft decree) | Clothing, footwear, household linen (excluding furniture, protection and decoration) | - | Clothing, accessories, leisure products (sleeping bags) | Clothing, leisure products (blankets, sails and tents) |

## Criticalities, future perspectives and conclusions

From the analysis conducted, the two most important regulatory issues in terms of the circular transition of the textile industry are linked:

- to the definition of the perimeter of the EPR and the identification of the entity responsible for the introduction of products and their management. An example of this is the extension of responsibility also to e-commerce sites, i.e. also considering "merchant" as "producer", i.e. sellers who place a product on the market for the first time;
- to the identification of the entity to which the secondary raw material belongs, which is currently difficult to manage, but which could already become a treasure to be exploited in the coming months.

There are also "structural" problems typical of the sector, such as:

- the lack of sensitivity of some categories of consumers towards the sustainability aspects of products (to which the fast fashion phenomenon is continuing to contribute);
- the lack/difficulty of controls on products imported from low-cost countries (fragmentation of the supply chain);
- the high number of environmental and social certifications (high lack of homogeneity);

- the strengthening of the sorting phase, given that, according to estimates of the sector, 60% of textile waste can still be reused.

The revision of EU Directive 2018/85 provides for the establishment of mandatory and harmonized EPR systems for all EU countries, with tariffs that will vary based on the level of pollution caused. The objective is to finance, through the contributions paid, investments in collection, sorting, reuse and recycling systems. The aim is also to encourage research activities and the development of technologies in order to maximize the circularity of the sector, such as fiber-to-fiber recycling, or solutions capable of containing the export of textile waste disguised by reusable materials to non-EU countries, equipped for a right management. In this regard, there may be different possibilities for upcycling and downcycling, while as regards waste management, the selection phase plays a fundamental role, as reusable garments must be correctly separated from the main flow, items such as zips and buttons removed and sorted according to color and/or fiber type. Most of the selection processes still take place mostly manually, but there is no shortage of innovations in terms of automatic selection, with the introduction of machines that operate using spectrometry or artificial intelligence techniques. Among the recycling technologies, the most consolidated are mechanical and thermo-mechanical recycling; chemical recycling is under development, while biological recycling, in which the action of enzymes is exploited, is being studied [16]. To estimate the potential environmental impacts of the waste management system, it is important to take into account assessments based on the life cycle, such as those proposed through the use of the LCA - Life Cycle Assessment methodology. In the scientific literature, most LCA studies on textile waste report reuse as the preferred method. In the study proposed by Sandin and Peters [17], in which 41 LCA studies on the topic were analysed, it was found that, among the main variables that influence the results of the analyses on the life cycle of textile waste management, there are the performance of the recycling processes, the modeling of the use phase (number of washes and reuses), the composition of incoming waste and the substitution coefficient between recycled fibers and virgin fibers or between a used dress and a new one. In conclusion, the main challenges in the circular management of textile waste, to date, seem linked to the exact identification of responsibilities, the establishment of efficient platforms and the ability of the actors, most directly involved, to manage a mix of heterogeneous materials, maintaining, with a view to circularity, the quality of the fiber as high as possible.

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# Life cycle assessment in multinational companies: analysis of guidelines for the packaging sector


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## Abstract

Multinational companies are increasingly investing in the assessment of environmental impacts of product life cycles using the Life Cycle Assessment (LCA) method. Alongside well-established standards that guide its application, new guidelines have emerged that specify some methodological aspects influenced by subjectivity (such as the choice of system boundaries) that can bias product comparisons and affect data consistency. In this context, companies have increasingly to deal with the requests of B2B customers who may require LCA analyses for the same product to comply with different documents, thus generating confusion. This study compares three LCA guidelines used in the packaging industry, a sector particularly concerned with environmental issues, to highlight their differences and similarities, and to provide the foundation for a management system that optimizes internal LCA analysis processes to efficiently respond to different requirements.



Keywords: *Life cycle assessment; LCA; packaging; guidelines; standard.*


## Introduction

Although ISO 14040-44 [1, 2] remains the reference standards for LCA analyses, several guidelines (such as the GHG Protocol and Product Category Rules - PCR) have been developed in recent years, providing LCA practitioners and companies with new frameworks that reflect a broader alignment between stakeholders and enable consistent methodologies [3]. However, more standardisation is needed to support fair and comparable claims, which are essential to differentiate products in the market based on their environmental performance [4]. In general, product and/or industry guidelines can play an important role, enabling the various actors in a supply chain to use more homogeneous data and parameters, and potentially achieve more reliable, comparable, sharable results that can be communicated to stakeholders and clients. However, the proliferation of frameworks, such as standards and guidelines, is highlighting critical issues related to differences in the approaches used with regard to some methodological aspects which have a certain degree of subjectivity. In literature, some authors have carried out comparative analyses of some established frameworks to understand their differences, hoping for greater harmonisation. Some studies analysed, e.g., different carbon footprint standards with regard to several methodological aspects [5] or the consistency of official guidelines and standards with some criteria identified by the authors [6]. The focus of this study is the plastic packaging sector, which has recently been the subject of special attention (e.g.: due to problems related to the depletion of fossil raw materials and their end-of-life disposal). The aim is to analyse recently issued sectoral guidelines, highlighting their similarities and differences, in order to help understand the potential and risks involved, with a view to the systematic management of LCA requests by interested companies.

## Methods

This study focuses on a multinational packaging company supplying dispensing systems, mainly for the cosmetics industry. Its B2B (Business to Business) customers require LCA analyses to comply with the different guidelines described in Table 1: the Pathfinder Framework (PF) [7], the SPICE (Sustainable Packaging Initiative for CosmEtics) Methodological Guidelines (SMGs) [8] and the PCR 2013:19 for Dispensing Systems [9]. The comparative analysis of the three frameworks was carried out according to the following methodological aspects: units of analysis, system boundaries, impact categories and impact assessment methods, inventory, transport, cut-off criteria, allocation methods, biogenic $CO_2$, removals and land use, End of Life (EoL), data quality, normalisation and weighting, sensitivity analysis. An overview of the main aspects is presented.

**Table 1.** Description of the main features of the three documents analysed

| | PCR 2013:19 | PF | SMGs |
|---|---|---|---|
| **ORIGIN** | Support for EPDs regulated by ISO 14025. | The Partnership for Carbon Transparency (PACT), promoted by the World Business Council for Sustainable Development (WBCSD). | Organisations of the cosmetics industry. |
| **GOAL** | Providing greater consistency and comparability of the environmental performance of products. | Helping to develop and exchange information on the Carbon Footprint along the supply chain with regard to the downstream company's Scope 3. Defines how data are communicated and exchanged along the value chain. | Providing a comprehensive and scientifically valid methodology to assess the environmental impact of cosmetics packaging throughout the product life cycle. |
| **APPLICATION** | Dispensing Systems. | All product categories. | Packaging in the cosmetics industry. |

## Results

The three documents analysed refer to the use of LCA as the assessment tool and were analysed from a B2B perspective, although PCRs can also be used for communication to end consumers. The definition of system boundaries is critical in the management of LCA within companies. Equal boundaries make it possible to adequately compare two or more products based on the same processes. In general, the wider the boundaries, the more reliable and consistent the final result will be, but sometimes narrower boundaries ensure higher data quality as they relate to processes for which accurate information is available. Responding to a customer's request for LCA analysis by following one of the three guidelines means including and/or excluding parts of the life cycle. The SMGs recommends broader boundaries than the other two documents (Fig. 1). In fact, the distribution, use and end-of-life phases are included, too ("from cradle to grave"). However, this involves a number of scenario assumptions concerning downstream processes that are not under the direct control of the company. PCR also require a "cradle-to-grave" analysis, but downstream processes only include the end-of-life of the packaging product. Only PF requires a "cradle-to-gate" analysis, consistent with the document's objective of resolving the issue of the availability of primary data falling under "Scope 3" (i.e.: referring to upstream processes). Moreover, PCR does not include the flows related to the storage of products in warehouses, unlike PF and SMGs. As these data are not under the direct control of the company, they may not reflect the actual consumption. The lack of homogeneity of the system boundaries provided by the three frameworks makes the management of LCAs by the companies receiving the request more complicated. While having the results of an analysis with wider boundaries allows more flexibility, thus allowing unnecessary processes for a given framework to be excluded, considering narrower boundaries requires fewer resources to carry out the LCA, but does not allow different requests to be easily met. If the system has multifunctional processes, a method must be adopted to allocate flows to co-products.

The SMGs provide only mass-based allocation, whereas PCR and PF both indicate a hierarchy of actions described in Table 2. The only solution provided by SMGs for managing the multi-functionality of processes allows the company requiring the analysis to have greater homogeneity and consistency of data from the different suppliers. Furthermore, it provides to the analyst an easier resolution of the allocation problem. Adapting the allocation criterion according to the request results in a greater expenditure of resources. The cut-off allows the exclusion of certain flows from the inventory according to criteria relating to mass, energy or environmental meaningfulness [2].

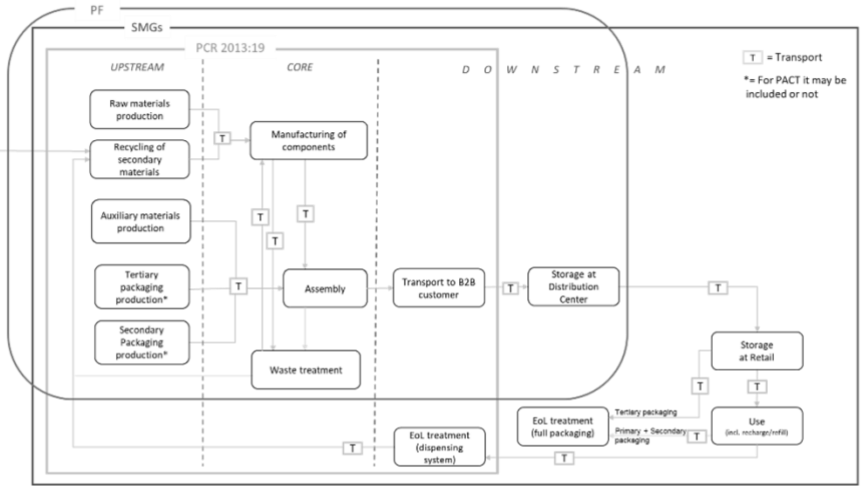


**Figure 2**. System boundaries required by the 3 frameworks analysed (PCR 2013:19, PF and SMGs) (authors' elaboration)

The SMGs provide only mass-based allocation, whereas PCR and PF both indicate a hierarchy of actions described in Table 2. The only solution provided by SMGs for managing the multi-functionality of processes allows the company requiring the analysis to have greater homogeneity and consistency of data from the different suppliers. Furthermore, it provides to the analyst an easier resolution of the allocation problem. Adapting the allocation criterion according to the request results in a greater expenditure of resources. The cut-off allows the exclusion of certain flows from the inventory according to criteria relating to mass, energy or environmental meaningfulness [2]. The cut-off criteria given by PCR and PF are described in Table 2. The SMGs do not mention cut-off criteria, thus leaving free interpretation by the analyst. This might be an advantage as it reduces the constraints imposed, but it does not address the problem of subjectivity and the analyst might influence the results. The issue of biogenic carbon is relevant for the packaging sector as the products under analysis may also consist of plastic material originating from biomass (as is also the case with dispensing systems). The SMGs, however, do not deal with this issue (Table 2). The document should be updated on this aspect as it currently does not fully reflect the need to report on biogenic $CO_2$ in a sector as concerned by the topic as packaging is. The seven impact categories required by the PCR match some of the sixteen of the SMGs. Moreover, the impact assessment methods for some of the categories shared by the two frameworks are different. This implies that the assessment of potential impacts may lead to different results, thereby requiring recalculation. Furthermore, the PF is restricted to GHG emissions only.

**Table 1.** Some methodological aspects required by the different frameworks.

| | PCR 2013:19 | PF | SMGs |
|---|---|---|---|
| MULTIFUNCTIONALITY | ▪ Allocation shall be avoided dividing process into sub-processes.<br>▪ Otherwise, the inventory data should be allocated in a way that reflects the underlying physical relationships between them (e.g.: mass).<br>▪ Otherwise, the inventory data should be allocated in a way that reflects other relationships between them (e.g.: economic). | ▪ Allocation shall be avoided dividing process into sub-processes.<br>▪ Otherwise, according to PCRs or industry-specific standards.<br>▪ Otherwise, system expansion.<br>▪ Otherwise, ratio of the economic value of co-products. | Based on mass. |
| CUT-OFF CRITERIA | ▪ A cut-off rule of 1% shall be applied. Included inventory data shall together give rise to at least 99% of the results of any of the environmental impact categories.<br>▪ 99% of the mass of the product content and 99% of the energy use of the product life cycle shall be accounted for. | ▪ Attributable processes representing less than 1% of the total product carbon footprint can be excluded.<br>▪ Total exclusions shall represent less than 5% of the total PCF emissions. | Not specified. |
| BIOGECNIC $CO_2$ | "Climate change" must include GHG emissions and removals from biogenic sources and "direct Land-Use Change" | Direct Land-Use Change, land-management-related changes, other GHG emissions | Not specified. |

The normalisation and weighting steps, which are optional according to ISO [2, 3], are not considered in the PF and are not allowed in PCR, whereas in SMGs they are only allowed for decision-making purposes for internal use. For these reasons, this issue essentially does not affect the results. Sensitivity analysis is not mentioned in the SMGs, whereas in the PF and PCR it is recommended to assess the effects of possible cut-offs in the inventory. Moreover, in the PCR, sensitivity analysis should be carried out to assess the influence of the chosen economic value, in the case of economic allocation. For the product's EoL, excluding PEF, which does not consider this phase in the boundaries, the SMGs go into more detail facilitating the analyst's work. The required accounting method is the Circular Footprint Formula (CFF), as defined in PEF 6.3 guidance [10]. The CFF includes disposal and recovery activities as well as reconditioning operations necessary to bring a reusable packaging back to a functional state for further reuse. In addition, the allocation of recycling must be carried out by the "cut-off method". For the treatment of pre-consumer waste (e.g.: production waste), in both PCR and PF the responsibility belongs to the process that generated it. Furthermore, for the accounting of emissions from material recycling and incineration with energy recovery, the three documents provide for the use of the "cut-off method" (i.e.: the allocation of environmental loads to the company using the recycled material). Finally, the PF and SMGs define data quality assessment. The former requires the calculation of at least one indicator between "primary data share" (PDS) and "data quality assessment" (DQR) by means of a matrix in which 5 criteria are assessed, which essentially correspond to those required by the SMGs. The PCR does not refer to the evaluation of data quality, except for the share of secondary data that can be used for analysis.

## Discussion and conclusion

An analysis of some methodological aspects in the three documents reveals some differences and similarities. In particular, the system boundaries, key aspect in LCA analyses, are not overlapped in the three frameworks. Therefore, in case of a request for a broader analysis, the company may need to deploy more resources for additional data collection and calculation. Furthermore, the allocation and cut-off criteria are different for all three documents. This means that an analysis previously carried out on a product according to a given framework does not ensure that the customer's request is answered consistently. Finally, two aspects need to be highlighted. First, the upstream company in the supply chain, such as the packaging company, could optimise the necessary resources by developing an internal LCA analysis system in order to adapt the inventory according to the required standard or guidelines and reformulate the analysis with the relevant methodological issues. Moreover, although the guidelines try to overcome problems related to the subjectivity of some methodological choices, a certain degree of analyst discretion remains in some issues (e.g.: for the calculation of the biogenic $CO_2$ in the SMGs). For this reason, the documents should be improved by defining the above-mentioned aspects even more precisely. Other standards and guidelines will be the subject of a broader analysis to understand all the possible requests a company may have to respond. Furthermore, starting from a case study of a packaging company future research will focus on the definition of an internal management system that speeds up and optimises LCA processes, also considering the aspects of internal organisation of LCA analyses within companies, such as operational steps and definition of roles.

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# Recovery and valorization of polyurethane mattresses at the end of their lifecycle: a concrete demonstration of circular economy and industrial symbiosis

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## ABSTRACT

Following the principles of the circular economy and industrial symbiosis, this study aims to find solutions for the recovery and valorization of end-of-life polyurethane mattresses managed by the company Servizi Italia S.p.A., with the goal of promoting sustainable solutions for the bedding sector. The research objective is to recycle the polyurethane components of the mattresses for reuse in the production of new products. Initially, the polyurethane mattress sector in Italy is examined, and its recoverability is explored. After identifying the potential industry sectors and companies interested in reuse, the agreement with the startup Re Mat for product recycling is illustrated, wherein the products are transformed into new eco-mattresses using the company's production process. Finally, a comparative carbon footprint analysis is conducted between the two scenarios to assess the different environmental impacts associated with the two product life cycles.

Keywords: *Circular Economy; Industrial Symbiosis; Recycling; Recovery and Valorization; Polyurethane.*

## Introduction

The aim of this study and research activity is to analyze the best solutions for valorizing end-of-life mattresses managed by the company Servizi Italia S.p.A. across the national territory. The purpose is to optimize the end-of-waste status of mattresses, following the principles of the Green Deal, Agenda 2030, circular economy, and industrial symbiosis, to promote environmental sustainability throughout the entire supply chain.

The materials comprising mattresses, such as fabric, padding layers, felt, polyurethane foam, latex, and steel springs, can be repurposed and reused in the production of new items. This study particularly focuses on managing and valorizing the polyurethane components of mattresses through new applications. It is important to study both the process aspects for recovering mattress elements and the legislative aspects for transitioning from waste to byproduct, in accordance with the provisions of the Unified Environmental Text Legislative Decree 152/2006.

The report identifies potential product sectors for establishing a circular economy and the companies interested in industrial symbiosis projects in the region. It also provides an overview of environmental sustainability aspects and the underlying philosophy guiding this project.

Subsequently, the startup Re Mat is introduced, with which a concrete agreement has been reached, explaining their innovative recovery process for recycling the mattresses under study. Lastly, a comparative analysis of the carbon footprint is conducted between the initial situation and the final system after the agreement between the two companies, to assess the overall environmental impact of the mattress recovery and recycling process.

## Methods

### *Polyurethane mattresses and recoverability*

According to ISTAT data [1], in 2021, approximately five million new mattresses were produced in Italy, with over two million (44%) made from polyurethane foam. When examining mattress production and sales in Italy from 2017 to 2021, it becomes evident that the share of polyurethane mattresses has consistently remained between 44% and 52% of the total national production.

Nearly half of the mattresses produced in Italy are made from polyurethane foam. These statistics highlight a consistent preference for polyurethane as the material of choice for mattress production in recent years. Attention now turns to the analysis of the recyclability and current recycling of polyurethane, with the aim of identifying existing challenges to transform them into opportunities for improving the disposal process.

It's important to note that polyurethane is an extremely durable material with an estimated lifespan of around fifty years. This characteristic places it in a more sustainable category compared to other petroleum-derived polymers. The long lifespan of a polyurethane mattress means that it requires less frequent replacements and can be used for an extended period, thereby reducing the overall amount of waste generated over time.

One of the main challenges associated with managing this material is its recycling complexity. Polyurethane is a composite material made up of various chemical substances and components that can make treatment and material separation during the recycling process challenging. For example, polyurethane mattresses may contain foams, fabrics, metals, and other materials that must be separated before the recovery process can commence, making recycling more intricate.

Unlike more commonly recycled materials like plastic or glass, polyurethane requires more specialized and costly recycling processes such as re-bonding [2], air-lay methods [3], or chemical recycling processes like glycolysis [4]. Additionally, the limited diffusion and availability of specific recycling infrastructure and technologies often lead to unsustainable disposal solutions such as landfilling. Currently, one of the primary disposal methods for polyurethane mattresses is incineration with energy recovery. Polyurethane contains a substantial amount of energy per unit weight, comparable to that of coal, making it suitable for burning in waste-to-energy facilities to generate thermal or electrical energy.

It's important to emphasize that polyurethane incineration should be viewed as a temporary disposal solution. Actively promoting polyurethane recycling is essential, as this approach preserves resources and reduces the overall environmental impact. Efforts should be directed toward developing better recycling technologies and infrastructure to make recycling polyurethane mattresses more economically viable and environmentally sustainable.

### *Servizi Italia mattresses*

Servizi Italia provides washing, sanitization, and sterilization services for mattresses and pillows on behalf of companies operating in the healthcare sector. All these products are single-component and made entirely of polyurethane, a feature that provides a significant advantage for the recycling process that will be initiated at the end of their useful life.

In fact, mattresses are much easier to separate and recycle compared to those containing mixed components or additional materials. Thanks to this single-component composition and the absence of other complex materials, the mattress recycling process becomes more efficient, resulting in reduced monetary, energy, and environmental costs. The "Hospital No Fire" model used by Servizi Italia is a comprehensive and highly secure solution for healthcare environments. It is available in different variants differing in shape, support surface design, and breathability. Its characteristics are reported in the technical data sheets (Figure 1).


SERIE HOSPITAL NO FIRE

- Materasso omologato in **CLASSE 1 IM (UNO I EMME)** dal Ministero dell'Interno in ottemperanza a quanto previsto dal D.M. del 26.06.84).
**PREVENZIONE INCENDI.**
**OMOLOGAZIONE N° RE1535D20D1IM00002**

LASTRA

- Materasso in poliuretano espanso densitá kg 30 al mc.
- Ad alta resilenza.
- Permeabile all'aria.
- Indeformabile.
- A cellula aperta per una migliore e salutare traspirazione.
- Prodotto senza l'impiego di CFC (Clorofluorocarburi).
- Conforme a quanto richiesto dalla normativa ATS. 1000.001 Airbus.
- Favorisce la corretta distribuzione del peso corporeo.
- Antibatterico e antimicotico.
- Adattabile a qualsiasi tipo di letto e disponibile in varie misure sia in un pezzo unico sia in piú sezioni.
- Lavabile in lavatrice con miscele calde disinfettanti e detergenti.

FODERA POLIESTERE ignifugo Classe 1

- Fodera di rivestimento in traliccio fasciato candido.
- Irrestringibile.
- Confezionata con apertura in **testa** o a **L** (lato corto piú lato lungo).
- Chiusura con robuste cerniere.
- Lavabile in acqua a 95°.

CARATTERISTICHE TESSUTO

| | |
|---|---|
| **Composizione** | 100% poliestere ignifugo Classe 1 |
| **Colore** | bianco |
| **Peso** | gr. 200 circa |
| **Armatura** | fili: 35 in ordito e 20 in trama al cm |

**Figure 1.** Technical data sheet "Hospital No Fire" mattress by Servizi Italia

Each year, approximately 1830 tons of polyurethane are processed in the company's two main facilities. [5] Considering the weight of a single mattress (10.5 kg), it is estimated that around 175,000 mattresses are processed annually. However, a portion of these mattresses cannot be reused due to reaching the end of their useful life. There are several reasons for this: some mattresses may sustain severe damage that makes them unusable for the cleaning, drying, and sanitization process. Another reason for mattresses reaching the end of their life is related to contract changes. Since Servizi Italia's customers primarily operate in the healthcare sector, where mattress procurement is regulated through tenders, when the concession expires, old mattresses must be replaced with new products that meet the new specifications. This results in previously used mattresses reaching the end of their useful life and needing to be disposed of.

**Table 1.** Tons of polyurethane mattresses processed and disposed of in 2021 by Servizi Italia

| | Processed mattresses [t] | Disoposed of matresses [t] | Disposal percentage |
|---|---|---|---|
| **Castellina (PR)** | 1428,3 | 76,5 | 5.4% |
| **Bolzaneto (GE)** | 293,4 | 31,2 | 10,6% |
| **Total** | 1721.7 | 107.7 | 6.3% |

In 2021 alone, over 107 tons of polyurethane were disposed of in landfills or incinerators, equivalent to nearly 10,200 units, generating a significant environmental and economic impact for Servizi Italia.

The goal of this project is to recover end-of-life mattresses, transforming them from waste, which represents only an environmental and economic burden, into resources from which value can be extracted. This objective will be achieved by reintroducing the polyurethane from end-of-life mattresses into new production cycles, reusing it as a new raw material to produce other products.

### *Re Mat startup and the recycling process*

In this context, Servizi Italia has established a supply agreement with Re Mat, a specialized startup in the recovery of polyurethane foam from mattresses at the end of their useful life and from manufacturing waste. This company has patented a recycling process that enables the production of new eco-mattresses using exhausted polyurethane as the primary raw material.

Servizi Italia's end-of-life mattresses, once they arrive at the Re Mat facility, undergo an initial process of disassembling and stringent sanitation. Subsequently, they are fed into two connected machines known as granulators, which grind them down into polyurethane flakes. With the objective of creating solid and compact blocks, these granules are blended with a biological adhesive and then pressed into large molds, where they remain for a certain period. The resulting blocks are then cut into sheets of recycled polyurethane, which are glued and combined with other sheets of virgin polyurethane (obtained from manufacturing waste). The resulting product is named "Eco-Foam”, offering technical performance comparable to traditional mattresses while ensuring comfort and durability.

Additionally, Servizi Italia not only entrusts the end-of-life management of exhausted mattresses to Re Mat but also repurchases the new Eco-Foam mattresses, thereby closing the loop. This practice reduces reliance on virgin materials and significantly contributes to reducing the environmental impact associated with the production of new polyurethane.


**Figure 2.** Re Mat "Eco-Foam" mattress

## *Findings - Comparative carbon footprint*

The objective of this study is to calculate and compare the carbon footprints associated with the life cycle of a mattress, both in the initial scenario characterized by a linear economy and in the subsequent scenario where a circular approach is adopted (Fig. 5). The analysis considers the environmental impact of the mattress throughout its entire life cycle, from the production of raw materials to the point of delivery to the end customer. The functional unit of the system is a single mattress (weighing 10.5 kg of polyurethane), and the analysis does not consider the environmental impacts associated with the internal operations performed by Servizi Italia.

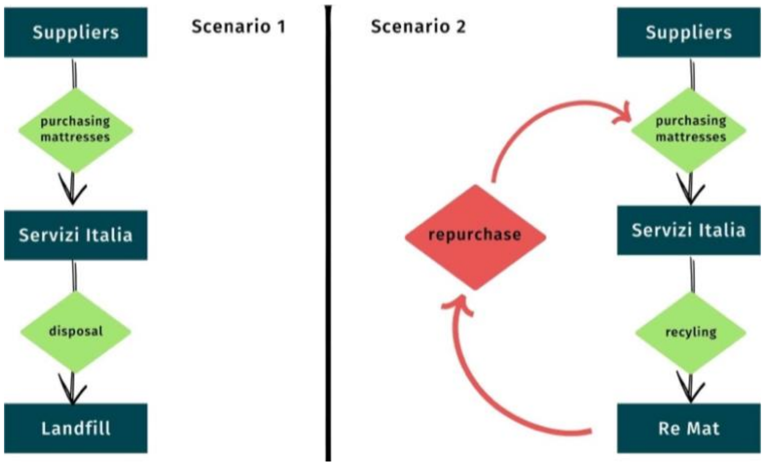


**Figure 3.** Scheme of the two life cycles

Using the SimaPro software, it was possible to compare the life cycles of the new mattress and the recycled mattress to analyze the emissions allocated to different impact categories defined by the chosen characterization and normalization method: the CML Impact Assessment method.

## Conclusions

The following table demonstrates that the environmental impacts expressed in kilograms of $CO_2$ equivalent associated with the life cycle of the recycled mattress are lower than those associated with the life cycle of the new mattress for almost every impact category defined by the CML-IA method.

**Table 2.** Environmental impacts of the two life cycles

| | Recycled mattress | New mattress | Difference | Difference [%] |
|---|---|---|---|---|
| **Abiotic depletion** | 2.16E-14 | 2.47E-14 | 0.31E-14 | -12.5% |
| **Abiotic depletion (fossil fuels)** | 1.01E-12 | 2.76E-12 | 1.75E-12 | -63.4% |
| **Global warming** | 4.67E-13 | 1.13E-12 | 6.63E-13 | -58.7% |
| **Ozone layer depletion** | 4.31E-15 | 1.33E-15 | -2.98E-15 | +69% |
| **Human toxicity** | 2.82E-14 | 3.49E-14 | 0.67E-14 | -19.2% |
| **Fresh water ecotoxicity** | 2.7E-14 | 4.93E-14 | 2.23E-14 | -45.2% |
| **Marine aquatic ecotoxicity** | 1.78E-12 | 3.29E-12 | 1.51E-12 | -45.9% |

| | | | | |
|---|---|---|---|---|
| **Terrestrial ecotoxicity** | 3.03E-14 | 1.25E-13 | 9.47E-14 | -75.8% |
| **Photochemical oxidation** | 5.42E-14 | 1.26E-12 | 12.1E-13 | -95.7% |
| **Acidification** | 3.58E-13 | 8.56E-13 | 4.98E-13 | -58.2% |
| **Eutrophication** | 1.5E-13 | 2.85E-13 | 1.35E-13 | -47.3% |

This confirms the environmental benefits arising from the adoption of a circular economy approach. The study's positive outcome highlights the importance of promoting a circular economy, as seen in the partnership between Servizi Italia and Re Mat. This collaboration represents a concrete example of cross-entity cooperation to enhance sustainability and resource efficiency. The research underscores the environmental benefits of transitioning to a circular economy, offering valuable insights for future waste management and recycling decisions. Furthermore, it demonstrates that industrial symbiosis programs yield mutual benefits for all parties involved, fostering sustainable economic development and environmental preservation. Creating an ecosystem of companies with shared values encourages resource sharing, waste reduction, and synergies, ultimately providing environmental and economic advantages.

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# A circular economy survey in sicilian agri-food sector

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## Abstract

The paper aims to present the current business panorama of eastem Sicily and to provide the results deriving from a survey on the diffusion of the circular economy which involved the agri-food sector. In particular, examples of circular economy on the island are first presented, secondly, the research methodology adopted is described, based on a specific questionnaire addressed to various supply chains in the Sicilian food sector: finally, the results and suggestions aimed at businesses are presented.

Keywords***:*** Agricultural sector; renewable resources; circular economy; sustainability.

## Introduction

The food production and consumption system is the sector that most clearly shows the impacts and contradictions of the linear economic model. Food production has contributed to the crossing of as many as four thresholds that determine planetary limits, that is, those values within which humanity must move to maintain a state of equilibrium of the biophysical systems that support its existence [1]. Climate change, loss of biodiversity, alterations to the nitrogen and phosphorus cycle, and changes in land use are respectively related to an agriculture that: produces about one-third of greenhouse gas emissions [2]; consumes 69% of water resources globally [3]; uses between 10 and 30% of the amount of energy consumed in industrialized countries [4]; and contributes heavily to chemical pollution. The current food production model is based on intensive production, monocultures and reckless use of manure and fertilizers. Carbon dioxide, methane and nitrous oxide are emitted directly and indirectly throughout the value chain of agri-food supply chains.

According to a study published in March 2021 in Nature Food, in 2015, $CO_2$ emissions related to food systems reached 18 billion tons, accounting for 1/3 of the total (34%), and of these 29% come from distribution, processing, consumption and end-of-life [5]. With reference to packaging, the emissions produced by the food sector, reach nearly 1 billion tons of $CO_2$ [6]. At the same time, primary activity is also one of the economic sectors most exposed to the climate change already taking place: scarcity of water resources, alterations in rainfall regimes, and frequency and intensity of extreme weather phenomena represent conditions to which the agribusiness sector must adapt quickly. Studies conducted by the FAO show that, due to severe pressure on natural habitats, 75% of the varieties of agricultural crops have been lost with severe repercussions on the variety of food diets worldwide [3]. The objective of this paper is to illustrate the potential of a transition from the current linear economic model, in which resources are used as if they were unlimited, to a circular model, which is essential considering growing environmental issues [7].

To this end, a survey was carried out to take a snapshot of the current situation of the Sicilian agribusiness ecosystem. Based on the responses obtained, some key suggestions emerged that could help promote relational networks, best practices and sustainable styles for the corporate world.

## Methods

This paper presents the results that emerged from a survey conducted on agribusinesses in eastern Sicily, aimed at assessing the degree of diffusion of the circular economy. The sample, to which the questionnaire was administered, consisted of 10 companies. As the data collected highlights, the heterogeneity of the companies nevertheless found unanimous responses in some cases, while in others it amplified the differences especially in terms of the performance of activities and planning of future expectations.

## Results

The first thematic macro-area (1-6), which is purely descriptive, aims to gather information on companies' characteristics; although the companies interviewed remain anonymous, a distinction by business sector, number of employees and average annual turnover is of interest.
The second macro area (7-11) aims to investigate the efforts already implemented by companies on environmental sustainability and circular economy. In particular, companies were asked to indicate voluntary certifications acquired, the presence of professional figures dealing with sustainability and circularity, medium- to long-term projects inherent to the circular economy, and the activation of training actions aimed at their employees, designed to share the principles of the circular economy.

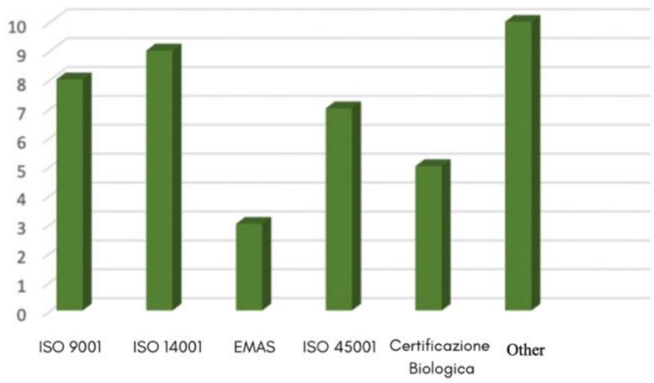


**Figure 1.** Voluntary certifications acquired

All of the companies surveyed have at least one certification, which denotes a particular sensitivity to issues of environmental sustainability and food safety (Figure1). Some of the certifications mentioned in the "Other" category include: BRC Food certification, ISO 50001, ISO 22000, IFS Food, Viva, SOStain. In almost all of the cases examined, there was not any professional figure with specific skills in the field of environmental and social sustainability. Only one figure, the Chief Sustainability Officer, responded positively to the question. All of the companies surveyed have taken or intend to take actions to limit their environmental impacts in the next 2 years. The third macro area (12-13) analyzes the future prospects that the surveyed companies envision. Specifically, companies were asked whether they plan to acquire certifications in the circular economy and what the impacts of a transition to a regenerative economy will be in their business sector (Figure 2).

All of the agribusinesses surveyed plan to acquire additional certifications in the circular economy. Regarding the impacts of a transition to a regenerative economy, all of the companies surveyed believe that it can lead them to limit the waste of resources; 90% of them surveyed believe it can lead them to improve their reputation and, given the growing consumer awareness of environmental issues, strengthen their relationship with their customers.

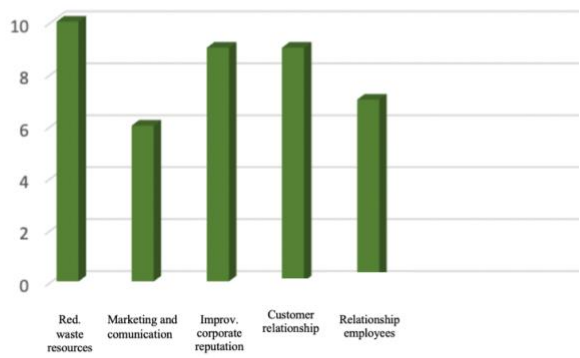


**Figure 2.** Impacts of a transition to a regenerative economy

The fourth macro area (14-20) analyzes the circular approach implemented by the agribusiness ecosystem surveyed, forming the core of the questionnaire. With reference to the best practices implemented, an extensive photovoltaic system, capable of powering the production plant, guaranteeing the production site a flow for energy sustenance entirely self-generated from renewable sources; a complex system of purification of processing water, reused to irrigate the company's vegetable garden, are mentioned; packaging that is fully compostable or made of recyclable materials to allow proper disposal of packaging; a "just in time" production system that produces small quantities based on sales, i.e., the quantity ordered in advance, and thus allows the company not to create surplus or leftover stock and to minimize waste; reuse of a food product that is slightly overcooked at the end of the cooking process as a semi-finished product for the production of another product, considering it illogical to discard a good, fresh product for aesthetic reasons; adoption of sustainable agricultural practices, such as organic farming and the rational use of pesticides and fertilizers, which allow the company to preserve soil fertility, protect biodiversity and reduce pollution from chemicals. All of the companies surveyed believe they are impacting the environment due to their energy consumption (Figure 3).

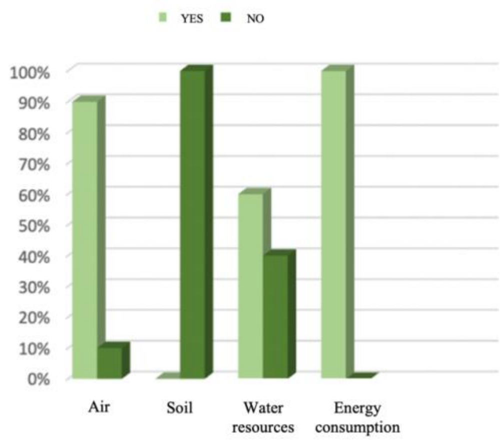


**Figure 3.** Environmental impacts

Although there are some barriers, including lack of financial resources and lengthy processes to acquire certifications, all the companies surveyed interpret the circular economy as a great opportunity and have undertaken and/or planned projects aimed at implementing the circular economy. The concluding question, to which all the companies surveyed answered in the affirmative, concludes the survey on a positive note, demonstrating a growing interest on the part of the Sicilian business ecosystem in the circular economy and its applications. The companies interviewed constitute a very heterogeneous set both in terms of organizational structure and dedicated staff, as well as in relation to the circularity practices adopted. This heterogeneity is evident because the companies belong to different market sectors and are distinguished by their business histories, which differ in terms of time; in fact, some of them were founded a few years ago or have recently started a transition to the circular economy, while others are long-lived companies on both fronts. Moreover, these companies possess entrepreneurial projects with divergent perspectives and goals. Despite these differences, the responses obtained were more than positive and, in some cases, showed particularly significant trends. The survey of Sicilian agribusinesses on environmental sustainability and circular economy provided valuable information on possible improvements that can be made by companies. Based on the responses obtained, some key suggestions emerged that could help promote circular economy principles. First and foremost, the priority aspect to consider is resource optimization. Companies should adopt practices that aim to minimize waste by implementing more efficient production processes and recycling materials. The introduction of advanced technologies and automation can help optimize processes and reduce environmental impact.

In addition, the survey highlighted the importance of promoting sustainable supply chains. Agribusinesses should forge partnerships with suppliers who adopt sustainable

practices such as, for example, organic farming and responsible use of water resources, while ensuring food quality for their customers.
Another key aspect concerns waste management. Companies in the industry should adopt policies on waste reduction, recycling and composting, helping to reduce their environmental impact.
Finally, the survey emphasized the importance of staff training and awareness. It is important for companies to invest in training their employees in order to promote environmental and social awareness and develop specific circular economy skills. This will result in all members of the organization being involved in the adoption of sustainable practices and actively contributing to the achievement of corporate goals. It is clear that the current system, based on a rigidly linear logic, does not work, and that a shift to a circular and regenerative economy would bring enormous benefits, enabling businesses to reduce their dependence on foreign countries while contributing to the achievement of Sustainable Development Goals 12 and 13 (SDGs), which are of crucial importance to humanity and the planet (Oliveri et al, 2022). Specifically, Goal 12, "Responsible Consumption," aims to halve global food waste, make the food supply chain more efficient, significantly decrease the amount of waste produced and improve its management; Goal 13, "Combating Climate Change," aims to strengthen resilience and capacity to manage environmental disasters affecting Planet Earth (Falzarano, 2020).

## Conclusions

In Sicily, the implementation of the circular economy is still in its infancy. Despite the bureaucratic complications, the regulatory environment characterized by complex and rigid rules and the lack of or poor knowledge of the topic on the part of many factors in the sector, there are many virtuous cases in the agri-food sector, which has long been engaged on the front of reducing food waste and, for some years now, on initiatives to reduce the use of packaging. In fact, some Sicilian companies can enjoy the title of "pioneers" or "forerunners." Being ahead of the curve, especially in the corporate world, can be a crucial advantage over the competition and thus represent a huge opportunity. The survey conducted on the Sicilian business ecosystem on environmental sustainability and circular economy provided valuable information on possible improvements that can be made by companies, contributing to the promotion of circular economy principles and relational networks between virtuous companies, institutions and civil society. It also found an awareness on the part of companies with reference to the benefits of a transition to a regenerative economy, including reduced resource waste, improved corporate reputation and, considering consumers' growing awareness of environmental issues, improved customer relations. As a major contributor to environmental degradation, the agri-food sector can be transformed into a valuable ally

in combating climate change and creating an economy that respects the natural balance. Therefore, it is necessary to rethink the agribusiness sector that provides nutritious, healthy and accessible diets for all while fostering the ecological transition, following the path set by the European Union, from field to table.
When talking about sustainability, green reconversion and, especially, circular economy, one must start from an inescapable assumption: Sicily will be able to achieve the expected results only if it succeeds in making this transition systemic and transversal, involving as much as possible the economic and productive system as a whole, but also institutions and citizens (Gatto and Lopez, 2019). Only through a collective commitment will it be possible to take full advantage of the opportunities offered by the circular economy, promote the region's sustainable development and preserve the island's natural resources.

## Acknowledgements

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# Industrial symbiosis in the Marche region. The preliminary results of the Marlic project

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## Abstract

The MARLIC project was born from the need to create a regional point of reference for the creation of new materials and to enhance the circular approach to the use of raw and secondary materials. This work aims to describe the results of the Operative Meetings (OM) on industrial symbiosis arranged in Camerino (Marche Region) and based on ENEA's methodology. The event had the purpose of investigating the synergies between local companies to enhance resource flows that companies may have in excess (material scraps, energy waste, services, skills, capacity, and logistics). Thirty companies belonging to different production sectors took part in the event. The results show a total of 199 resources and 86 potential synergies. The identification of the most significant resource flow was developed and three main flow categories were determined namely: "paper/cardboard", "leather" and "plastic/rubber". Each flowchart was developed, and an analysis of the main synergies that emerged during the OM was performed.

keywords: Industrial symbyosis; circular Economy; Marche; Enterprises; Resource efficiency; Synergies.

## Introduction

This article illustrates the activity carried out by ENEA (Italian Agency for New Technologies, Energy and Sustainable Economic Development) within the MARLIC (Marche Applied Research Laboratory for Innovative Composite Materials) project.

The MARLIC project has the mission of creating a regional point of reference for the development of new materials, with particular attention to the use of biomaterials and the circularity approach to the use and reuse of raw and secondary materials in the Marche region. The project partnership includes 21 local companies and 5 University and Research Centers. The project's activities were divided into two different consequential actions:

- the first project concerns the development of biomaterials and mixed advanced materials studying the utilization of new raw and/or secondary materials;

- the second project follows a circular approach through a "De-manufacturing with a view to circular economy according to the rules of the 4Rs (Reduce, Reuse, Recycle, Recover).

Moreover, the project represents the first structured attempt to implement industrial symbiosis in the Marche region. Among the project activities, ENEA was also in charge of those related to industrial symbiosis according to a validated methodology due to decades of experience on this issue. In 2011 ENEA started the development and the implementation of an IS network model thanks to several projects in Italian regions [ [1], [2], [3], [4], [5]].

The ENEA's laboratory RISE (Resources Valorization) has successfully used its methodology to support companies in the realization of IS matches during the MARLIC project. An Operative Meeting (OM) was organized during the project and held in Camerino.

## Methods

The goal is to launch a structured action in the Marche region, on industrial symbiosis through the methodology developed by ENEA because of consolidated experience on industrial symbiosis issues.

The methodology includes:

- The involvement of companies from different production sectors. Production sector heterogeneity is one of the fundamental requirements for intercepting potential synergies;
- The organization of Operative Meetings (OM) between the companies involved as fundamental moments of comparison, knowledge and exchange of information and data;
- A phase of elaboration and systematization of the collected data in which the potential exchanges emerged during the OM and identified ex-post based on the information provided is identified;
- OM with companies for an in-depth study of some aspects and issues related to resources and processes.

## Results

The OM was organized by ENEA with the support of local associations and held in Camerino. Thirty (30) local companies belonging to different production sectors actively participated in the event.

**Error! Reference source not found.** shows the representation of the different production sectors, as defined through the ATECO code of the companies. The company's macro-sectors were also identified: in blue the companies belonging to the "manufacturing sectors" in yellow the organizations belonging to the category "production and distribution of water, sewerage and waste management", in red and green respectively the companies relating to "services of communication" and "agriculture, hunting and forestry", finally in orange companies operating in the "legal activities and consultancy" sector. A greater presence of companies in the manufacturing sector (76.7%) is evident, with many companies operating in the "manufacture of rubber/plastic material articles" (6 companies, equal to 20%). The size of the companies that took part in the OM was also analyzed, based on the current reference legislation [6] (Figure ): a uniform distribution of companies based on size is observed with a slight majority of large companies (30%), followed by micro (26.7%) and small firms (23.3%).

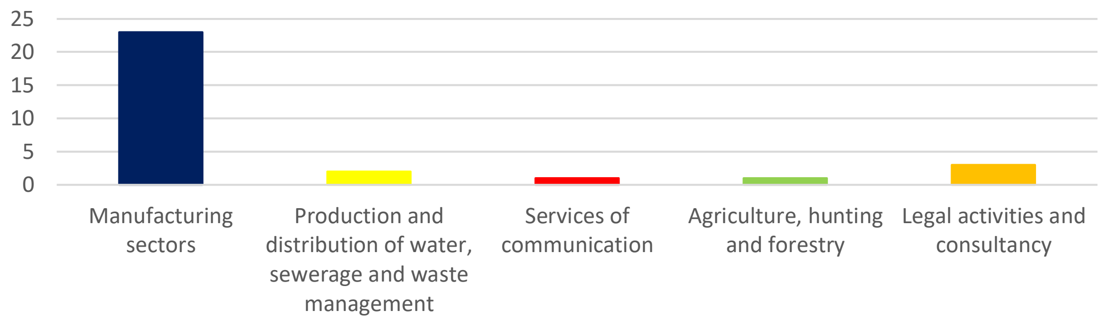


**Figure 1.** Production sectors of the thirty companies that participated in the OM (ENEA elaboration)

The data collected during the OM were post-processed and the results are shown in Figure 3. The total number of resources shared was 199. Of these, 76% (151 resources) are outputs made available by the companies and 24% (48 resources) are inputs, requested by the companies participating in the OM (Figure 3 on the left). Most of the shared and requested resources are production waste, by-products or material surpluses. The graph on the right in Figure 3 shows that 85% of shared resources are material, while the remaining 15% is represented by services and skills.

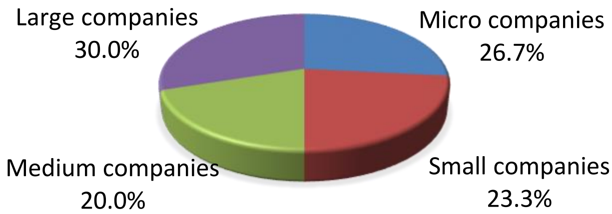


**Figure 2.** Estimated size of companies participating in the MARLIC OM (ENEA elaboration)

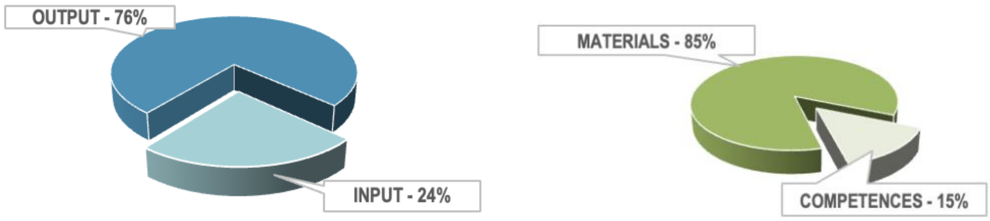


**Figure 3.** Output and input resources (on the left), categories of resources discussed during the OM (on the right) (ENEA elaboration)

The synergies identified were 86. The graph in Figure shows that, compared to the total potential synergies that emerged, 53% involved output resources while the remaining 47% involved input resources.

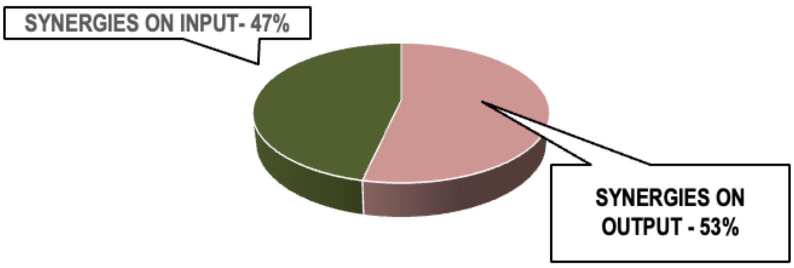


**Figure 4.** Potential synergies on input and output resources (ENEA elaboration)

Specific criteria were defined for the creation of different macro categories of resource flows. The following 8 macro-categories were therefore identified: plastic, paper, tissue, services, wood, skins, organic, other.

According to this subdivision into macro-categories, those that recorded a greater number of shared resources and synergies were identified. The "leather", "paper/cardboard" and “plastic/rubber” flows had the greatest interest from an economic and quantitative point of view. A more in-depth study was therefore dedicated to these flows and three different flow diagrams were identified containing information relating to the companies involved in the potential synergies, the relative distances between them and the quantities of materials involved.

## Conclusions

Activities related to industrial symbiosis were carried out as part of the MARLIC project. An OM was organized by ENEA in Camerino in October 2022. Thirty companies of different industrial sectors were involved and almost 200 resources were shared by them as output/input flows. More than 85 potential synergies were identified during the OM. The data collected were post-processed by ENEA identifying eight macro-categories (i.e. plastic, paper, tissue, services, wood, skins, organic, other) of flows and creating specific flow diagrams relating to the most important flows (leather, paper/cardboard, and plastic/rubber materials) emerged during the OM.

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# Innovative sensors to detect the ripening stage of tomato fruits for efficient crops control in smart greenhouses

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## Abstract

Smart technologies have been recently applied to agriculture in order to reduce water resources and to increase the crops yield. This resulted in the deployment of smart greenhouses that integrate solar panels for power generation, smart irrigation systems to minimize the water consumption and sets of sensors to optimize plant growth.

The evaluation of the ripening stage of fruit and vegetables is of primary importance to maximize crops production and minimize waste. This is usually carried out by visual inspection and firmness evaluation by an operator, techniques that are both subjective and prone to errors.

In this work, a novel technique, based on Electrical Impedance Spectroscopy, is presented to evaluate the ripening status of tomato fruits in the post-harvest stage. Three different electrodes configurations are investigated for both destructive and non-destructive measurements. The results show that the proposed technique can be efficiently implemented to increase crops yield in smart greenhouses.

Keywords*: Food sensors; electrical impedance spectroscopy; internet of things; smart greenhouse.*

## Introduction

In recent years smart technologies in the paradigm of the Internet of Things (IoT) have been extensively applied to agriculture [1]. This resulted in the deployment of smart greenhouses that integrate sensors and actuators for in-the-field monitoring, wireless transmission protocols (such as Bluetooth and Wi-fi) to transfer the measured data to a remote host and powerful processors for intensive data processing. Sensors usually integrated in smart greenhouses include, for example, light, temperature and humidity sensors for environmental monitoring [2], strain sensors for dynamic measurement of plant growth [3], high resolution cameras using computer vision for the analysis of complex traits related to the growth, yield and adaptation to biotic or abiotic stress [4] and chemical sensors for the measurement of important soil parameters [5]. All the sensors and actuators, as well as the electronic systems used to acquire, process and transmit the measured data, are powered using energy harvested by natural sources (solar, mechanical, heath, biochemical) [6], thus resulting in high energy efficiency of modern smart greenhouses.

Innovative techniques for the automatic quality and safety monitoring of agricultural products have been recently proposed in literature, such as: portable sensor systems for the measurement of the free acidity, the peroxide index and the total phenolic content of virgin olive oils [7,8]; an electronic nose for fast diagnosis of aphid infestation on greenhouse tomato plants at early stages [9]; a technique based on optical attenuation measurements to estimate the solid fat content in vegetable oils and fats [10]; an electronic nose for fast, inexpensive, and non-destructive detection of different potato cultivars [11].

The determination of the ripening stage of fruits and vegetables is of primary importance to maximize crops production. Standard techniques for ripening stage measurement include visual inspection, where the fruit skin colour is evaluated, and firmness monitoring, that can be carried out by hand or using a penetrometer. Such standard techniques are usually time-consuming, must be carried out by trained personnel and are prone to errors.

In this paper Electrical Impedance Spectroscopy (EIS) is investigated as a suitable technique to monitor the ripening stage of tomato fruits using three different electrodes configurations that are compared in terms of measurement accuracy. The results have shown that non destructive EIS measurements can be easily implemented for tomato ripening stage detection in smart greenhouses.

## Methods

The measurements carried out on tomato samples are based on Electrical Impedance Spectroscopy (EIS), a popular technique where a sine-wave voltage signal V(t) is applied to the sample under test and the current I(t) flowing through the electrodes is measured. The complex impedance (Z) of the sample can be calculated as:

$$Z = \frac{V_{ac}}{I_{ac}} \times e^{-j\varphi} = Re(Z) + jIm(Z)$$

where Vac and Iac are the amplitudes of the sine-wave signals V(t) and I(t) and φ is the phase difference between V(t) and I(t).

EIS measurements have been carried out using the impedance analyser Agilent E4980A (in the frequency range 20Hz – 2MHz with a voltage stimulus of amplitude 100mV), controlled by USB interface by means of ad hoc developed LabVIEW programs running on a laptop PC. Three different electrodes configurations have been tested, shown in Fig. 1 along with the corresponding equivalent electrical circuits used to model the impedance spectrum.

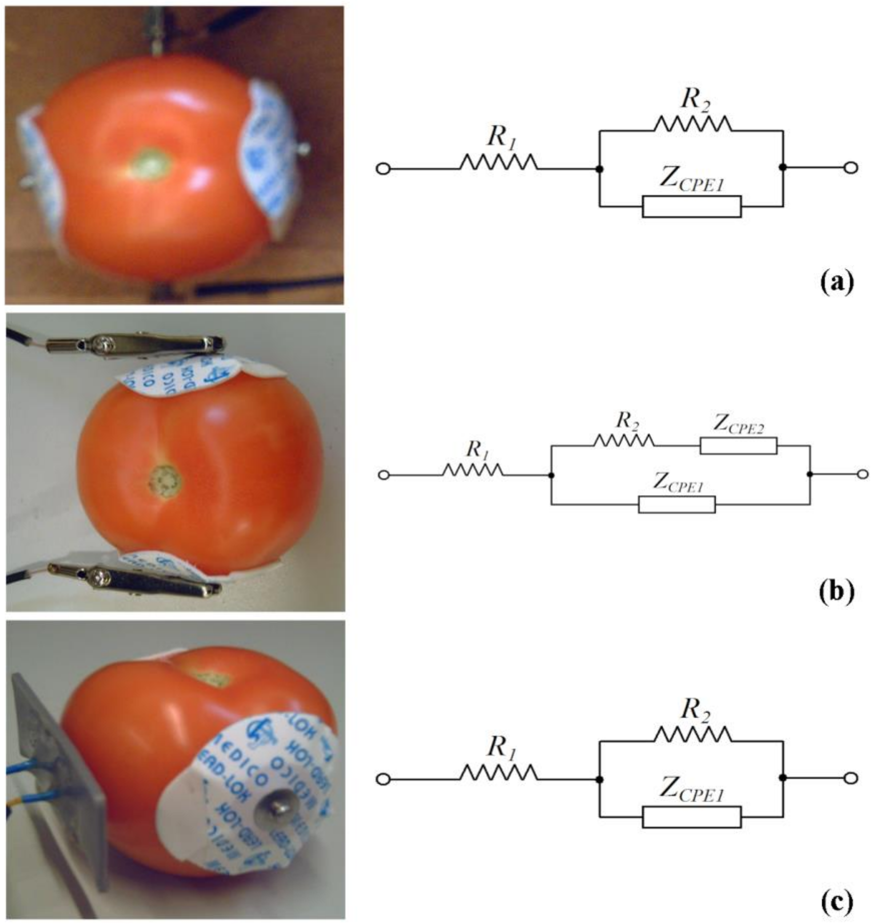


**Figure 1.** Photograph of the electrodes configuration and equivalent electrical circuit for setup A (a), setup B (b) and setup C (c)

Setup A is a non destructive measurement configuration where two cylinder shaped stainless steel electrodes (diameter 6mm) are placed in direct contact with the tomato sample. Its equivalent electrical circuit is composed of a resistance that models the electrode-sample interface (R1), a resistance that accounts for the electrical conductivity of the tomato (R2) and a constant phase element (ZCPE1) that models the capacitive electrode-sample interface. Sample B is a non destructive measurement configuration where a couple of adhesive commercial ECG electrodes, featuring high quality Ag/AgCl electrodes and high conductivity gel for optimal adhesion to the test surface, are applied to the tomato sample. Its equivalent electrical circuit also features a constant phase element (ZCPE2) that models the capacitive component due to the high conductivity gel. Setup C is a destructive measurement configuration where two stainless steel needle electrodes (15mm length, spaced 20mm) are inserted inside the tomato sample. Its equivalent electrical circuit is the same as setup A.

## Results

Three tomato samples from the same batch have been stored in a thermal incubator (WTC Binder) at 27°C and impedance measurements have been carried out at intervals of 1 day for a total of 7 days using the three different measurement setups presented in Section 2.

In the case of setup A no correlation was found between the electrical parameters and the ripening stage of the tomato. In the case of setup B, the measured impedance sprectrum is reported in Fig. 2 (a) and the values of the equivalent circuit parameters are presented in Table 1.

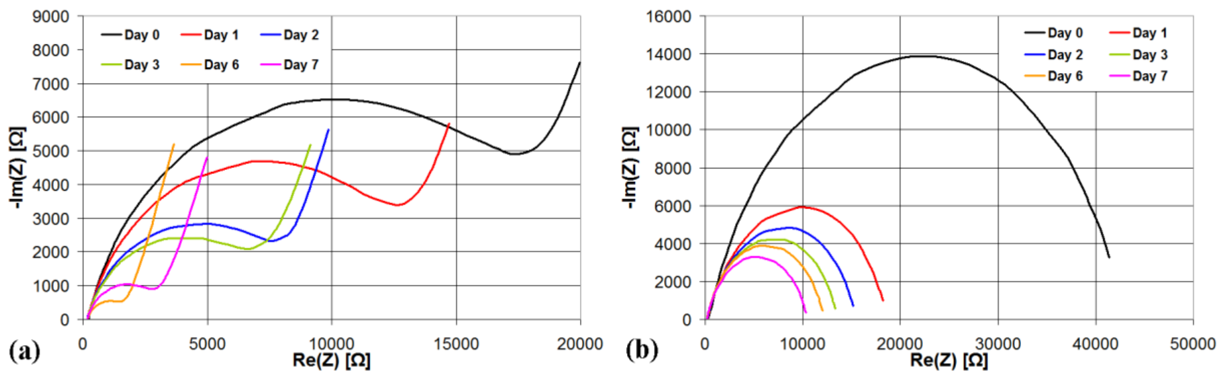


**Figure 2.** Nyquist plots of the measured impedance spectra obtained with setup B (a) and setup C (b)

In this case, the resistance R2 decreases with the ripening time while the capacitance Q1 increases with the ripening time between the start of the measurements and day 6. During this period, R2 presents an average decrease of 2.68 kΩ/day and Q1 presents an average increase of 69.02 nF/day.

In the case of setup C, the measured impedance sprectrum is reported in Fig. 2 (b) and the values of the equivalent circuit parameters are presented in Table 2.

**Table 1.** Equivalent circuit parameters in the case of impedance measurements with Setup B

| *Time (days)* | *$R_1$ (Ω)* | *$R_2$ (Ω)* | *$Q_1$ (nF)* | *$\alpha_1$* | *$Q_2$ (μF)* | *$\alpha_2$* |
|---|---|---|---|---|---|---|
| **0** | 151.71 | 18929 | 83.91 | 0.76 | 3.05 | **0.79** |
| **1** | 146.42 | 13520 | 98.51 | 0.76 | 4.15 | **0.77** |
| **2** | 143.13 | 8592 | 157.41 | 0.73 | 3.70 | **0.79** |
| **3** | 134.58 | 7527.4 | 179.54 | 0.72 | 4.99 | **0.74** |
| **6** | 167.23 | 1789.9 | 488.26 | 0.67 | 3.94 | **0.77** |
| **7** | **149.4** | **3154.9** | **247.18** | **0.70** | **5.00** | **0.74** |

In this case, only the resistance R2 features a correlation with the ripening time. However, R2 presents a strong decreases in the first day of measurements and then only marginal variations. In particular, the average decrease of R2 is 24.6 kΩ/day in the first day of measurements and 1.16 kΩ/day hereafter.

**Table 2**. Equivalent circuit parameters in the case of impedance measurements with Setup C

| *Time (days)* | *$R_1$ (Ω)* | *$R_2$ (Ω)* | *$Q_1$ (nF)* | *$\alpha_1$* |
|---|---|---|---|---|
| **0** | 35.53 | 43560 | 65.87 | **0.72** |
| **1** | 7.18 | 18947 | 110.64 | **0.70** |
| **2** | 21.34 | 15698 | 115.62 | **0.70** |
| **3** | 19.75 | 13758 | 115.59 | **0.70** |
| **6** | 27.60 | 12350 | 108.55 | **0.71** |
| **7** | **14.37** | **10597** | **122.74** | **0.70** |

## Conclusions

The test results have shown how destructive measurements produce significant alterations to the dynamics of the ripening process and the measured impedance values. In the case of non-destructive measurements, instead, reliable data can be obtained by using a high conductivity gel between the electrodes and the sample under test. In the end, the proposed technique is very promising for quick evaluation of tomato ripening stage in smart greenhouses.

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# ETV as a supporting tool for the achievement of specific goals of the Italian national strategy for the circular economy on the issue of industrial symbiosis

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## Abstract
In the framework of the LIFEproETV project (https://lifeproetv.eu/), ENEA has developed a Roadmap for Italy, highlighting the importance of a third-party verification tool, such as ETV (Environmental Technology Verification), as a tool to support national circular economy policies, and thus to achieve some of the ambitious objectives of the Italian National Strategy on the Circular Economy, with particular focus on the ones intended to foster industrial symbiosis implementation. ETV, in fact, can help to generate more favourable conditions for a market for by-products, helping to build greater recognition and provide concrete evidence of the environmental and economic benefits arising from their use. ETV provides information on the functional and environmental performance of by-products for their circular application in industrial processes. The ETV Declaration also ensures that verified by-products meet the technical parameters for use as raw materials, helping to eliminate their waste status and promoting their use in industrial symbiosis pathways.

Keywords*: Third-party verification; green performance; environmental technologies; innovation; circular economy.*

## Introduction
ETV (Environmental Technology Verification) is a voluntary verification scheme. It has been established to deliver objective and market-relevant information about the performance of new environmental technologies. With the role to support market uptake of green technical solutions, it has been announced by the European Commission in the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan (SCP/SIP) and implemented based on a Commission Staff Working Paper “The Environmental Technology Verification (ETV) initiative helping Eco-Innovations to reach the Market” accompanying the Ecoinnovation Action Plan in 2011 [1].

ETV provides a consistent, third-party operated process for delivering an impartial and credible evidence on the technical/functional performance of market-ready or new on the market environmental solutions i.e. products, processes or services with business-to-business (B2B) applications. The process is based on verification whether the technical design of a technology delivers the performance and environmental benefits claimed by a technology provider based on the evaluation of quality assured test data. It allows to demonstrate how effective a new solution is in addressing an environmental problem and whether it will result in a reduced environmental impact compared to current technologies with the same purpose available on the market [2,3,4].

The technology areas originally identified by the European Union within which ETV has been applied are 7 (Figure 1). Indeed, ETV has the potential to be applied to almost all innovative and green technologies in almost all technological areas.

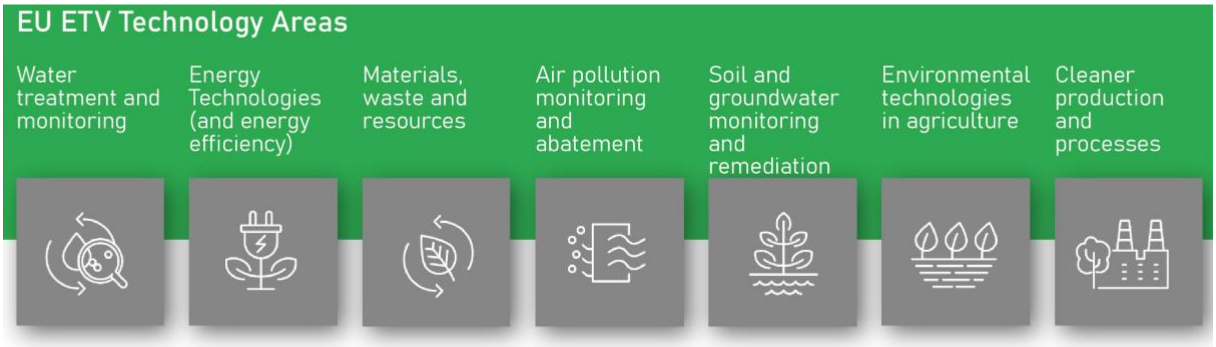


**Figure 4.** EU ETV Technology Areas

The ETV process involves three internationally recognised and European harmonised standards:

• ISO 14034: Environmental Management: Environmental Technology Verification (adopted as European Norm in 2019)

• ISO 17020 Conformity assessment -Requirements for the operation of various types of bodies performing inspection

• ISO 17025 General requirements for the competence of testing and calibration laboratories.

## The Italian Roadmap

In order to develo knowledge and understanding of ETV among different stakeholders, including policy and decision makers, so as to maximise the potential of the system to link the political objectives of EU and national green policies with their implementation in the technology sector [5], ENEA produced an 'ETV Market Acceptance and Recognition Roadmap' for Italy [6]. The document defines strategies and actions to exploit the potential of ETV as a tool to support policies aimed at achieving the specific objectives defined by the Italian National Strategy on the Circular Economy (SNEC) [7].

## ETV to support the specific objectives defined by the Italian National Strategy on the Circular Economy (SNEC)

The Italian National Strategy on the Circular Economy (SNEC) provides an important contribution to the acceleration towards circular models by establishing a roadmap with precise actions to be implemented in defined periods. On the basis of this guide, ENEA defined use cases of ETV as a tool to facilitate and support the transition, within the framework of the programmatic and strategic objectives of the Italian Strategy that guides the development of paths towards the circular economy.

In particular, the ETV use cases in relation to 4 specific objectives outlined in the SNEC (Table 1) are:

- Support companies, especially SMEs that are representative of the Italian industrial system, with tools and services in order to steer them towards efficient and sustainable resource management;
- Strengthen the market for secondary raw materials and facilitate, also from a regulatory point of view, the procedures for the End of Waste (EoW);
- Create all the necessary conditions to strengthen the by-products market by also providing tools that facilitate the exchange between companies with a view to industrial symbiosis;
- Creating the conditions for life extension of products through eco-design.

**Table 1.** Objectives considered in the roadmap, selected from the specific objectives defined by the Italian National Strategy on the Circular Economy (SNEC)

| | |
|---|---|
| G1 | Provide tools and services to support companies, especially SMEs, in the implementation of technologies, methodologies and approaches aimed at the efficient and sustainable management of products. |
| G2 | Create the conditions for a market of secondary raw materials that are competitive in terms of availability, performance and costs, acting on the standardization of materials, and on the criteria for removing the qualification of waste from materials ("End of Waste"). |
| G3 | Create the conditions for a market of "by-products" in terms of greater certainty in recognition, availability, acting on standardization for certain supply chains (e.g., residues and by-products of agricultural origin) and on the revitalization of the by-product exchange platform, to concretely support operators in the full implementation of the industrial symbiosis also in the field of bioeconomy. |
| G4 | Set the conditions for the extension of the life of the product through its design inspired by the principles of modularity and repairability. |

### Problems and barriers

The main barriers and challenges in relation to these objectives and with specific reference to industrial symbiosis (IS) can be summarised in four main categories:

- CULTURAL barriers, mainly related to the lack of awareness and capacity of companies and market to embark on innovation paths in the circular economy and IS in particular;
- NORMATIVE barriers, linked to a lack of a complete, organic and standardised framework of rules, tools and policies supporting circularity. This, in reference to IS, is due to the lack of mandatory product certifications, lack of clarity in the definition of waste and by-product and therefore the lack of reference standards.
- TECHNOLOGICAL barriers, related to the lack of dissemination and adoption of innovative environmental technologies. Many potential users are often sceptical about their purchase. Many prefer to adopt a new technology only after its success has been widely proven. This greatly hampers the upscaling process and many technologies remain at pilot scale or do not find a favourable environment for their diffusion in the market.
- ECONOMIC and market barriers, related to the lack of economic feasibility or the need for large investments to boost innovation even in the field of using secondary raw materials or preparing MPS to make them usable in other production processes. There must therefore be clear evidence of the value of innovations on the basis of measured and quantified performance of products and processes based on a life-cycle impact assessment approach.

**Solutions and opportunities**

The valorisation and dissemination of ETV as a tool to support industrial symbiosis will be one of the objectives of the promotional campaign for Italy, aimed at highlighting, on the basis of real use cases, the effective contribution that this tool can make in facilitating transition processes towards circular economy models.

ETV can indeed provide solutions and opportunities for the resolution of the main problems/barriers mentioned above.

In relation to the cultural barriers, ETV can help verify the performance of innovative technologies related to resource utilisation and support companies to undertake IS paths based on an audit that highlights the benefits of adopting innovative solutions. In addition, ETV can provide certified proof of the benefits of technologies in relation to reducing health and environmental impacts and help companies obtain the necessary permits to transform their waste into by-products or SRM.

From a regulatory point of view, ETV can become a circular economy standard by providing valid proof of compliance and can provide a standard to verify the performance of: new technologies that allow the conversion of waste into resources;

secondary raw materials for industrial applications; products based on secondary raw materials.

In order to overcome the technological barriers, ETV helps to determine and demonstrate the innovative scope of the technology as well as the technological feasibility in addressing an environmental problem and the flexibility in choosing the parameters to be verified allows to select the most suitable technology to solve a specific environmental challenge.

Finally, ETV can contribute to the diffusion and market acceptance of innovative environmental technologies as it can guide the establishment of appropriate sıgnıfıcant and ımpactıve incentives for producers/suppliers/buyers/users of ETV verified technologies.

## Conclusions

ETV helps overcome technology and materials performance barriers hindering development of industrial symbiosis paths and circular business models. ETV can:

- Be a proof of effectiveness in reducing the use of virgin raw materials and energy, enhancing the application and dissemination of verified and reliable technologies that have effectively proven to increase business efficiency and limit impacts on the environment;
- Define the use of critical raw materials (CRMs) and secondary raw materials (SRMs), to demonstrate that the new materials or process do not cause additional pollution to the environment (especially with hazardous substances) compared to the conventional process;
- Help overcome performance barriers related to technologies and materials that hinder the development of industrial symbiosis pathways and circular business models;
- Provide information on the functional and environmental performance of by-products for circular applications in industry;
- Be crucial in enhancing and promoting green innovation in public procurement (Green Public Procurement - GPP and Innovation Procurement - IP), functioning as a conformity assessment tool that is also recognized as an equivalent means of proof;
- The ETV Verification Statement can serve as a source of information to support compliance with environmental performance schemes for products such as the Environmental Product Declaration (EPD), Eco-label, Product Environmental Footprint (PEF) and eco-design.

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# Planning industrial districts development through the is-based waste-wastewater-energy nexus

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## Abstract

This work represents a step forward in the proposal of a new approach aimed at maximizing material and energy recovery processes through Industrial Symbiosis (IS) within the "waste-wastewater–energy nexus". The IS synapses, partially reported in previous SUN (Italian Industrial Symbiosis Network) proceedings, enhance the closing of the loops in recovery of waste and wastewater while providing low cost energy (electricity and heat) which can significantly support novel industrial opportunities for the development of existing and new companies in a modern industrial district. The proposed integration is particularly suitable to bridge the gap in Southern European regions which continue to have disjointed and unsustainable management of waste, wastewater and sludge, unacceptable levels of material recovery, waste of potentially exploitable energy and significant environmental burdens. The proposed symbiotic model should be intended as an evolved material and energy community, able to self-producing new products, electricity, heat, and biomethane to be used both in the same industrial districts and in surrounding cities, efficiently favouring the increase of a sustainable circularity and a rapprochement toward the New Green Deal required by the European Union, which are clearly lagging behind in these regions. Specifically this work focus on quantitatively evaluating the potential for residual heat exploitation for agricultural products processing with a view of a more holistic and symbiotic planning of new industrial activities allocation.

keywords*: Industrial Symbiosis; Waste; Wastewater; Anaerobic digestion, Energy, heat.*

## Introduction

Most of Mediterranean regions have disjointed approaches to the management of waste, wastewater and residual biomass. In many of these regions these "sole" approaches are also not fully sustainable as they entirely focus on material recovery (both from waste and from wastewater) while neglecting the energy issues so leading to unjustifiable energy waste and related direct/indirect impacts on the environment. Significant delay in the planning and construction of plants for the valorisation of recyclable material and -above all - for a sustainable and concurrent energy and material recovery from the residual waste (i.e. Waste to Energy (WtE) plants) and organic waste (i.e. Anaerobic Digestion (AD) plants) [1] is still detected in many of these regions [2] also due to the opposition of citizens which, in turns, affects political choices and planning. The immediate consequence of this scenario is still an abnormal resort to landfill not taking into account the approaching 10% landfill limit in 2035 as expected by the European Directives. Furthermore, despite the historical water scarcity in many of these areas [3], no effective actions for wastewater reuse are implemented [4,5] mostly because of the still too high costs of the reclaimed wastewater which make this marginal resourse not competitive with the albeit limited natural water [6]. The disposal of sludge from wastewater treatment is likewise still problematic, both in land-based applications, composting and landfill routes.

An IS application, based on waste-water-energy nexus, was recently proposed to address the overmentioned issues and well-assessed through material end energy flow analysis [7]. The proposed symbiotic application is intended as a modern IS-based circular industrial district, able to self-provide electricity, heat, and biomethane to itself and the surrounding cities. The proposed scenario was also compared in term of environmental impact with other management scenarios [8,9].

In this works a further advance in the implementation of the proposed Industrial symbiosis application [10] is reported focusing on the symbiotic exploitation of thermal energy for different industrial processes whose main characteristics were identified in order to support stakeholders in planning the development of an efficient IS-based ecosphere as the one described in Figure 1.

to support companies in the realization of IS matches during the MARLIC project. An Operative Meeting (OM) was organized during the project and held in Camerino.

## Methods

*The IS-based waste/water energy nexus "ecosystem"*

The proposed IS scenario includes three different treatment and recovery sections: 1) a wastewater treatment plant; 2) an anaerobic digestion section for the separate treatment of organic fraction from separate collection of municipal solid waste (OFMSW) and the WWT sludge (this last assumed to be already occuring in the WWTP AD reactor); 3) an incinerator with production of electricity and heat able to thermally valorize the residual waste (unsorted + scraps from selection). There are many other symbiotic exchanges between the three plants, that have been deeply explored - through mass and energy balances also in terms of overall sustainability [9].

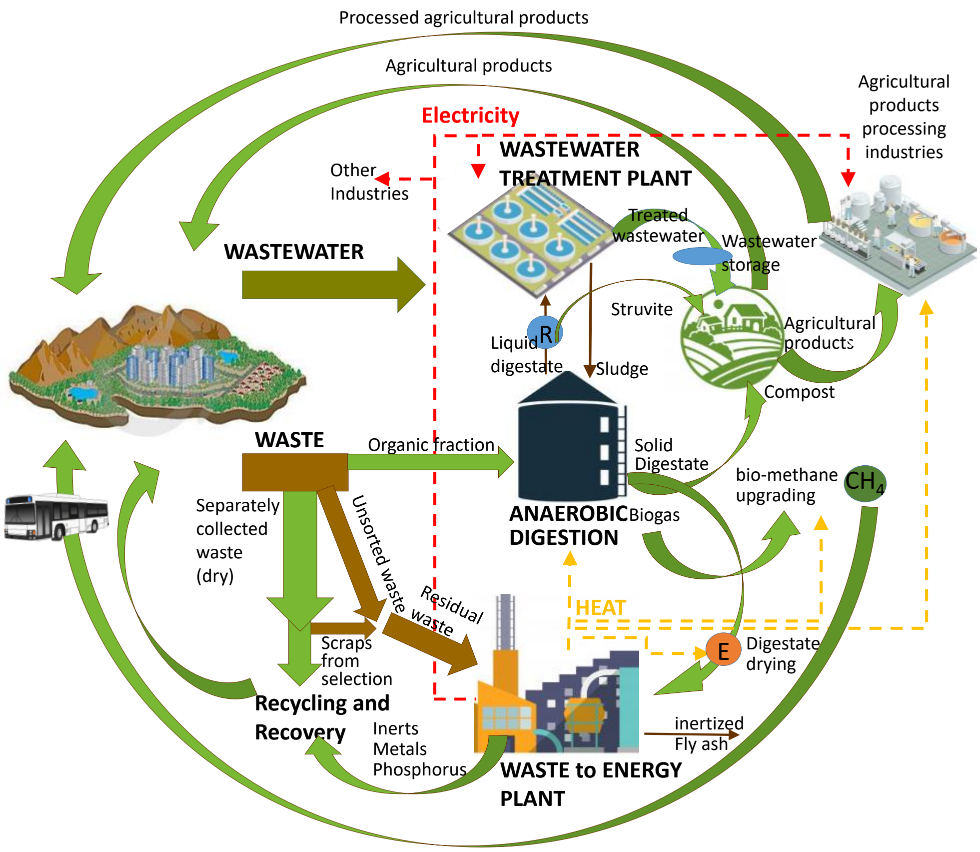


**Figure 1.** Industrial symbiosis ecosphere

New industrial opportunities for existing and new companies in an industrial district can supported by the additional electric and -above all – thermal energy made available, at reduced cost, from the energy recovery exploitation of the residual waste - otherwise destined to be disposed of in landfill producing more relevant impacts.

The assessment here presented refers to a metropolitan area involving 2 million inhabitants with a waste production per capita of about 511 $kgd^{-1}$ $inh^{-1}$. The metropolitan area embraces a main large city and smaller surrounding towns with an overall mean separate collection efficiency that is assumed to be 70% in compliance with the 2030 EU target. The WWTP is assumed to treat only the wastewater produced by the citizens of the main city ( 545,000 inhabitants).

Energy production in WtE plant and energy demands of the processes involved in the symbiotic exchanges are calculated according to [7]. Furthermore, an evaluation of exceeding thermal energy production (and related temperatures) is provided and compared with potential demands by different industrial sector in order to identify the most suitable industrial sectors, where residual thermal heat could be fruitfully used.

## Results

Electric and thermal energy production in WtE plant and energy demands of the processes involved in the symbiotic exchanges are represented in Figure 2.

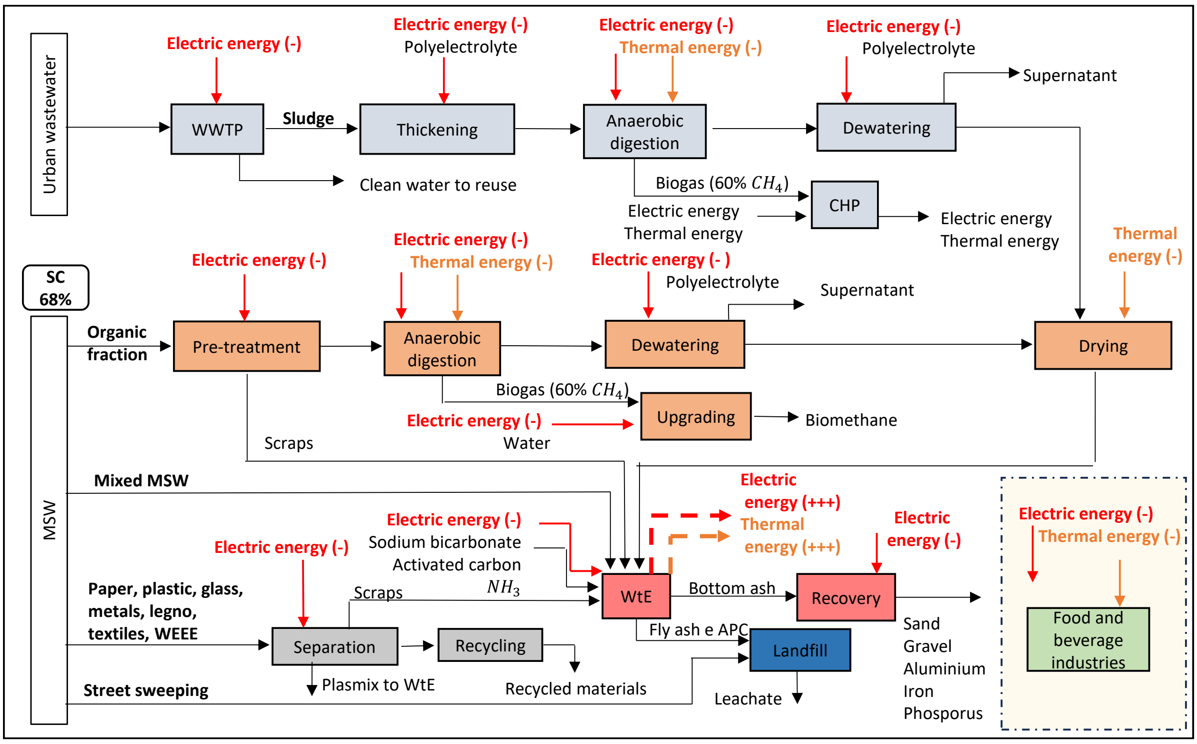


**Figure 2.** Energy-material flow analysis of the IS scenario

### Analysis of the heat requirement for other IS processes

Figure 3 quantitatively reports the results of the analysis in term of energy productions (heat and electricity) from the thermal treatment of the residual waste along with their utilization, within the same IS-based "ecosystem", and their potential in supporting further industrial processes.

As it can be observed the thermal treatment of 452383 tons of residual waste produces more than 453 GWhy$^{-1}$ of electricity (230 kWh y$^{-1}$ per capita) and 726 GWhy$^{-1}$ of thermal energy (360 kWh y$^{-1}$ per capita) - as hot vapor - respectively. The electricity produced is used (just few percentage units) to support the tertiary and quaternary treatment - essential to satisfy the reuse standards requirement - and to pump the treated wastewater to agricultural fields (generally located at a higher altitude). Specifically the energy demand for the enhanced treatment and pumping reclaimed wastewater to the agricultural areas is evaluated in 20 GWh per year. As a consequence of the additional energy supply, provided at competitive prices, the cost of treated wastewater could be reduced with respect to groundwater and superficial waters promoting its full reuse (a storage phase should be specifically designed) so to achieve the ZERO -discharge conditions into water bodies. This last result, favored by the energy recovered from residual waste, is of particular interest in islands and coastal areas for preserving touristic activities. In order to furtherly reduce the cost of the treated wastewater also the energy for the oxidation phase in the WWTP - evaluated in 9,9 GWh per year (5 kWh $y^{-1}$ pro capita) could be provided by the residual waste thermal treatment plant so achieving a net zero energy WWTPs.

Part of the heat generated by the WtE process - appropriately commensurate, through a well-dimensioned management of steam tapping is also used to shift AD to thermophilic regime thus reducing digestion times and volumes and/or increasing the biogas production yield with respect to traditional mesophilic processes. The heat required is calculated in 19,4 GWh per year (10 kWh $y^{-1}$ pro capita) and 14,2 GWh per year (7 kWh $y^{-1}$ pro capita) for the AD of OF-MSW and WWTP sludge respectively. In the proposed scenario WWTP sludge is dehydrated - after mechanical dewatering by centrifugation - using the excess heat (29 GWh per year) produced by the WtE process. This option, aimed not only to provide a robust solution to the severe issues of sludge management but also to recovery the phosporous content from the deriving ash. Analogously the digestate from OFMSW is is dehydrated using 112 GWh per year. The availability of extra thermal energy suggests the potential to collects and treat also the sludge produced by the other smaller nearby towns.

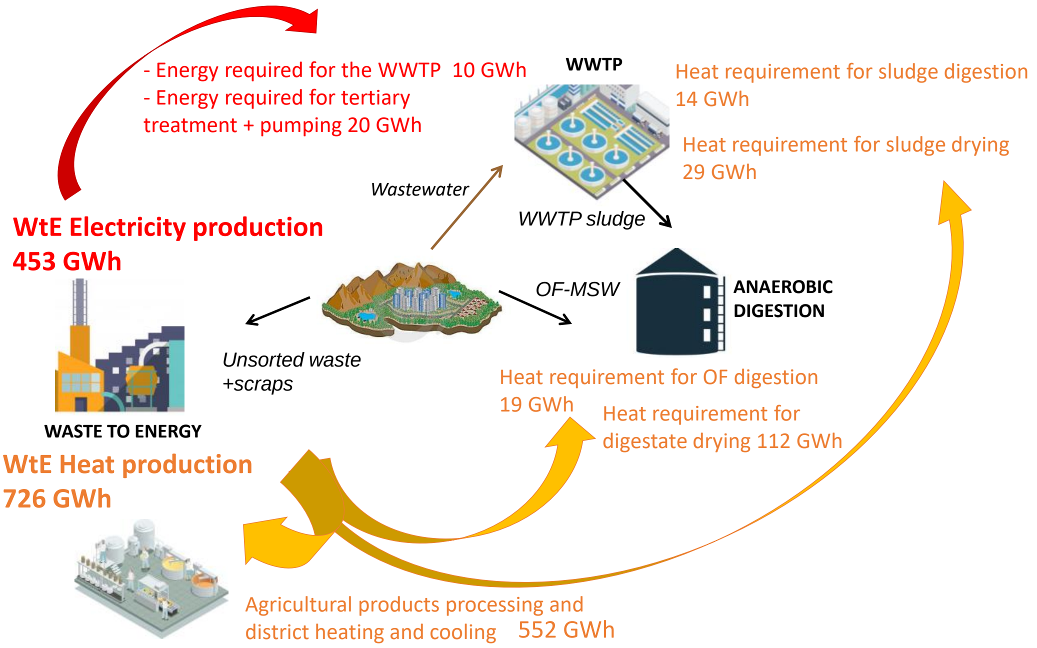


**Figure 3** – Energy (electricity and heat) produced and required by the various processes considered in the waste wastewater energy nexus industrial symbiosis

**Potential of industrial symbiosis heating applications**

Industrial heat constitutes two-thirds of industrial energy demand and almost a fifth of global energy consumption. It is also associated to the majority of direct industrial $CO_2$ emitted each year, as the vast amount of industrial heat comes from the burning of fossil fuels. According to an industrial heating analysis in European countries by the International Energy Agency (IEA), 30% of industrial heating applications need heat below 100 C, another 27% would operate between 100 and 400 ◦C, and the remaining 43% of the mentioned applications require heat above 400 ◦C [11]. Low-temperature (< 100 °C) process heating (228 TWh), characterised by the use of hot water, is mostly used in chemicals (34%, 78 TWh); food, beverages and tobacco (27%, 61 TWh); paper, pulp and printing (13%, 29 TWh) and other industries (11%, 26 TWh) [12].

After the proposed uses are satisfied still most of the heat produced from thermal treatment of the residual waste is available for further applications (552 GWh). This relevant amount of heat can support other companies (existing or wishing to enter the industrial district) by exploiting the hot vapor - provided at advantageous conditions - for their processes (e.g. agri-food process industry), in addition to any heating and cooling (i.e. trigeneration) needs, in a full perspective of industrial symbiosis and with a consequent reduction in $CO_2$ emissions from current fossil-fuel energy production.

By considering the thermal energy required per tons of produced product in food and beverage sector [13] an evaluation of the amount of products produced with the residual thermal energy was developed and reported in Table 1. Related temperatures range for the different processes are presented in Figure 4.

**Table 1** – Amount of product produced with the residual thermal energy (552 GWh) in food and beverage sector

| | Production Sector | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Backeries | Beverages | Dairy | Fruits / vegetable | Meat | Beer | Sugar | Slaughtering | Meat Processing |
| **Production ($10^3$ t/y)** | 414 | 1743 | 524 | 1204 | 1083 | 1481 | 728 | 3565 | 903 |

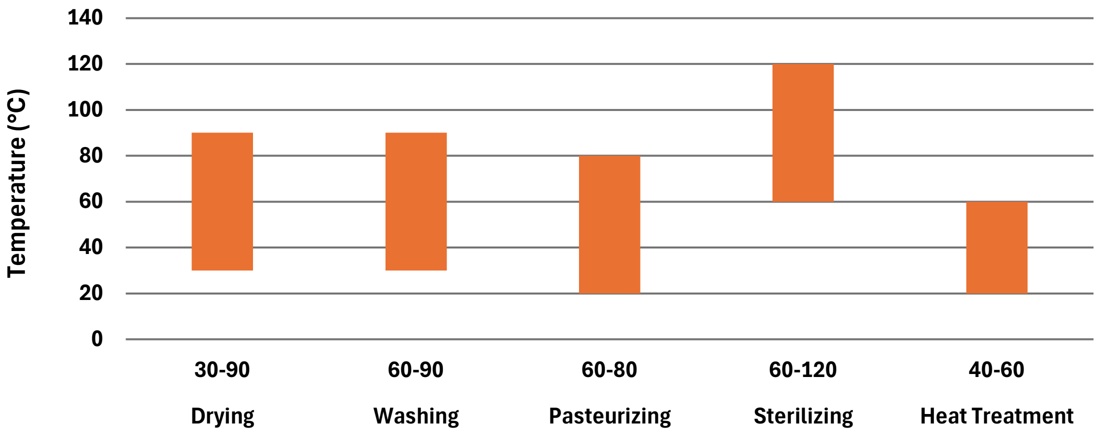


**Figure 4** – Temperatures range for different processes in the food and beverage transformation industry

## Conclusions

It is well assessed that to achieve the goal of reducing the landfill need to less than 5-10% - as required by 2035 from the EU, both material and energy recovery must be implemented. However in most of the countries where landfill has already achieved a really residual role this implementation has been carried out in a separate, additive way, mostly limiting thermal energy recovery to urban heating. Recovery of sludge has not been frequently placed in relation to the energy recovery from waste and even rarely with wastewater reuse, at least within an holist approach. This work has provided a wider perspective to be implemented also in those area where winter temperatures are less severe – so requiring limited urban heating - but water shortage is - or is rapidly becoming - a critical issue. The proposed Symbiotic approach allows a much higher circularity to the community, making possible the fruitful recovery of the energy from the residual waste treatment to supply the sustainable recovery of sludge and wastewater and the processing of agricultural products grown through the recovered wastewater and nutrients (i.e. phosporous) from the sludge. A further not negligible advantage is the sensible reduction of pollution thanks to a minimized landfill role and the zero wastewater discharge to water bodies.

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# Water, waste and energy: prospects and opportunities

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## Abstract

Gruppo CAP is the green utility that manages the integrated water service of the Metropolitan City of Milan. Water, waste and energy are the assets on which Gruppo CAP has decided to focus for the future. In line with the strategic guidelines of its sustainability plan, the Group has embarked on a transition to a circular economy that aims to recover materials and energy from waste so that waste is minimized.

keywords: Water; green; waste; energy; circular economy.

## Introduction

CAP Group is the green utility that manages the integrated water service of the Metropolitan City of Milan, province of Varese and other cities in the provinces of Monza-Brianza and Como. The company serves an area of about 2.5 million citizens, ranks among the leading Italian operators of integrated water service and is the first single utility by assets in the national panorama.

Managing water service means dealing with the complexity of an articulated system, made up of thousands of kilometres of aqueduct and sewage network, high-tech plants such as purification plants and drinking water systems. It means, above all, guaranteeing quality, safe and constantly controlled water to everyone.

Water, waste and energy are the assets on which CAP Group has decided to focus for the future. In line with the strategic guidelines of its sustainability plan, the Group has embarked on a path of transition towards a circular economy, which aims to recover materials and energy from waste to minimise waste. According to this logic, CAP has transformed what until a few years ago was a linear process into a virtuous cycle. On one hand, by optimising all activities from an organisational and energy point of view, and on the other hand, by reusing what is already being produced - purified water and sewage sludge - thanks to the use of innovative, cutting-edge technologies (engineering and innovation and digital transformation) that make it possible to extract all possible value from what has always been considered waste.

**CAP Group business plan - Sharing economy and asset network**

Sustainability is a key tool for sustaining a company's competitiveness and reputation and consequentially its profitability. With a view to lasting success for the company, it is therefore increasingly necessary to integrate sustainability into the core business: using it as a driver becomes a prerequisite when determining business strategies.

Our goal is to guarantee all citizens safe, of high quality and controlled water by managing the complete cycle of waterworks, purification and sewage. To achieve this, we have chosen to develop the Industrial Plan in line with the sustainability strategy, thus integrating our ambition and sense of responsibility into the business objectives.

We have chosen to integrate sustainability into our industrial activity by leveraging the theory of shared value, based on the assumption that the economic value generated should benefit not only the company but also the territories in which we operate and our stakeholders.

We have started implementing a decarbonisation plan with a 2030 horizon that envisages the partial electrification of the company fleet, self-production of electricity through photovoltaic systems, the use of less impactful chemicals, the use of the Sesto San Giovanni bio-platform for the internal disposal of a portion of sludge, and the production of biomethane [1].

## Methods

**Recovery and reuse of resources**

***From sewage treatment plants to resource recovery* plants**

Wastewater treatment plants can be upgraded and integrated with technologies of a different nature to become multi-purpose urban biorefineries serving the population by treating a variety of flows: municipal waste such as wastewater and organic waste [2] .

The combination of eco-innovative technologies with anaerobic co-digestion allows a high possibility of integrated recovery of water, biomethane, phosphorous, sands, biopolymers, leading to an urban strategy consistent with the needs of the territory. Sewage sludge is one of the most promising fronts in terms of circular economy and value recovery. The waste par excellence is actually a potential source of numerous nutrients, and the purification process itself has great potential for the production of energy, biogas and biofuels. With this in mind, sewage treatment plants, which have always been considered problematic elements of the territory by citizens, are gradually being transformed into true cathedrals of nature, with immense energy potential. To date there are 21 CAP purifiers authorised for indirect reuse and 4 for direct use (Assago, Bresso, Peschiera and Basiglio).

## Results

***From purifier to biorefinery***

Our strategy aims to transform some large purification plants into biorefineries for the treatment of organic waste and sewage sludge.

At the Bresso sewage treatment plant we produce quality biomethane suitable for use as automotive fuel and for feeding into the SNAM network from sewage sludge.

This is the first plant in Italy to feed biomethane from sewage sludge into the SNAM network.

Biomethane production from April 2019 to the end of 2022 amounted to more than 2 million cubic metres, with a daily output of around 1,200 m3 of biomethane. With this production, it would be possible to fuel 558 cars (15,000 km/year) [3].

**Liquid waste recovery**

At Robecco sul Naviglio purification plant there is an innovative drying plant with a low environmental impact and reduced energy consumption, which treats mainly dehydrated sludge, valorising mainly agricultural waste through anaerobic digestion. In this context, CAP Group has started a collaboration with Milano Ristorazione for the recovery of food waste, which envisages the treatment of 100 tonnes per year of liquid waste made up of the 'Centro di Cottura' waste. The plant also recovers sands coming from buildings sitesto re-use them in maintenance activities of the company.

**BioPiattaforma, sludge incineration and nutrient recovery**

The BioPiattaforma in Sesto San Giovanni is the industrial symbiosis project that will transform the existing facilities consisting of a waste-to-energy plant and purifier into a Bio-Platform dedicated to a carbon neutral circular economy with zero $C0_2$ emissions of fossil origin.  The project guarantees the creation of a virtuous waste treatment system whose impact on the territory is minimal, thanks to the technologies employed and the solutions identified.

The BioPiattaforma has two production lines: the first for the thermal treatment of sludge from water purification to produce thermal energy and fertilisers; the second for anaerobic digestion for the treatment of wet waste (FORSU) to produce biomethane.

**Neutalia**

Neutalia is a benefit company created to promote the green transition of his local area. It generates energy f from waste that cannot be recovered in any other way and creates value through circular economy projects.

It is a benefit company that has one goal above all: to help the region in its green transition.
Neutalia's integrated waste management is a perfect example of a circular economy: from material that can no longer be recycled, energy is generated. From municipal and hospital solid waste that can no longer be recovered, thanks to the recovery and valorisation process, electricity is obtained and reused, thus avoiding the consumption of energy from non-renewable sources. Thanks to this process, waste is reduced, the environment is protected and carbon dioxide emissions are reduced, overcoming the energy model linked to the linear economy.

Its central location, between the upper Milan area and the Lower Varese area, ensures the minimisation of the environmental impact associated with transporting waste from where it is produced and collected in the area [4].

The pre-treatment plants, in addition to reducing the amount of material that will be burnt in the waste-to-energy plant, will treat bulky materials, rigid plastics and RUR, residual municipal waste, the latter being treated mechanically. Integrated 'downstream' plants will allow the recovery of thermal energy used for district heating and the recovery of PSR and slag, and $CO_2$ capture.

The waste-to-energy plant treats municipal and assimilated solid waste, special hospital waste and bulky waste. Waste that cannot be recycled arrives at the plant, is sent to the feed pit of the waste-to-energy plant and is subsequently upgraded through a complex combustion and recovery process. From this process, steam is recovered, which, thanks to two turboalternators, is converted into electrical energy. In addition, the fumes produced by combustion, thanks to the use of state-of-the-art technology, undergo specific treatments that allow them to be filtered before being released into the atmosphere.

The process of transforming waste into a resource is continuously monitored by the plant's technicians and by Arpa technicians who, thanks to a series of detectors installed throughout the plant, keep emission data under control, thus protecting the territory, the environment and the community.

The production of energy is part of a strategy based on sustainability and circularity that envisages the reduction of fossil fuels, used to power vehicles and boilers. In particular, heat is recovered from the waste-to-energy process, which can be used for district heating, and electricity is generated from the steam, thanks to two turboalternators. The electricity thus produced makes it possible to cover internal consumption; in fact, part of the heat recovered from the combustion processes is used to provide heat for the office building, for the heating system and for hot water production. A portion of the electrical energy produced, on the other hand, will be fed into the heat exchange plant and made available to the national grid, as stipulated in the development business plan [5].

## Conclusions

In conclusion, the assets on which CAP Group has decided to focus for the future are water, waste and energy. As shown, the combination of eco-innovative technologies with anaerobic co-digestion allows a high possibility of integrated recovery of water, biomethane, phosphorous, sands, biopolymers, leading to an urban strategy consistent with the needs of the territory.

Neutalia, created with the aim to improve the quality of the environment and to promote the green transition of the region, generates energy from waste that cannot be recovered in any other way, and creates value through circular economy projects. Neutalia's integrated waste management is a perfect example of a circular economy.

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