PROCEEDINGS

Symbiosis Users Network – SUN
Proceedings of the third SUN Conference

Best practices on industrial symbiosis in Italy and the contribution of regional policies

Rimini
November 7th 2019

Edited by Tiziana Beltrani and Marco La Monica

Symbiosis Users Network

ENEA
Italian National Agency for New Technologies, Energy and Sustainable Economic Development

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2020 ENEA

National Agency for New Technologies, Energy and
Sustainable Economic Development

ISBN: 978-88-8286-394-4

Editorial review: Giuliano Ghisu

Cover design: Cristina Lanari

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INTRODUZIONE

Uno dei primi passi della nuova Commissione Europea guidata da Ursula von der Leyen è stato quello di adottare, nel dicembre 2019, il Green Deal, cioè una tabella di marcia per rendere l'UE un leader mondiale nell'economia circolare e nelle tecnologie pulite. In tale direzione ad inizio marzo 2020 è stato presentato l'aggiornamento del piano d'azione per l'economia circolare del 2015. Subito dopo la sua presentazione è iniziata l'emergenza sanitaria legata al coronavirus, che oltre ai malati e morti, si sta rapidamente tramutando in una grave crisi economica con l'impoverimento di milioni di persone e un forte aumento del disagio sociale.

Per far fronte a questa grave situazione di emergenza la Commissione sta predisponendo, nel 2020, un ulteriore strumento innovativo, il Recovery Fund, per favorire rilancio delle economie nazionali attraverso politiche industriali che vadano in direzione di una transizione ecologica. Nel prossimo futuro si può concretizzare, quindi, l'opportunità di avere dei fondi per realizzare una ripresa resiliente per il continente europeo. A tal fine l'economia circolare dovrà e potrà giocare un ruolo cruciale anche attraverso la simbiosi industriale, uno dei suoi principali strumenti.

La simbiosi industriale, infatti, genera una virtuosa interazione tra aziende e territorio che consente contemporaneamente di favorire la competitività, l'innovazione e l'occupazione e di salvaguardare gli ecosistemi e la biodiversità. Ciò permette alle comunità locali di convivere in armonia con i sistemi industriali, senza rinunciare alla qualità della vita delle persone.

Per questo motivo la simbiosi industriale è sempre più riconosciuta a livello internazionale come uno nuovo strumento di policy a livello industriale. In tale direzione, già nel 2015 all'interno del piano d'azione dell'Unione Europea per l'economia circolare "L'anello mancante" (COM(2015) 614 final), la Commissione aveva riconosciuto l'importanza di promuovere processi industriali innovativi come la simbiosi industriale. Al fine di agevolare la simbiosi industriale in Europa, la Commissione si proponeva di revisionare la legislazione sui rifiuti ed in particolare "di chiarire le norme relative ai sottoprodotti e di creare pari condizioni concorrenziali nell'Unione".

Tale indirizzo di policy è stato ribadito anche a marzo 2020 con il nuovo piano d'azione per l'economia circolare "Per un'Europa più pulita e più competitiva" (COM(2020) 98 final) (PAEC2020). Nel documento, infatti, la Commissione afferma di voler favorire l'incremento della circolarità dei processi produttivi agevolando la simbiosi industriale, attraverso un sistema di comunicazione, di reporting delle imprese e di certificazione. Al contempo, al fine di istituire un mercato interno delle materie prime seconde ben funzionante, la Commissione intende valutare il campo di applicazione entro cui sviluppare a livello comunitario "criteri volti a definire quando un rifiuto cessa di essere tale per determinati flussi di rifiuti sulla base del monitoraggio dell'applicazione da parte degli Stati membri delle norme rivedute sulla cessazione della qualifica di rifiuto e sui sottoprodotti e sostenere le iniziative transfrontaliere di cooperazione volte ad armonizzare i criteri nazionali che definiscono la cessazione della qualifica di rifiuto e i sottoprodotti".

È interessante rilevare che per dare impulso nei prossimi anni alle riforme politiche necessarie per favorire una transizione verso un'economia circolare a livello europeo, "la Commissione intensificherà la cooperazione con gli Stati membri, le regioni e le città per utilizzare al meglio i fondi dell'UE". A conferma di questo la Commissione sfrutterà "il potenziale degli strumenti di finanziamento e dei fondi dell'UE per sostenere gli investimenti necessari a livello regionale e assicurare che tutte le regioni traggano beneficio dalla transizione. Oltre a favorire la sensibilizzazione, la cooperazione e lo sviluppo delle capacità, i fondi della politica di coesione aiuteranno le regioni ad attuare strategie di economia circolare e a rafforzare il tessuto industriale e le catene del valore". Nelle conclusioni del PAEC2020 "la Commissione invita pertanto le istituzioni e gli organi dell'UE ad approvare il presente piano d'azione e a contribuire attivamente alla sua attuazione e incoraggia gli Stati membri ad adottare o aggiornare le rispettive strategie, piani e misure nazionali in materia di economia circolare alla luce degli ambiziosi obiettivi ivi delineati".

È importante evidenziare che la transizione verso l'economia circolare adotta percorsi specifici in ogni Stato membro, regione e città in base a fattori geografici, ambientali, economici, normativi e/o sociali.

A tal riguardo le regioni e le città svolgono sicuramente un ruolo chiave nella realizzazione di un modello di governance multilivello che possa avviare e accelerare questa transizione del sistema-Italia. Per questo motivo è opportuno che le Regioni, all'interno di una strategia nazionale sull'economia circolare, elaborino propri documenti strategici e di programmazione che, sentite le parti interessate, contengano ad esempio le priorità locali, le misure pianificate e le forme di sostegno disponibili. Ciò darebbe sicuramente un chiaro indirizzo agli stakeholder, locali, regionali e nazionali nella loro pianificazione delle attività a lungo termine.

Come affermato anche dalla Commissione nel PAEC2020, la transizione verso l'economia circolare sarà sistemica, profonda e trasformativa. Le conseguenze di questa transizione, in alcuni casi, potranno essere destabilizzanti in quanto alcune regioni subiranno un profondo mutamento socioeconomico. Come sottolineato dalla Presidente della Commissione europea, Ursula von der Leyen "la trasformazione che ci si prospetta è senza precedenti e avrà successo solo se è giusta e va a beneficio di tutti". A tal proposito la Commissione specifica che "saranno necessari un allineamento e una cooperazione tra tutti i portatori di interesse a tutti i livelli — unionale, nazionale, regionale e locale, e internazionale".

Per questo motivo il sistema-Italia dovrebbe avvalersi del supporto di un'apposita Agenzia Nazionale per l'Economia Circolare, sull'esempio di quanto fatto in altri Paesi europei. Una tale organizzazione, sfruttando competenze e strutture esistenti, potrebbe, ad esempio, favorire la corretta applicazione della normativa sui sottoprodotti, stimolare l'adozione di strumenti di diagnosi delle risorse e di simbiosi industriale collaborando con le diverse Regioni. Il risultato porterebbe all'implementazione di un efficace sistema integrato di gestione delle risorse in un'ottica di economia circolare che sia sinergico e unitario su tutto il territorio nazionale.

In tale direzione l'ENEA, a seguito delle esperienze maturate negli anni, già dal 2016 si propone di mettere a sistema tutte le competenze in materia di simbiosi industriale in Italia, attraverso il coinvolgimento di stakeholder che a vario titolo e con diversi ruoli hanno avuto ed hanno un ruolo per l'implementazione operativa della simbiosi industriale in Italia. Per questo motivo, ENEA si è fatta promotrice della costituzione della prima rete italiana di simbiosi industriale, SUN - Symbiosis Users Network, che nasce per valorizzare le esperienze maturate da anni in queste tematiche, condividerle e collaborare per favorire un'applicazione sistematica della simbiosi industriale ed approfondire anche eventuali criticità nella sua applicazione. SUN promuove modelli di economia circolare attraverso la simbiosi industriale, approfondendo tematiche di carattere operativo che possono riguardare, ad esempio, normative, standard tecnici, buone pratiche.

Allo stato attuale, aprile 2020, SUN riunisce 39 partner, tra università, istituzioni politiche, enti di ricerca, società private, reti tecnologiche ed enti locali ed è aperta a nuove adesioni.

Data la rilevanza del ruolo delle politiche e della governance regionale per l'implementazione della simbiosi industriale, su iniziativa di SUN, del CTS di Ecomondo e di ENEA, si è tenuta il 7 novembre 2019 a Ecomondo la terza conferenza di SUN dal titolo "Buone pratiche di simbiosi industriale in Italia e il contributo delle policy regionali quale leva strategica".

Il convegno, presieduto dal Ing. Laura Cutaia, Presidente SUN e Responsabile per ENEA del "Laboratorio di valorizzazione delle Risorse" (RISE), e dal Dr. Luigi Rossetti, Direttore Generale "Salute, welfare, sviluppo economico, istruzione, università e diritto allo studio" della Regione Umbria, ha fornito una panoramica degli strumenti di policy e di finanziamento che le regioni italiane stanno implementando per favorire, in particolare, l'adozione della simbiosi industriale quale leva competitiva industriale e territoriale.

Il convegno ha offerto l'occasione a manager, ricercatori, funzionari regionali e studenti universitari di confrontarsi sul ruolo che le Regioni possono svolgere nella transizione verso l'economia circolare favorendo, nei propri territori, l'adozione di modelli sostenibili di produzione e consumo come la simbiosi industriale e di raccogliere, attraverso la call for paper, casi di buone pratiche operative (a livello di cooperazione tra aziende, in aree e distretti industriali, casi di simbiosi urbane e/o territoriali ecc.) su questa tematica.

Il presente documento raccoglie i contributi pervenuti dagli interventi sia oral che poster offerti al convegno, cui hanno preso parte più di 100 persone.

Ing. Laura Cutaia, Presidente SUN, ENEA - Responsabile del "Laboratorio di valorizzazione delle Risorse" (RISE) nel Dipartimento "Sostenibilità dei Sistemi Produttivi e Territoriali"

Dr. Luigi Rossetti, Regione Umbria - Direttore Generale "Salute, welfare, sviluppo economico, istruzione, università e diritto allo studio"

INTRODUCTION

One of the first steps of the new European Commission led by Ursula von der Leyen was to adopt, in December 2019, the Green Deal, a roadmap to make the EU a world leader in circular economy and clean technologies. In this direction, at the beginning of March 2020, the update of the Circular Economy Action Plan of 2015 was presented. Immediately after its presentation, the health emergency linked to the coronavirus began which in addition to the sick and dead, is rapidly becoming a serious economic crisis with the impoverishment of millions of people and a strong increase in social hardship.

In response to this serious emergency situation, the Commission is preparing, in 2020, an additional innovative tool, the Recovery Fund, to promote the boosting of national economies through industrial policies that go in the direction of an ecological transition. In the near future, therefore, the opportunity can be realized to have funds to achieve a resilient recovery for the European continent. To this end, the circular economy must and can play a crucial role also through industrial symbiosis, one of its main tools.

The industrial symbiosis, in fact, generates a virtuous interaction between companies and the territory that simultaneously allows to promote competitiveness, innovation and employment and to protect ecosystems and biodiversity. This allows local communities to coexist in harmony with industrial systems, without sacrificing people's quality of life.

For this reason the industrial symbiosis is becoming increasingly recognized at international level as a strategical tool for the implementation of circular economy. In fact, since 2015, the European Commission recognized the importance of promoting innovative industrial processes such as industrial symbiosis through the Action plan for circular economy “Closing the Loop” (COM(2015) 614 final). In order to facilitate industrial symbiosis in Europe, the Commission proposed to review the legislature on waste and in particular “to clarify rules on by-products to facilitate industrial symbiosis and help create a level-playing field across the EU.”

Such a guideline was also emphasized in March 2020 with the new Action plan for circular economy “For a cleaner and more competitive Europe” ((COM(2020) 98 final)) (PAEC2020). In this document the Commission wants to favour the increase of circularity in the production processes facilitating industrial symbiosis through an industry-led reporting and certification system. At the same time, in order to create a well-functioning EU market for secondary raw materials the Commission intends to “assess the scope to develop further EU-wide end-of-waste criteria for certain waste streams based on monitoring Member States’ application of the revised rules on end-of-waste status and by-products and support cross-border initiatives for cooperation to harmonise national end-of-waste and by-product criteria”.

It is interesting to note that in order to promote all political reforms needed for the transition towards a circular economy at a European level in the upcoming years, the Commission will “step up cooperation with Member States, regions and cities in making the best use of EU funds”. The Commission will also harness “the potential of EU financing instruments and funds to support the necessary investments at regional level and ensure that all regions benefit from the transition. In addition to awareness-raising, cooperation and capacity-building, Cohesion Policy funds will help regions to implement circular economy strategies and reinforce their industrial fabric and value chains". In the PAEC2020 conclusions, "the Commission invites EU institutions and bodies to endorse this Action Plan and actively contribute to its implementation, and encourages Member States to adopt or update their national circular economy strategies, plans and measures in the light of its ambition".

It is important to underline that the transition towards a circular economy needs the adoption of specific pathways in every Member State, region and city based on geographical, environmental, economic, legislative and/or social factors.

Thus, regions and cities certainly have a key role in implementing a multi-level governance model which is able to start and accelerate the transition of the Italian system. For this reason, it is important that regions within a national strategy on circular economy, having consulted all stakeholders, elaborate an own strategical documentation and plans containing, for example, local priorities, planned measures and available resources. This would give local, regional and national stakeholders a clear indication on planning activities in the long term.

As also stated by the Commission in PAEC2020, the transition to a circular economy will be systemic, deep and transformative. Consequences of such a transition in certain cases could be destabilising since some regions will face with relevant socio-economic changes. Furthermore, as underlined by the President of the European Commission Ursula von der Leyen "the transformation ahead of us is unprecedented. And it will only work if it is just –and if it works for all". The Commission specifies to this extent that "it will require an alignment and cooperation of all stakeholders at all levels EU, national, regional and local, and international".

Accordingly, Italy should have the support of a National circular economy agency, as other countries, not only in Europe, have. Taking advantage of available competences and structures and collaborating with the various regions, such an organisation could for example favour a correct application of regulations on by-products, stimulate resources audit and industrial symbiosis. This activity would lead to the implementation of an effective integrated resource management system from a circular economy perspective with a coherent approach throughout the country. In this direction, in 2016 ENEA promoted the initiative SUN (Symbiosis Users Network), with the aim to boost the application of the industrial symbiosis in Italy by the involvement of the different stakeholders. SUN promotes circular economy models through industrial symbiosis deepening operative issues which can involve, for example, legislation, standards, market conditions and good practices. Currently, in April 2020, SUN has 38 partners among universities, political institutions, research centres, private companies, technology networks, local authorities and it is open to collect new partners.

Since the regional policies and governance systems play a crucial role in the implementation of industrial symbiosis in Italy, SUN promoted its last conference on "Good practices of industrial symbiosis in Italy and the contribution of regional policies as a strategic lever". The conference co-organized by SUN, CTS of Ecomondo and ENEA was held on November 7th, 2019 within Ecomondo exhibition in Rimini (IT).

Chaired by Laura Cutaia (President of SUN and responsible of the "Laboratory for Resources Valorization" (RISE) in the ENEA Department for "Sustainability") and Luigi Rossetti (General Director of the Umbria region “Health, welfare, economic development, education and the right to an education”) the conference has provided a broad view of policy and funding tools that Italian regions are implementing for boosting the implementation of industrial symbiosis as a lever for industrial and territorial competitiveness.

The conference allowed managers, researchers, regional officers and academia to dialogue on the role that regions should have for the transition towards a circular economy, and offered also the opportunity to show some very good experiences of collaboration between private companies and researchers for the implementation of real industrial symbiosis cases.

This report collects proceedings received by the oral and poster presentations held at the conference, which attracted more than 100 participants.

Laura Cutaia, President of SUN, ENEA - Responsible of the "Laboratory for Resources Valorization" (RISE) in the Department for "Sustainability"

Luigi Rossetti, Umbria Region - General Director of Dept. “Health, welfare, economic development, education and the right to an education”


ECOMONDO

MAPPING OF REGIONAL POLICIES AND ACTIONS FOR INDUSTRIAL SYMBIOSIS – ACTIVITIES OF THE SUN WORKING GROUP N° 2

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ABSTRACT

This paper presents the results of the mapping of Industrial Simbyosis actions in the Italian regional policies, with a specific focus on Smart Specialisation Strategy. The mapping has been realized during 2019 by the Working Group 2 of SUN Network, coordinated by ART-ER Emilia-Romagna, Sviluppumbria, ENEA and ARTI Puglia. The methodology was based on the use of a specific template and the analysis was realized on a basin of eight "pilot" regions. From the mapping was possible to identify two Regions (in the first version) and four Regions (in the update) that have explicitly included Industrial Symbiosis topics in their Smart Specialisation Strategy. Also several thematic projects were identified. As a conclusion, it was highlighted that there is a large awareness on sustainability issues in the Italian regional context, but further efforts are necessary.

Keywords: *Industrial Symbiosis, Regional Policy, Resource Efficiency, Smart Specialisation Strategy, Circular Economy*

Introduction

Industrial symbiosis (IS) is a useful territorial planning tool for the valorisation of regional and local resources, an undoubted factor of eco-innovation and enrichment for the territory. From an industrial area holistic management point of view, IS is an essential tool for ensuring resource efficiency and for boosting territorial and economic competitiveness conditions. Regional governments can encourage the creation of symbiosis, in particular among territorial industries, through various policy tools and by initiatives and practices that facilitate synergy between companies.

The working group n° 2 of SUN Network was formed in 2018 and is coordinated by ART-ER Emilia-Romagna, ARTI Puglia, ENEA and Sviluppumbria. During this first year, the activities of the working group aimed to: 1) analyse regional policies and actions on IS within a basin of "pilot" regions, with a particular focus on regional Smart Specialization Strategies (S3) but also on other policy tools; 2) identify regional stakeholders in each region to share the results of the analysis and to exchange good policy practices in the field of IS.

Methods

Regional policy tools were collected on the basis of a specific template elaborated by the working group, with the support of several thematic keywords which were agreed among all participants of the working group. The following regions were included in the mapping process: Basilicata, Emilia-Romagna, Friuli-Venezia-Giulia, Lazio, Marche, Molise, Puglia, Umbria [1;2; 3;4;5;6;7;8;9;10]. The objective of the mapping was to collect and analyse the S3 and other policy tools in these regions, and evaluate how and to what extent they include specific action or reference to IS. Smart Specialization Strategy (S3) is a tool used throughout the European Union to improve the effectiveness of regional public policies for research and innovation. S3 can include direct references to IS as a tool for develop competitiveness in regional territories, or indirect references, citing topics and preparatory practices for the creation of IS paths. The "regional IS actions" have been sought both in the first versions of the S3 documents and in their recent updates. As regards other regional policy tools, the review included the following regional documents which contain indirect or direct reference to IS: regional documents, i.e. plans, regulations, resolutions, acts, regional laws, other supporting actions, i.e. territorial projects, programmes, european and national projects, fora and working tables.

Results

The results of the mapping in the S3 regional documents is presented here below and is summarized in Table 1.

- **Basilicata:** The S3 does not explicitly identify the topic of IS but identifies in a fairly explicit way "sectoral" themes related to it in 13 "thematic trajectories". At the moment, there is currently no shared processing of the new S3 or an update. The process is ongoing, IS will be probably included in relation to both circular economy and specific innovation topics [1].
- **Emilia-Romagna:** IS is explicitly mentioned in the first version of the S3 (2014), both as a transversal "key element" of the innovative processes, and within 3 Technological Trajectories. Within the 2018 revision, IS is explicitly mentioned within 4 Strategic Objectives [2;3].
- **Friuli-Venezia Giulia:** References to aspects of sustainability potentially close to IS topics were found in three areas of specialization. In the 2017 update, some elements explicitly connected to circular economy and more attributable to IS were identified in two areas of specialization [4].
- **Lazio:** Two strategic priorities included in the "green economy" area of specialization are directly related to IS (use of resources; symbiosis paths). The updating process of the S3 document is ongoing. IS and circular economy will be explicit mentioned in several areas of specialization [5].
- **Marche:** IS is not mentioned. Three strategic objectives refer to sustainability aspects. No update of the S3 document is ongoing [6].
- **Molise:** IS is not mentioned. Some passages are indirectly related to IS. The update has not been implemented yet; topics strictly connected to circularity and resource efficiency may be introduced [7].
- **Puglia:** IS and circular economy are not explicitly mentioned, but sustainability is mentioned in some specific sectoral areas. The updating process is ongoing. The explicit inclusion of IS is almost certain, both in cross-cutting areas and in specific innovation areas [8].

- **Umbria:** There are not any explicit references to IS and circular economy. In some sections, reference is made to potentially "cross-cutting" concepts related to IS. A trajectory linked to "sustainable process solutions in the field of industrial production" has been introduced in the updated S3 document [9;10].

Region	First version of S3	Update
Basilicata	++ (2016)	+++ (hypothesis)
Emilia-Romagna	+++ (2014)	+++ (2018)
Friuli-Venezia Giulia	+ (2014)	++ (2017)
Lazio	+++ (2016)	+++ (hypothesis)
Marche	- (2014)	-
Molise	- (2016)	++ (hypothesis)
Puglia	+ (2016)	+++ (hypothesis)
Umbria	+ (2014)	+ (2018)

Table 1. Results of the IS mapping in the S3 documents (first version and next update)

Legend:
-: no reference to IS or similar concepts
+: few references
+ + : explicit references to IS or circular economy
+++: explicit references to IS
"Hypothesis" is referred to the process of S3 updating, where this process is ongoing or not yet started

The Regional Operational Programme of the European Regional Development Fund (ERDF) 2014-2020 deals directly with IS in some regions (Marche and Lazio), and indirectly in other ones, with reference to environmental sustainability and resource efficiency (all regions), integrated waste management (Basilicata), support to green economy (Friuli-Venezia-Giulia, Molise, Puglia), ecoinnovation (Marche). All the analysed regional economy and finance documents included actions for innovation, sustainability and resource efficiency.

The article 58 of Friuli-Venezia-Giulia Regional Law 20th February 2015, n. 3 "RilancimpresaFVG - Reform of industrial policies") provides for the financing of supply chain projects through:

- The sharing of resources, activities and knowledge;
- The coordination and integration of phases of the production cycle and distribution actions;
- The development of integrated eco-innovation interventions also with reference to the prevention of waste production;
- The conversion of the working cycle and the use of renewable sources as well as industrial symbiosis projects and projects aimed at goods sustainable mobility;
- The establishment of business networks.

The Emilia-Romagna Regional Law n° 16 of 5th October 2015 includes direct measures for reducing the production of waste and for waste recovery by the reuse, recycling or any other material recovery. The law draws the attention to the upstream part of the supply chain, by means of the progressive reduction of waste which are not recycled and the industrialization of recycling.

The Umbria Regional Law 13th May 2009, n° 11 includes priority measures for the development of an integrated waste cycle, such as the reduction of waste quantity and danger, in particular by the development of clean technologies, the technical development and the introduction on the market of products which do not contribute to increase the waste quantity or harmfulness and the risks of pollution, the development of appropriate techniques for the elimination of dangerous substances contained in waste intended to be recovered.

The Marche Regional Law 17th July 2018, n°25 promotes the combination of new forms of Impresa 4.0 with circular economy and aims to leave the linear concept of "producing, consuming and discarding" to encourage the circular concept "reducing, reusing and recycling", promoting a synergy between research and innovation and the transversal application of circular economy methods and tools.

The Basilicata Regional Law 16th November 2018 incorporated the circular economy principle in the regional policy. The law promotes sustainable waste management in order to reinsert recovered waste in the production cycle, saving new resources.

The regional plans for waste management of Friuli-Venezia-Giulia and Umbria are two best practices for the connection between waste management and IS. The former highlights the necessity to strengthen the connection between waste reduction and resource efficiency, the latter plans to develop a policy aimed to create waste closed loops and to support recycling and reuse measures. Moreover, in the annex of the preliminary technical document "For a zero waste circular economy in Umbria region", five intervention areas for circular economy are described: prevention; reuse; minimisation of the residual urban waste and the relevant material recovery; extended producer responsibility; proximity principle and definition of industrial cycles for material recovery.

As regards the territorial projects, several projects related to IS were identified, realised with the support of the Regions or in the framework of the European programmes:

- **Emilia Romagna:** Green-Industrial Symbiosis project, in cooperation with Unioncamere Emilia Romagna and Aster and technical-scientific coordination of ENEA; several research and innovation projects on IS-related topics, funded by POR-FESR;
- **Umbria:** Industrial symbiosis in Umbria project: new opportunities for companies by IS and Pilot PROject for resource efficiency in Umbria, in cooperation with Umbria Region, Sviluppumbria and ENEA (Innetwork);
- **Friuli Venezia Giulia:** Industrial Innovation Harbour project, in cooperation with Area Science Park (ARGO System). The following fora, working tables and observatories were mapped.

The following fora, working tables and observatories were mapped:

- **Basilicata**: permanent forum on circular economy;
- **Umbria:** "Sustainable development" working tables and public forum for sustainable development;
- **Friuli-Venezia-Giulia:** Regional Forum for circular economy; permanent working table for circular economy; interdepartmental working group "Circular Economy"; Observatory for circular and sustainable economy;
- **Emilia-Romagna**: Regional Table on By-products;
- **All regions**: thematic working tables.

Finally, Environmental Equipped Industrial Area - EEIA (Aree Produttive Ecologicamente Attrezzate - APEA) are industrial, craft or mixed production areas, characterized by environmental sustainability and minimization of the impact on the surrounding environment and unified and integrated infrastructures and services management in a sustainable development perspective.

They have been established in Friuli Venezia Giulia, Emilia Romagna, Marche and Lazio and specific laws on this issue have been produced by Umbria, Molise, Puglia, and Basilicata.

Discussion

The mapping activity was performed considering eight regions and included both S3 documents and other policy tools. In the first version of the S3 documents, only two regions explicitly mentioned IS. After the revision and update of these documents, four regions are expected to mention explicitly IS. In addition, the other analysed policy tools, such as regional laws, plans and regulations, mainly deal with waste management and resource efficiency or circular economy in general, which are in any case indirectly connected to IS. The same situation occurred for the regional projects, fora and working tables, which are active in these general topics. This mapping therefore highlighted that there is a large awareness on sustainability issues in the Italian regional context, but further efforts are necessary and expected towards a full inclusion of IS concepts in the main regional planning documents and regulation. Also supporting actions, in order to ensure "policies coordination" at national level on IS topic, would be necessary.

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ASSESSMENT OF POREM, THE NEW BIO-ACTIVATOR FOR BETTER SOIL MANAGEMENT

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ABSTRACT

This work presents the first results obtained in the European Project LIFE17 ENV/IT/333 POREM. The project goal is to demonstrate the technical feasibility and applicability of an innovative bioactivator, POREM, for the restoration of degraded soils, poor in organic matter, also in semi-arid climate. POREM is obtained from poultry manure, the main by-product of poultry meat and egg productions, subjected to innovative bio-treatment based on patented process, in a circular economy strategy. The bioactivator was produced at pilot scale in Italy and was monitored via chemıcal-physical methods. Thermogravimetric Analysis (TGA) was applied to evaluate thermal stability and decomposition phases, Scanning Electron Microscopy (SEM) to observe morphology and perform semiquantitative analysis and X-Ray Diffraction (XRD) to detect mineralogical phases. The replicability of measured properties was highlighted both at pile and sample levels. The presence of struvite, a Nitrogen compound able to reduce environmental impact and to enhance N ritention, was observed.

Keywords: *Poultry Manure, Bioactivator, Struvite, XRD, SEM, TGA*

Introduction

Poultry manure (PM) represents the main by-product of poultry farming, both for egg and meat production. It is rich in nutrients but particularly in Organic Matter (OM), and in microorganisms. In a circular economy strategy, this side-stream must be reconverted to new products. On the other hand, soils need organic matter to maintain its functionality and fertility. In Europe [1] 45% of soils have low OM content, principally in Southern Europe.

The European Project LIFE17 ENV/IT/000333 POREM ("Poultry manure-based bio-activator for better soil management through bioremediation", project co-funded by EC within the LIFE programme) tries to match these objectives. It proposes the innovative bioactivator POREM to restore the degraded soils, extremely poor in OM. It is obtained from PM/PL (poultry manure/poultry litter) by means of innovative and low-cost technologies. The aim of this paper is to exploit chemical-physical methods to verify final bioactivator features, to demonstrate its applicability for soil restoration/bioremediation (low organic matter soils, also in semiarid areas). The characteristic investigated in particular are the retention of, inside of bioactivator:

- Organic Carbon for soil enrichment and nutrients for plants;
- N in a special valuable form, struvite. Struvite is recognized as a slow N release fertilizer, with low water solubility (therefore low contribution to salinity) [2]. It represents a sink for N, preventing its losses to atmosphere as ammonia, with its environmental impact.

Methods

POREM bıoactıvator was produced at pılot scale, in Calabrıa, treating PM produced in an intensive laying hen farm, predried with manure belt system, which is a manure management system recognized as BAT [3]. Three piles with 3 tons of PM each were set up in a barn, with the addition of a natural enzyme preparation (VAP) layer, according to EP1314710 (Figure 1). Then the piles undergone a static biostabilization process, with oxigen avaılable from natural convenctıon, along 120 days.

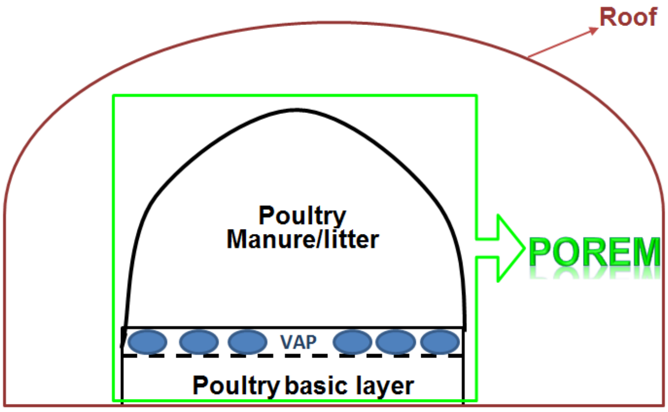

Figure 1. Diagram of POREM production pile

A sampling system was planned. Time sampling was scheduled at t= 0, 30, 60, 120 days. Each pile was divided teorically in 3 section: from each of them, 6 subsamples were collected and mixed in order to obtain a sample representative of the section. A total of 9 samples were realized and analized for each sample time.

Chemical-physical characterization. The samples chemical-physical characterization was performed. In particular:

1 Thermogravimetric Analysis (TGA) was carried out to measure thermal stability and detect decomposition phases (ΔT and % mass loss);
2 Scanning Electron Microscopy (SEM- EDS) was performed to analyse morphological structure and carry out semiquantitative analysis;
3 X-ray diffractometric analysis (XRD): to detect mineralogical phases.

Thermogravimetric analysis was carried out to measure the thermal stability and decomposition phases of the samples (ΔT and %mass loss). The STA 409 simultaneous analyzer (Netzsch, Selb, Germany) was used, equipped with TG sample carrier supporting a S type thermocouple. During the tests, the weight change of the sample was measured during the thermal program (TG expressed as % weight loss). The first derivative of the TG curvee represents the weight loss rate DTG (expressed as %/min) and is used for the exact identification of relative decomposition steps. Analyses were performed with a heating rate of 10 °C/min up to 1000 °C and under inert atmosphere (Argon) with a flow rate of 100 ml/min. The Netzsch TA window software was used for data processing of the results. To perform these analyses around 850 mg of samples was weighed and placed in a sample carrier of 3.4 ml in volume.

The samples morphological characterization was performed using a LEO 438 VP SEM, equipped with EDS microanalysis Oxford Link ISIS 300. The SEM observation was used to examine the bioactivator morphology, while the EDS semi-quantitative analysis was performed to provide the elemental composition. POREM samples at different maturation time, up to 120 days, and from three different treated manure piles were characterized and the analysis was performed in Variable Pressure to minimize the charging effects of non-conducting samples. In all POREM samples the morphology observation and semi-quantitative analysis were carried out on different areas to obtain more representative and reliable results. Moreover, both average and localized composition on specific morphology were analyzed.

Powder X-ray diffraction patterns (XRD) were collected for grinded poultry manure in Bragg-Brentano geometry at room temperature (Philips PW 1710, Bragg–Brentano geometry, CuKα 40 kV and 30 mA, step 0.02°, time 3 s); the phase analysis was carried out with the PC X'pert High Score software Version 2.2a (PANalytical B.V., Almelo, The Netherlands).

Results and discussion

The following figure (Figure 2) shows the comparison of POREM samples TGA and DTG at time t_0 and t_{final}=120days.

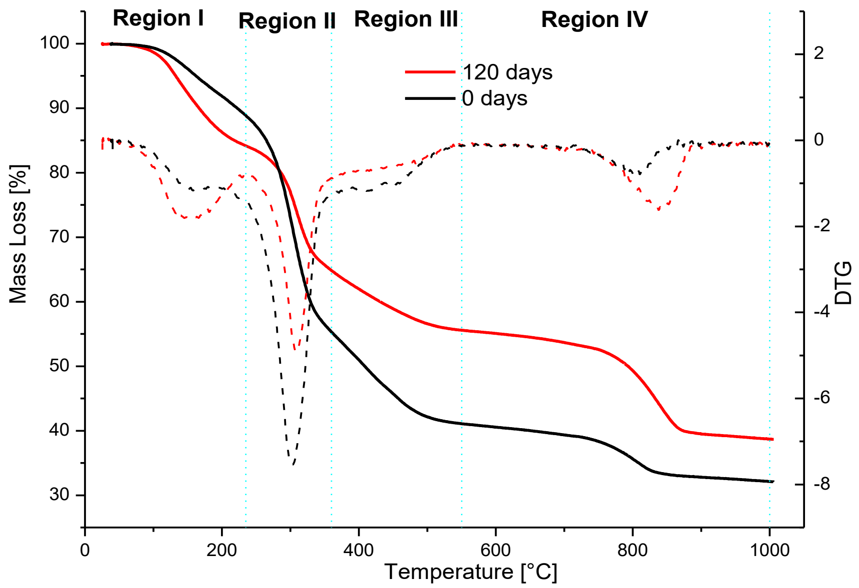

Figure 2. Comparison between POREM samples TGA and DTG at t_0 and $t_{final=120}$: thermal stability and decomposition phases

Four main steps were detected. The first region of the weight loss of POREM samples ([25-200]°C) is due to the evaporation of the adsorbed or not-structured water, which has a maximum degradation rate at around 100°C. The main step of mass loss ([200–550]°C) corresponds to the decomposition of organic matter and pyrolysis, in particular aliphatic fraction (carbohydrates and alkyl labile systems), in the region between [200-360] °C and aromatic moieties between [360-550]°C. The last step [550-1000] °C is ascribable to the decomposition of poultry manure inorganic fraction.

The Figure 2 highlights that the curves shift to smaller mass losses; it means that there is a better thermal stability. It is ascribable to the 2nd and 3rd steps reduction (organic fraction) which probably refers to CO_2 formation. In addition, the inorganic fraction increases over the time and it is probably due to mineralization, favored by presence of Ca in the poultry diet. Indeed, the poultry are deliberately fed calcium stones in order to help them create the eggshell.

All POREM bioactivator samples exhibited heterogeneous morphology with the presence of various residues, both fibers and granular particles of different shape. Typical micrographs at two different magnification were shown in the following figure (Figure 3).

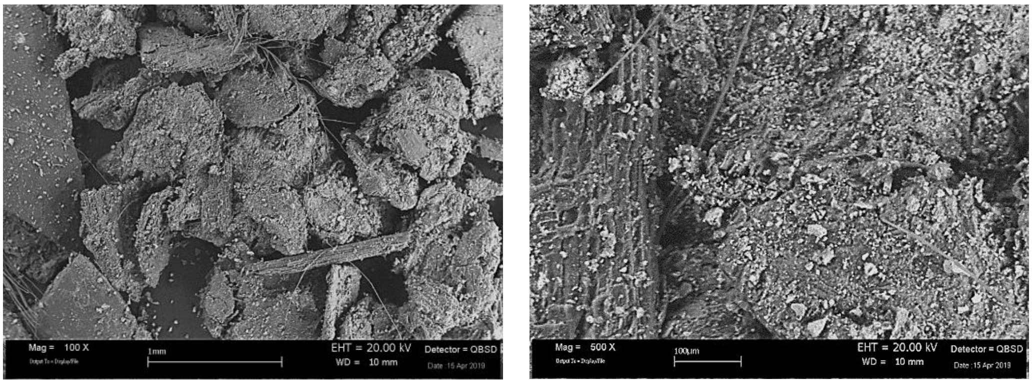

Figure 3. Typical micrographs at different magnifications of POREM bioactivator

The average semi-quantitative EDS composition revealed O and C as the main elements, but Ca, P, K, Mg, S are also detected. The replicability of POREM bioactivator production was demonstrated and no remarkable differences between the pile's composition was detected. Moreover, the composition remains comparable both inside the pile and among the piles during the maturation process. The average composition trend over time is highlighted in the following Figure 4. The histogram showed similar composition during the maturation process, with most of every sample made of O and C and presence of soil nutrients (Ca, P, K, Mg, S, etc.). The strongly increase of some values after 120 days may be due to the flooding occurred at the end of the second month. Excluding the last data, remarkable process uniformity was pointed out.

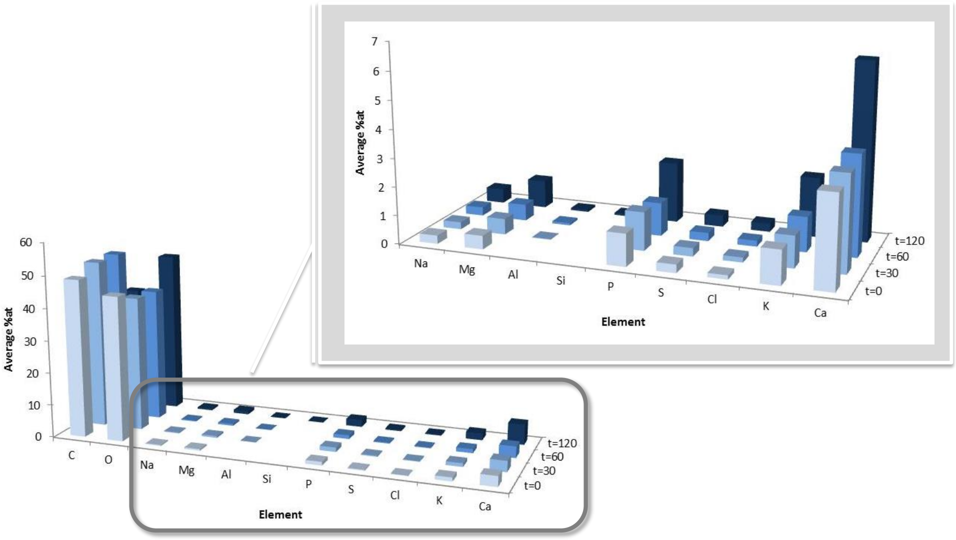

Figure 4. Average composition trend of POREM bioactivator during the maturation process

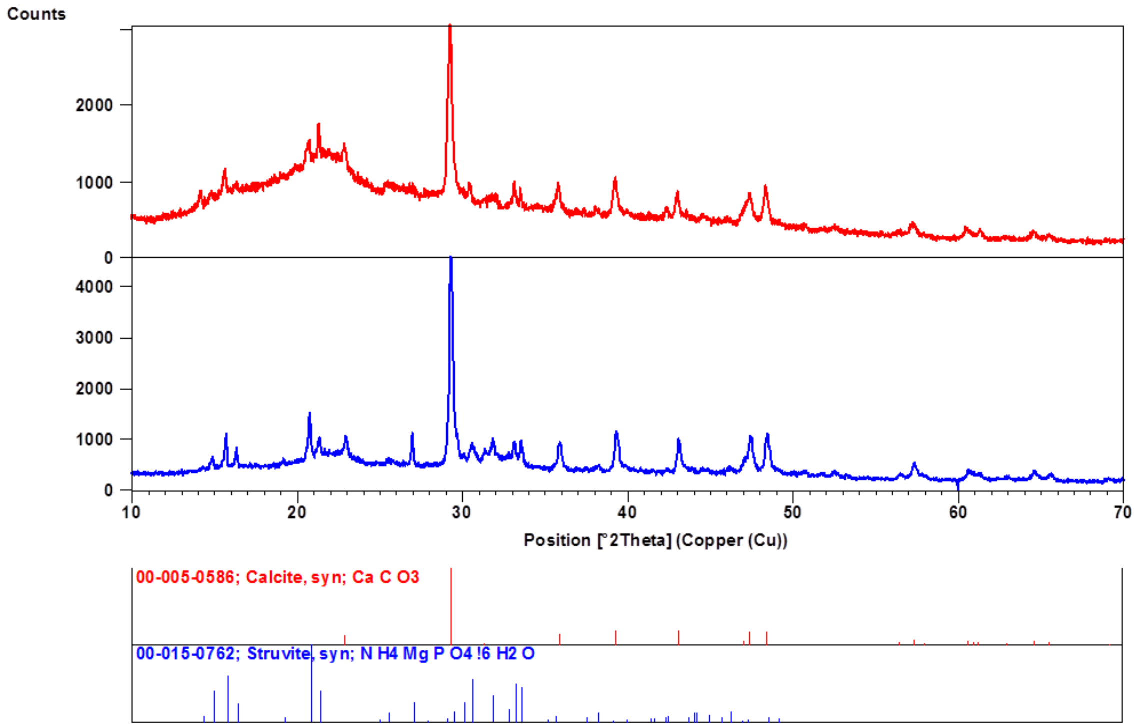

Figure 5. XRD patterns of poultry manure samples at maturation time 0 (a) and 120 days (b)

XRD was carried out to detect mineralogical phases. As shown in Figure 5, in both samples, two main crystalline phases were identified: calcite ($CaCO_3$) and Struvite ($NH_4MgPO_4{\cdot}6H_2O$).
The amorphous phase is clear present at the beginning but decreasing with maturation time and the crystalline and inorganic phases are more evident. XRD patterns of each sample piles were also compared at the same sampling time observing closed patterns. Concerning the XRD evaluation, the replicability of sampling in different area of poultry piles, at the same maturation time, is observed.

Conclusion

The characterization results are mutually consistent and highlight an improved bioactivator stability, correlated to the maturation time. The time trend of POREM bioactivator properties is demonstrated as well as the replicability of POREM production.

The presence of struvite a N slow release compounD able to reduce environmental impact was observed.

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SME AND INDUSTRIAL SYMBIOSIS IN EUROPE: GOOD PRACTICES FROM CESME AND SINCE-AFC

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ABSTRACT

SMEs are experiencing difficulties in adopting circular processes. The CESME project tried to help SMEs through the collection of good practices, the development of different tools, and action plans to improve local policies. This four-years learning process has generated solid results, affirming circular economy as a priority in the local agenda and encouraging the launch of new projects.

Keywords: *Circular Economy, SMEs, Industrial Symbiosis, Policies, Good Practices*

Introduction

In the last few years, thanks also to the Circular Economy Package adopted by the EU Parliament, an increasing number of large corporations is starting to adopt resource efficiency, eco-innovation and circular economy as key principles for their strategies. On the other hand, SMEs - which represent 99% of all businesses in the EU and account for 85% of new jobs created over the last years [1;2] - are experiencing more difficulties in adopting such strategies, due to their more limited organisational, technological and financial capacity, less access to financing and to knowledge. This could limit the speed at which Europe can transit toward a more circular economy.

To try to overcome this barrier, the Metropolitan City of Bologna has decided to join the CESME project (funded by Interreg Europe programme) with the goal to boost and facilitate SMEs inclusion into circular economy. Ten public organization from six European countries (Denmark, Finland, Wales, Italy, Greece and Bulgaria) worked together during the last four years, sharing experiences, identifying good practices, providing guidance, supporting tools and better policies to help SMEs to scale-up circular economy.

Methods

Collaboration: a key word for circular business models. According to Ellen MacArthur Foundation [3], Circular economy is a sustainable economic model [4;5] that improves and optimizes systems, trying to eliminate all or most waste, or recycle it, thus reducing the use of virgin resources and energy-water consumption, extending the life cycle of products (aging and repairing), which in turn reduce the environmental impact of the consumer society.

Accenture [6] and OECD [7] have identified five circular business models: circular supplies, resource recovery, product life extension, sharing platforms, product as a service. According to the most recent policy brief from the Interreg Europe Policy Learning Platform [8], circular economy business models should be instead divided into four approaches: industrial symbiosis, sharing economy, circular design, reverse logistics and re-manufacturing. These approaches concern every dimension of economic activity: business-to-business, business-to-consumer and consumer-to-consumer.

This latter classification better organizes the good practices studied within CESME project. Here's a brief description of each model, accompanied by examples.

Industrial Symbiosis. Business-to-business approach, using underused resources (such as energy, water, capacity, expertise, assets, by-products, etc.). Industrial symbiosis is a commercial collaboration between companies, where the residual product from one company is reused as a resource by another one. Thereby, Industrial symbiosis reduces provider's waste, while saving buyer's new resources. This approach often involves finding non-conventional and innovative solutions, exploiting untapped synergies. From 2013 to 2015, Denmark set up a database and a matchmaking service to facilitate symbiosis initiatives. The project "Less waste using Industrial Symbiosis" was funded by the Danish Government involving five Regions, among which North Denmark, partner of CESME project. Two were the main actions realized: a national web database (GIS, Green Industrial Symbiosis), and the establishment of a Task Force providing free advice. By the end of the project period, more than 750 companies were registered in the database. The advisers visited 516 companies in order to help them to clarify their resource flow and map their waste and need for resources. 174 companies matched their need with another company, as a first step to sign an agreement on industrial symbiosis. Despite the positive results achieved, the initiative stopped when the initial subsidy ran out, also because of data security reasons.

Sharing Economy. Assets and services are shared among private individuals, but also among companies, either for free or by payment, typically on online platforms, covering a great variety of sectors (from sharing houses to car journey), often encompassing the development of new business models. Leila-Bologna is a front-runner example of off-line platform, being the first "Object library" in Italy: people who want to join the initiative bring an object they want to share and, after having got their membership card, they can borrow any object that has been shared by all the other members.

Circular design. Design is fundamental to develop resource efficient, long-lasting, easily repairable and recyclable products. Designing sustainable products and services requires innovative process workflows, new working methods, broadened systemic view. ILAP group is an Italian food-service packaging manufacture with a circular r-PET's supply chain. They redesigned their products to reduce their weight, using recycled materials. Moreover, they acquired a PET recycling facility, where the post-consumption materials are sorted and washed; then, other companies of the group grind, extrude and thermoform the recycled PET to manufacture new packaging, to close the circle.

Reverse logistics and Remanufacturing. The process of moving goods from their typical final destination in order to capture value, mainly driven by Extended Producer Responsibility (EPR), and its re-manufacturing, where an obsolete or degraded product is brought to at least the quality level of a new product through dismantling, cleaning, repairing and reassembling collected used parts. In 2015, Orange Box, a Welsh company leader in the design and manufacture of office furniture, developed a take-back and re-manufacture scheme for one of their most successful products, the G64 office chair. The pilot study has shown that 98% of the G64 is recyclable, and re-manufactured chairs have 78% recycled content. The refurbishment scheme also provides a new revenue stream for the company and an expanded value network. Taking into account re-manufacturing costs, re-manufactured chairs are likely to generate between 60 and 90% of the sales value of a new G64.

Identifying relevant stakeholders. Circular business models are collaborative business models in their majority. Though collaboration often happens spontaneously, in many cases there is a need for external facilitation. This inevitably leads to wider collaboration among different stakeholders: local authorities, research centres, companies, citizens.

For a better and faster scaling-up of circular business models, we need to refer to quintuple-helix approach. The triple helix alliance university-industry-government [9;10] for innovation in the production, transfer and application of knowledge, is still not sufficient [11;12]. The role of civil society - the quadruple helix- is very important for the take up of circular business models, as well as the benefits generated for citizen-consumers: for example, having access to better quality eco-designed products, local distribution channels leading better traceability of products, money saving thanks to extended life of products or selling or buying second hand goods. Social economy (such as reuse, donation or sharing platforms) considered as a functional economy (disconnecting consumption from ownership) is able to structure help, optimizing the use of resources. The quintuple helix innovation model is even broader, adding the perspective of the natural environments of society, stressing the importance of socio-ecological transition and supporting a win-win collaboration among ecology, knowledge and innovation, creating synergies between economy, society and democracy. Moreover, the quintuple helix model should consider also financial-economic system [13].

CESME tools and action plans. CESME partners took action in order to facilitate the adoption of circular approach among SMEs. The knowledge shared has been organized in a “White book” [14] developed in a wiki manner, available online for public consultation. The White book has been written with the efforts of all partners, collecting and capitalizing previous experience and systematizing lessons learnt. It collected insights on good practices and local policy systems on major topics and themes: built environment, textile, packaging, food and beverages, machinery, energy, wastewater, green public procurement, green raw materials. Barriers to implementation have been pointed out too, as well as relevant stakeholders have been identified.

A “Circular Economy Toolkit” has been set up, to get a sort of online advice on the circular potential of companies. It includes a Return on Investment (ROI) tool, quantifying the economic and social benefits of circular value chains. The toolkit was developed starting from already existing tools which have been readapted and customized. Moreover, support materials have been produced. The toolkit has been initially tested in all involved regions; a more in-depth test was then conducted in Finland through a pilot project. According to test results, we should confirm that, when ROI is positive on a three/five years’ time horizon, we can label the operation as a win-win, which is the best condition to foster and spread circular economy; some difficulties have detected with environmental and social indicators, which are harder to express and insert in the model.

Finally, an action plan has been drafted in every partner's region, aiming to improve local policies and to transfer good practices. The main measures foreseen are: to set up a knowledge hub in North Denmark, information campaign and Green SMEs database in Emilia-Romagna, to test and further develop the toolkit in South Ostrobotnia, to develop a web-based platform for business in Bulgaria, to establish an academic network on circular economy to further support innovation in Welsh, and to establish a one-stop-shop in Central Macedonia to promote circular economy and related good practices. The implementation of the action plans was monitored on a quarterly basis. At the moment, more than two hundred SMEs have been involved and two and a half million of Euros have been influenced by the project just into two partner regions.

Results and discussion

In 2015, joining the CESME partnership, the Metropolitan City of Bologna decided to address the ROP-FEASR together with Art-ER, considering that circular economy was not addressed yet by local policy instruments. A long way has been done since then.

In June 2017, Bologna hosted the G7 Environment and the first Italian Circular Economy National Forum, hosting prominent experts (among which Kate Raworth) and representatives of institutions, entrepreneurs and associations. The G7 gave the occasion to sign the "Bologna Charter for the Environment", the first protocol of its kind in the environmental field at national level. Bologna's Charter for Environment identifies eight macro-objectives to be included in the metropolitan agenda for sustainable development: from waste to air and water quality, from energy transition to sustainable mobility, from biodiversity to circular economy. Promoted by the Metropolitan City of Bologna, the Charter was signed by thirteen Italian Metropolitan cities at the presence of the Italian Minister of the Environment. The Charter identifies the goals to be achieved in the next years, in line with the UN 2030 Agenda, and this is the first structured and concrete step made by the Italian Metropolitan Cities toward resilience and circular economy. Large cities could act as 'natural laboratories' to identify solutions to major global challenges, to experiment and implement innovative solutions for sustainable development, with positive effects not only on the environment but also on the economic, social and institutional dimensions.

Last summer the Metropolitan City of Bologna launched the "Metropolitan Agenda for sustainable development", a voluntary tool to measure progress towards the goals set in the Charter and guide the thematic planning. The Agenda is part of the metropolitan strategic planning, in collaboration with the City and the University of Bologna. The Agenda point out the baseline and sets targets to reach; it mapped strategies and ongoing short and medium-term actions for each of the eight macro objectives, among which circular economy. The CESME action plan has been fully included into the Agenda.

The lessons learned during CESME project contributed also to the development of new projects, aiming to respond to challenges and opportunities emerged at a local level. In particular, the Metropolitan city of Bologna is partner of two new Interreg Europe projects that will allow to continue the improvement and the support offered to its local system, giving the possibility to make a comparison with other European systems.

The first one is SinCE-AFC, which aims to involve SMEs from the Agri-Food chain in circular economy through the promotion of appropriate managing and financial horizontal mechanisms. The overall objective of SinCE-AFC is to improve policies by facilitating horizontal mechanisms that support and enhance SMEs entrepreneurship in Agri-Food sector through the exploitation of Circular Economy opportunities, strengthening cooperation among local authorities and agri-food operators in order to create new business opportunities.

The second project is GRESS - GREen Startup Support, which aims to improve policies for SMEs competitiveness by strengthening capacities to trigger and support formation of sustainable and competitive start-ups and spin-offs within the green economy. Five partners from Norway, Greece, Poland, Italy and Bulgaria, will apply a policy-learning process in five steps: 1) status on green growth [15] in each region, 2) scan and exchange of experience and identification of good practice for mutual learning, 3) assessment and ranking of relevant practices through peer assessments, 4) idea generation on policy intervention with interregional knowledge transfer, and 5) development and monitoring of regional action plans.

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INDUSTRIAL SYMBIOSIS AND STRATEGIES TO ENHANCE PAVEMENT SUSTAINABILITY

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ABSTRACT

In civil and environmental field, the general approach to move towards more sustainable strategies includes, among others - reducing virgin materials, using recycled materials, reducing energy consumption and environmental impacts. Towards achieving a vision of sustainability, the Cooperativa trasporti Imola Scrl (CTI) decided to collaborate with Department of Civil, Chemical, Environmental and Materials Engineering (DICAM), University of Bologna. The study aims to evaluate the envirnonmental and physico-mechanical performances of designed asphalt mixtures by means of hot technologies and recycled materials. The life cycle assessment (LCA) methodology was applied to evaluate the current environmental impacts, to identify critical aspects and to suggest improvement actions. The proposed approach in the production of asphalt mixtures promotes the Industrial Symbiosis (IS), using primary and secondary materials which came from local/regional industrial activities, located close to CTI company. By definition, it supports the circular economy (CE) and its principles, according to Directive 2008/98/CE [1].

Keywords: *Industrial Symbiosis, Sustainable Pavement, LCA, Circular Economy, Construction and Demolition Waste*

Introduction

Towards the effort of the road engineering industry to reduce waste, this paper presents a case study of circularity by sharing materials among firms, in a local and regional context. This is the reasoning of Industrial Symbiosis, which is aimed at helping the companies to environmentally optimize their production approaches and to reduce waste and virgin materials. The Cooperativa trasporti Imola Scrl (CTI) has been operating in the recycling and recovery sector for many years. It is based in Imola (BO) and has four plants adjacent to its main headquarters, to produce aggregates, bituminous conglomerates and concrete. In this study, the possibility of using recycled aggregates was evaluated and scientifically demonstrated; these materials can be mixed to the aggregates naturally extracted from quarries in the production of bituminous conglomerates for road construction, in a medium-high percentage, equal to 50 % by weight per surfacing layer and 56 % by weight per binder layer. In addition, the possibility of using recycled aggregates and fillers from other industrial processes was tested, thanks to the collaboration with other firms, located near the company's plant, in order to partly or completely replace the aggregates and virgin fillers used by CTI.

Methods

The whole approach includes on one hand, the quantification of the amount of RAP – Reclaimed Asphalt Pavement – and slag, the evaluation of volumetric-physical-mechanic performances for each mixture through tests for geometrical properties of aggregates, determination of particle size distribution; and on the other hand, the assessment of environmental impacts associated with the mixture production, through LCA studies. The study has been performed from 2018 still 2019.

Recycled Material. The study considered construction and demolition waste, coming from the milling of old pavements and from industrial processes. The asphalt mixtures under study contained RAP, a valuable and high-quality material generated from milling operations of existing flexible pavements at their end-of-life stage and artificial aggregates, coming from an industrial plant in Verona (Italy). Other wastes under the study were the recycled filler from ceramic industrial processes, fly ashes and bottom ashes, resulting from coincineration. In particular, the involved companies are located at a distance of 100 km or less from Imola CTI plants. Materials and asphalt mixtures were tested in laboratory (University of Bologna).

LCA – Life Cycle Assessment. This LCA study aimed at evaluating the alternative alphalt mixtures: the "green mixture", containing high amount of recycled aggregates; the "traditional asphalt mixture", containing virgin aggregates only. The LCA, formalized by the BS EN ISO 14040 [2] e BS EN ISO 14044 [3], was performed with the software SimaPro 8.0.

System boundaries. The objective of the LCA analysis was to evaluate from a life cycle perspective the environmental impacts of each asphalt mixture, the *green* hot mixed asphalt (HMA), also referred to as "Green mixture", and the traditional HMA. The functional unit of the LCA is one kilometer of secondary suburban road (width: 10,5 m, thickness: superficial course 4 cm, binder course 6 cm) . The CML 2001 method (April 2013) was selected for the environmental impact assessment. The system bounderies included all the treatment processes, starting from the waste entering the CTI plant until when it leaves the plant as an emission (solid, liquid or gaseous) or as a new material. The system bounderies were expanded upstream to include the avoided primary productions due to material recovery from waste. Hence, this LCA is a cradle-to-cradle analysis (Figure 1).

Life Cycle Inventory: All data regarding the core processes were primary data collected in CTI company, while data related to other foreground processes were taken from SimaPro databases. Life Cycle Inventory contains processes, data quality and databases.

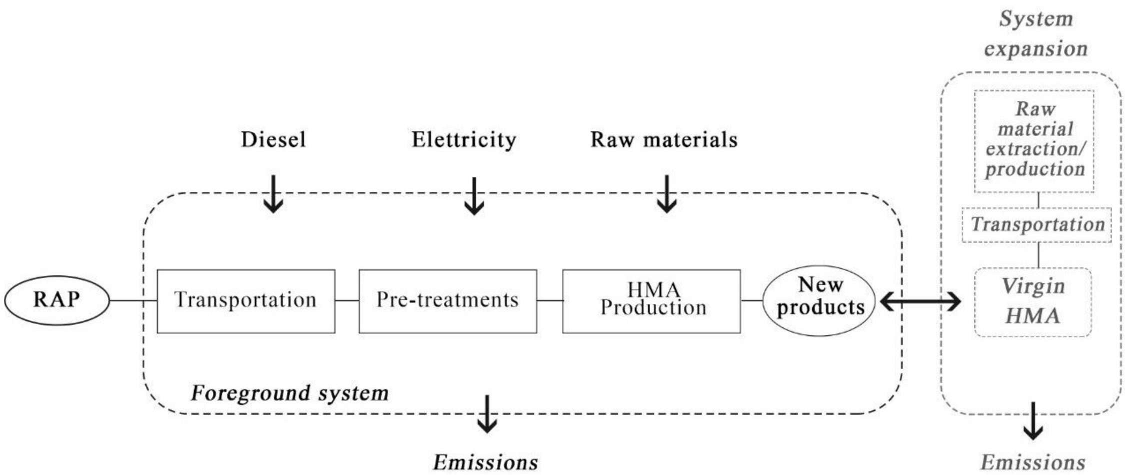

Figure 1. System bounderies

Results

The comparison between the two asphalt mixtures for a binder course and a surfacing course has been performed for a better interpration of the LCA results. The absolute values of the envirnomental impacts associated with recycling of RAP in hot mix asphalt plants and the tests in laboratory shows that:

- Recycling RAP and slags in HMA Green mixtures provide benefits in all impact categories, given the reduction in the consuption of bitumen and aggregate;
- No defects have been found in the Green mixture, in terms of volumetric and physical – mechanic performances;
- The environmental burdens are mainly related to the transportations.

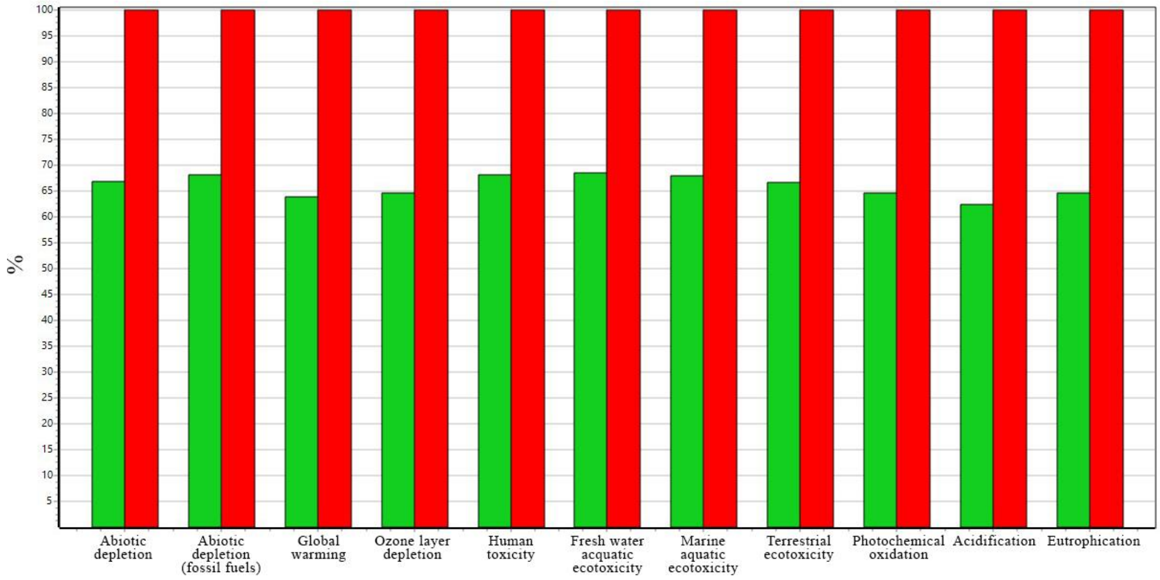

Figure 2. Contribution analysis related to recycling RAP and slag in hot-mix-asphalt HMA Green mixture (green) and traditional (red) plants for surfacing course

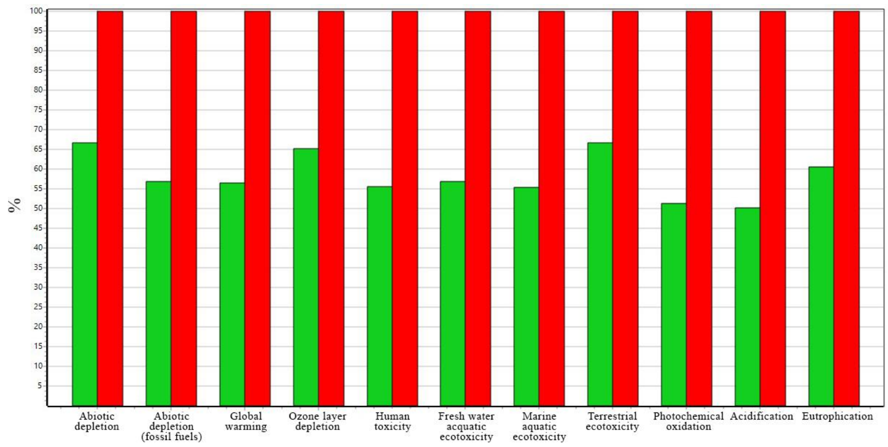

Figure 3. Contribution analysis related to recycling RAP and slag in hot-mix-asphalt HMA Green mixture (green) and traditional (red) plants for binder course

Discussion and conclusion

In conclusion, it has been demonstrated that the LCA methodology can be used to verify compliance with the environmental requirements, and also having due consideration of the performances. It is hoped that this will guide road design towards industrial symbiosis practices, an undoubted factor of eco-innovation, enrichment for the territory and transition to a circular economy. Moreover, the green bituminous mixtures represent a realistic alternative to the traditional ones, having less environmental impact. The economic aspects and environmental impacts of the end-of-life and use phases of bituminous mixtures, commonly neglected by many studies but decisive for obtaining a more complete view of the life cycle, have not been evaluated [4]. The study conducted at regional level on recycled materials suggests the formulation of a multimedia catalogue of materials and resources, a platform for interconnection. Therefore, a clear and adequate regulation is strictly necessary in order to promote industrial symbiosis practices for sustainable pavements [5]. Future research activities can focus on the following aspects:

- Widen the boundaries of the LCA system, using the Cradle-to-Cradle methodologies;
- Carry out LCC - Life Cycle Costing economic analysis.

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RECYCLED AGGREGATES: CIRCULAR ECONOMY IN THE CONSTRUCTION SECTOR – THE CASE STUDY OF SARDINIA REGION

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ABSTRACT

The research project funded by Sardegna Ricerche (POR FESR 2014/2020 funds) aimes to define applicable Circular Economy strategies in the construction sector to support the Sardinia Region, in particular recycled aggregates in the structural concrete. The research group of the University of Cagliari, the stakeholders (recycling plants, concrete producers, precast concrete companies) and the Regional Public Administration carry out a synergic work to activate virtuous processes, through case studies, that can be replicated. The analysis regards the recycling of demolished large structure rubble, the use of recycled aggregates in precast concrete companies and the use of aggregates and recycled concrete and their amount in the urban planning of three town of Sardinia.

Keywords: *Construction and Demolition Waste, Recycling, Recycled Aggregates, Mechanical Properties, Circular Economy*

Introduction

The construction sector consumes annually huge amount of aggregates that contribute to environmental losses. Recycling of Construction and Demolition Waste (C&DW) as recycled aggregates in new concrete limits the exploitation of natural resources and the extension of landfills. It is important to highlight and inform that there are no technical or economic obstacle to the use of recycled aggregates obtained by recycling concrete debris [1-5].

A life cycle assessment of a building includes all the stages in the assessment: raw material supply, manufacture of construction products, the construction process stage, use stage, demolition and when the materials are disposed of or recycled and used in new building [6-8]. C&DW are special waste and, therefore, must be disposed in landfills; otherwise, the unlawful practice to litter them causes serious environmental impacts.

The recycled C&DW are usually used as fill materials or in road construction but, in Northern Europe, their use is more noble and profitable: they are also used in reinforced concrete structures.

The European and National Standards impose the recycling of C&DW.

The Minimum Environmental Criteria (CAM), that allow the identification of the design solution, the product or the best service from an environmental point of view throughout the entire life cycle, must be applied according to Italian Legislative Decree No. 50, 2016 and the Law N. 221, 2015. In Italy, at present, there are two important unsolved problems: there isn't an End of Waste criteria for construction waste and selective demolition is not obligatory. The aim of this work is to strengthen the sustainability concept in civil construction and to provide an important contribution to the C&DW management plan of Sardinia.

Methods

The University of Cagliari research group and the stakeholders (recycling plants, concrete producers, precast concrete companies), through case studies, demonstrate the possibility of activating virtuous processes that can be replicated, in order to support and direct to the C&DW management plan of Sardinia.

The case studies examined are the following:

- Recycling of C&DW produced by the demolition of a large building;
- Use of recycled aggregates (RA) in Precast Concrete Companies;
- Use of recycled aggregates and recycled concrete in the urban planning of three town of southern Sardinia.

Recycling of C&DW produced by the demolition of a large building. The football stadium located in Cagliari (Sardinia, Italy, constructed in 1968) will be demolished and a new generation stadium will be built. The large amount of waste consists mainly of reinforced concrete structures. There are two important problem: the landfill disposal and natural aggregates (NA) supply. The Municipality of Cagliari, owner of the Stadium, authorized the research group to start an extensive experimental campaign to characterize the structural concrete element of Sant'Elia Stadium, the RA (according to the CE + marking) and the recycled concrete produced by RA, in order to evaluate their mechanical properties. Figure 1 shows the San'Elia stadium, the demolition operations, the C&DW recycling process and the RA produced.

Figure 1. By demolition to production of RA

The experimental data show that the San'Elia stadium structural concrete has a limited compression strength and the carbonation depth is important (compression strength 21 N/mm^2, carbonatation depth 31 mm). RA produced by demolished concrete, characterized according to the CE + marking, are suitable for structural concrete. Performance of recycled concrete made with coarse RA, even when the replacement percentage of coarse RA reaches 80%, are suitable for structural concrete. In all concrete mixes the same cement dosage was used. The performances of recycled concrete have comparable mechanical performances to the conventional concrete, with the same manufactoring process.

Use of RA in Precast Concrete Companies. Precast concrete companies can have advantages in recycling the scraps of their manufacturing processes or using RA by recycling plants, for the new elements production. This system reduces production costs (the cost of RA is half as much as NA), respects the CAM and therefore respect the Environment.

The concrete blocks are ordinary precast concrete elements, widely used in construction sectors. The experimental campaign to explore the feasibility of using the coarse recycled concrete RA in the concrete blocks production has been carried out. The experimental campaign has shown that it is possible to use the RA to produce precast recycled concrete blocks, without change manufactoring process and additional costs.

The performance (compressive strength and water absorption) are excellent even when the replacement percentage of RA reaches 100%. Figure 2 shows the production process and the performances obtained.

Mix	Average Density (Kg/m^3)	Average Absorption (g/(m^2 · s$^{0.5}$)	Average Compressive Strength (N/mm^2)
NA	2069	108.9	3.77
20% RA	2009	103.9	3.58
50% RA	2087	93.3	3.58
70% RA	2039	126.3	2.85
100% RA	1954	111.1	3.40

Figure 2. Concrete blocks manufacturing process with recycled aggregates and their performances

Use of RA and recycled concrete in the urban planning. Three case studies have been carried out in the South of Sardinia (towns: Carloforte, Calasetta and Portoscuso) to explore the feasibility of RA using in compliance with urban and coastal areas planning, that include construction of cycle and pedestrian path, new buildings and existing buildings maintenance.

The estimated amount of aggregate required for the new constructions is approximately 2 t/m^2, 0.1 t/m^2 for the maintenance of existing constructions and 0.5 t/m^2 for cycle and pedestrian paths. The evaluation shows that up to 800,000 tons of C&DW by concrete can be recycled. Figure 3 shows the towns geographical location and assessments.

Town	Calasetta		Carloforte		Portoscuso	
% RA	30%	80%	30%	80%	30%	80%
RA in new constructions (t)	8673	23127	15336	40897	18753	50008
RA in maintenance of constructions (t)	152	404	342	911	486	1296
Town	Calasetta		Carloforte		Portoscuso	
% RA	100%		100%		100%	
RA in subbase layers (t)	34198		167872		66989	
Town	Calasetta		Carloforte		Portoscuso	
Total RA (t)	43022	57729	183550	209675	86228	118794
Recycled concrete C&DW (t)	86044	115458	367100	419359	172456	236587

Figure 3. Towns geographical location and assessments

Conclusions

1. The concrete with coarse recycled aggregates has comparable mechanical performances to the conventional concrete, even when the natural aggregates replacement percentage reaches 80%.
2. The performance of recycled concrete is not related to the parent concrete mechanical properties, but it is essential to define carefully the mix design.
3. Concrete blocks, ordinary precast concrete elements, can be produced using RA, without changes in the manufactoring process. The recycled concrete blocks properties are not significantly affected by RA also when replacement percentage reaches 100%.
4. Waste mapping and selective demolition processes should be promoted and enforced to facilitate recycling.
5. Trade association, University of Cagliari Research Group and Regional Public Administration carry out pilot projects to demonstrate the feasibility of using recycled aggregates in structural concrete, in precast concrete elements and not only as fill materials or in road construction.

The Authors would like to acknowledge SardegnaRicerche for the financial support (POR FESR 2014/2020 - Asse Prıorıtarıo I “Rıcerca Scıentıfıca, Svıluppo Tecnologıco e Innovazıone”).

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REGIONAL POLICIES TOWARDS CIRCULAR ECONOMY. THE EXPERIENCE OF ABRUZZO REGION

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ABSTRACT

This article addresses and analyzes the role played by regional policies in promoting a transition to a circular economy. In particular, it will be presented the initiative named "Carta di Pescara" for sustainable industry, a programmatic document of the Abruzzo Region, co-designed together with the business and academic world, which incorporates the guidelines of European policies on environmental sustainability applied to industry. It represents a strategic and virtuous tool capable of stimulating and promoting the implementation of individual and collective initiatives inspired by the canons of circular economy and sustainable development. This article will describe the general features of the governance tool, highlighting the first results, the potential benefits as well as the criticalities of this initiative.

Keywords: *Regional Policy, Circular Economy, Sustainable Industrial Development*

Introduction

The "Carta di Pescara" for sustainable industry (CdP) [1] can be defined as a programmatic document of the Abruzzo Region, co-designed together with the business and academic world, which incorporates the guidelines of European policies on environmental sustainability applied to industry. It is characterized by a collaborative and facilitative/rewarding mechanism in which the voluntary adherence stimulates the implementation of individual and collective initiatives inspired by the canons of circular economy and sustainable development.

The CdP is inspired by the European Union's strategic orientation and its policies on the environment [2-4]. In particular, it is based both on the general European principles of precautionary, correction at source, proximity, prevention, sustainability, empowerment, and cooperation and the "Europe 2020 Strategy". This strategy played a relevant role in the path of development of the CdP, as it proposes a ten-year strategy for the advancement of the economy of the EU, in order to reach a smart, sustainable and inclusive growth [5,6]. At local level, this strategy provides that each member region defines its own Smart Specialization Strategy (S3) which allows the concentration of policy interventions in those application areas that may have relevance for the European regions, in terms of competitive advantage [7]. The Abruzzo Region, through the entrepreneurial discovery process implemented in 2015 to put into practice the S3, has identified its own specialization technological domains, among which there are Automotive, Life Sciences, Agri-Food, Fashion Design and ICT&Space [8], which were chosen for the CdP.

Methods

The article describes the general features of the CdP. In the following sections, the choice of stakeholders, the structuring process, the selection and definition criteria of the rankings, the rewarding mechanisms are described. The first results obtained, some data on the current members and the potential benefits as well as the critical aspects of this initiative are presented.

The research uses a scientific and secondary literature base and qualitative and quantitative data deriving from direct participation in the project and from direct interviews conducted with the regional referents of the initiative, as well as reports related to the results obtained so far.

The "Carta di Pescara": a brief analysis of the main features. The CdP is the result of a participatory path of co-planning developed together with the business and academic world; it offers companies that sign it a "business-regional partnership path" that recognizes specific advantages for companies that are committed to pursuing the goals of sustainable industry.

In view of this commitment, the Abruzzo Region identifies some benefits in terms of:

- simplified procedures (level of bureaucracy and local administrative costs are minimized);
- reduction of administrative and local taxes (regional taxes related to production activities are as low as possible);
- supporting legislation (dedicated legislative initiatives for simplification are on the way);
- priority (every call for proposal founded by European Regional Development Fund 2014 – 2020 Axis I and III is oriented towards the 5 technological dominions; among these, specific additional evaluation score is allocated for companies' partner of the CdP).

The main features of CdP are described below and the main steps of development are shown in Figure 1:

<u>The path of development</u>: From January 2016 about 500 SMEs and about 10 large companies have been selected, using the following criteria: SMEs participating to Horizon 2020 or to the Seventh Framework Program or at least to ERDF 2007-2013 Program; SMEs having patents registered in the last 2 years; SMEs investing in research more than the regional average, and so on. The selected stakeholders were directly interviewed in order to know their main prospects for medium-term investments. At this point, the decision to focus on environmental sustainability and circular economy, as they emerged as salient and challenging aspects by all the interviews, was taken. In fact, the companies involved, recognize the environmental sustainability as a "market choice" to be more competitive in the international benchmarking of their products.

How to join. To be eligible to become a CdP partner, the applicant must meet several conditions, having the environment as the priority. Depending on the number and type (quantity and quality) of conditions met, CdP membership may be "basic", "intermediate" or "advanced"; each level of membership will offer different types (or rate) of advantages. In the CdP, 61 is the total amount of the conditions recognized for the environmental, economic and social dimensions of sustainable development. Among the conditions of environmental sustainability (29 in total), were included solutions concerning the adoption and implementation of approaches and tools to minimize the waste and emissions; solutions for the recycling/re-using of water within the process; implementation of Life Cycle Thinking approaches for products and processes; solutions for the adoption of tools and approaches for waste treatments inspired by circular economy.

Local stakeholders involved: The CdP is the result of the active participation of all the stakeholders involved by the Abruzzo Region. Among them there are the three regional universities (University of Chieti-Pescara, University of L'Aquila and University of Teramo) and regional research centers, the unions, the innovation hubs, representing the 5 vertical sectors of the S3 chosen for the CdP (Automotive, Life Sciences, Agri-Food, Fashion Design and ICT&Space). At regional level, the Department of Production Activities, the in-house structures of the Abruzzo Region, and the regional offices corresponding to these activities, such as the Energy and Environment Office, were involved. A control room was therefore established, chaired by the Director of the Region.

Monitoring phase: The progress of the CdP and the monitoring of the actual implementation of the commitments undertaken by the Abruzzo Region will be carried out by a steering committee composed of the following members: General Director of the Abruzzo Region; Director of the Department of Economic Development, Labor, Education, Research and University; a representative of the regional university system; a business representative for each of the five technological domains of the regional S3; a representative of the trade union organizations.

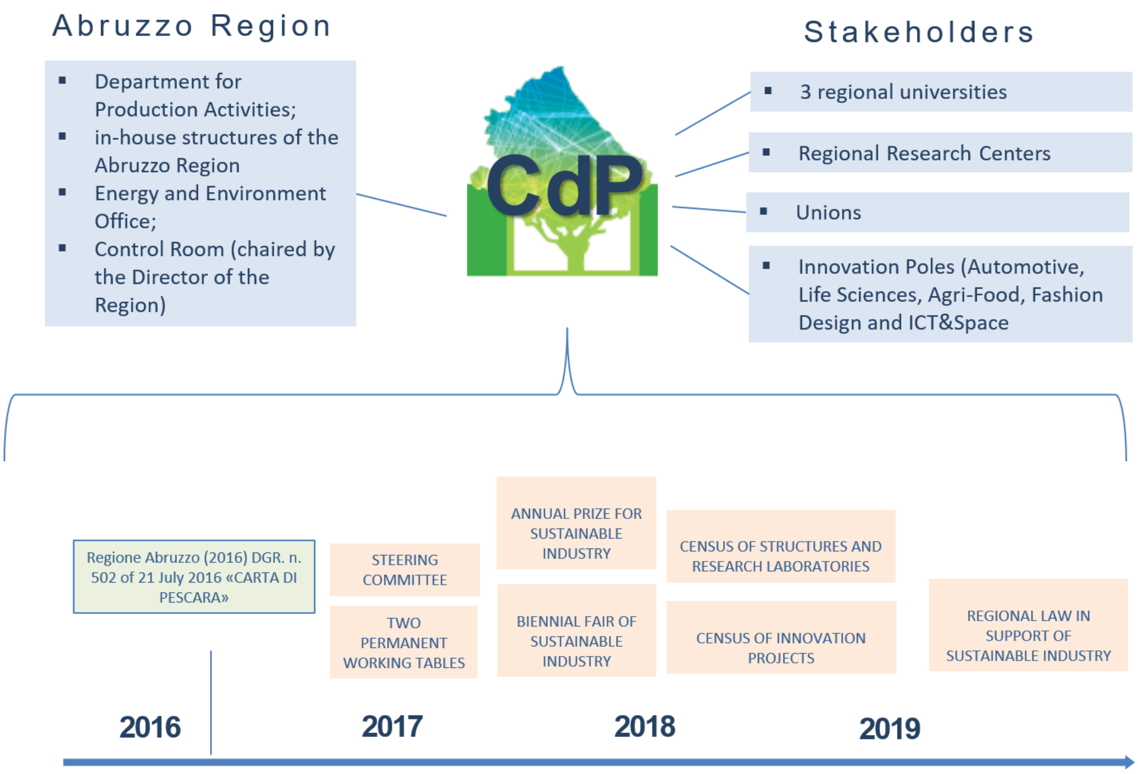

Figure 1. The path of development of the CdP and the main stakeholders involved

Discussion and Conclusion

The CdP can be considered a policy and local government tool, designed and developed to achieve the goals of circular economy and sustainable development, and, at present, it represents a concrete attempt to guide the change towards a regional model of circular economy.

It uses an open approach as any company operating in the Abruzzo Region can try to become a partner; it is immediate, as the relative web platform is managed directly by the regional offices, and at low cost, as no additional resources are needed to support and promote innovative and sustainable companies, using the funds made available by the EU.

At present, about 130 companies are officially registered on the CdP web platform, with different levels of affiliation: 12% advanced; 25% intermediate; 63% base and actively involved in circular economy-based processes; this can be considered a direct result of the initiative. Alongside it, it is worth noting some indirect results, such as: i) having stimulated companies to collaborate with each other and with universities and research centers (a foundation and an association were born from this collaboration in 2018 and 2019); ii) the possibility of orienting the European Regional Development Fund towards research programs that have given birth to innovative projects, making research projects admissible even outside the regional boundaries with effects on the regional territory.

Among the critical issues recognized, there is still a limited participation of small companies and a limited involvement of the regional training system. The future challenges will concern both the involvement of a growing number of small businesses by exploiting the experience of other (leading) companies that are already partners of the CdP to create an emulative and virtuous effect, and working with the regional training system in order to train professionals capable of operating in this new and evolving context.

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NETWORK ANALYSIS AS A TOOL FOR PLANNING INDUSTRIAL SYMBIOSIS IN THE FRAMEWORK OF REGIONAL POLICIES: CASE STUDY FROM BRESCIA

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ABSTRACT

The efficiency of industrial symbiosis programs is highly depended to the typology of networking relations among their partners, including the local industries, the public sector, and local policymakers. Networks at regional scale are commonly assessed by measuring one or more benefit(s) expected to be brought by them. However, the focus on the results may neglect the system characteristics and sustainability. This research uses social network analysis (SNA) as a tool for visualizing such features as well as the symbiosis potentials in an industrial zone of the province of Brescia. Different patterns of relationship among the nodes were compared to each other to have a more precise picture of the existing opportunities and threats. This approach can be used as a supporting tool for initiating the facilitated or planned regional industrial symbiosis. It also has the flexibility to provide updated assessments based on proposals for modification or scenarios for development.

Keywords: *Industrial Symbiosis, Social Network Analysis, Network, Regional Planning*

Introduction

Regional industrial symbiosis involves numerous advantages, including cost savings, reductions in the consumption of natural resources and waste minimization. However, there are also challenges in implementing symbiosis. These challenges are principally rooted in the initiation phase. The initiation of the regional industrial symbiosis is consisted of several steps such as mapping the potentials, creating trust among businesses and provision of the incentives [1]. These steps are usually undertaken by local authorities, public research institutes, industrial associations or maybe by a combination of them which are referred to as the facilitator organization or even by a leading local business. This organization has to encounter the followings problems:

- Policy development to shift from the linear economy to the circular economy;
- The leadership and investments of the private sector;
- The culture of collaboration between industries and research institutes;
- The flow of information to increase the stakeholders' awareness .

The process of collecting the basic information about the above-mentioned problems and identifying the potentials for IS initiation is usually referred to as mapping. It serves the policy making bodies to support local firms in a way that encourages industrial symbiosis solutions. This consists of data collection from a specific area and evaluation of the economical potentials for different models of synergic collaborations among the industries in that specific territory. It may be done by applying different methodologies of data processing for predicting and evaluating the possible scenarios from the economic and technologic points of view. Meanwhile the principal objective of regional industrial symbiosis is to be able to cover a wide range of actors' presence in the network. Therefore, network analysis approaches have the capacity to play an important role for this purpose. Social network analysis (SNA) has been used in practice for evaluating already stablished networks but not for a network to be developed. This study attempts to uncover the usability of SNA as a method for big data analysis in managing the collected data about the industrial potentials of an area (in territorial scale) and to find optimum scenarios for collaboration. Brescia as one of the leading European industrial territories has many potentials for moving toward circular economy through the innovative symbiotic pathways. However only a few studies were published about the industrial context of this area and possible synergic scenarios which are already developed. Therefore, we started with modeling a network for a small district with typical industries of the province in order to assess our SNA methodology in building regional resource scenarios.

Methods

Data Collection. In order to perform this research, we first accomplished a data collection phase to understand the geospatial distribution of industrial activities as well as the facilities and infrastructures required for preforming the symbiosis. An indicator for measuring the IS potentials in a region is the diversity of industrial sectors. Hence, data regarding the active companies in each economic sector (i.e. number of firms, their size based on the number of employees) was gathered for the each of the municipalities of the province. The network of Industrial symbiosis may engage various partners from quite different sectors such as waste management and energy businesses, research institutes, agriculture, etc. It was also attempted to survey similar information about these potential partners for each municipality.

Contextual considerations. Geographical proximity is considered as the decisive factor for initiation of the synergic collaborations among dissimilar companies [2]. It is the main principle in design of eco-industrial parks and APEAs (Ecologically equipped productive areas) in Italy [3], which can support the idea of industrial symbiosis by collocating different productive processes in a way that they can benefit from shared infrastructures and facilitated exchange of byproducts. For this reason, in the next step the collected data were transferred to the maps, in order to see the geospatial distribution of the activities and to assess the typical districts which may have the proper geographical proximity for IS activities [4]. The areas with high concentrations and high diversity of the businesses were identified [5], and the distances between the districts as the routes for sharing by-products were also measured. The province of Brescia consisted of different geographical zones with a mountainous region in the north, the high-density urban and industrial area in the center (mainly the municipal territory of the Brescia), and the plain agricultural regions in the south. The difference among the densities of the urban centers, which are in middle of agricultural regions and mountains, determined the conditions for considering the zones and boundaries for industrial symbiosis networks. In many cases, especially in the southeastern and southwestern parts of the province, industrial activities are collocated in districts in vicinity but well-separated from the historic urban centers.

These districts can be regarded as the cores for local symbiosis networks which may gradually be connected to each other and grow up to the scale of a regional network.

Network Analysis. After identification of the industrial districts, representatives of each type were chosen for a more detailed analysis. As steel making and foundries are among the main industries of the region, we focused on districts that contain these sectors and also considered the previous published data about the potentials of symbiosis in the region [6]. The analysis consisted of the following steps:

- Modeling the synergic relations in the environment of Gephi (an open source software for SNA);
- Comparing the current situation with already stablished well-known regional symbiosis examples at European and international level such as Kalundborg and Lubei [7].

This may be followed by one of these alternative pathways:

- Attempting to imitate the previous successful IS examples by modifying the network characteristics to obtain similar results for our system (changing the number of nodes or partners and/or changing the relations between them);
- Defining the characteristics based on theoretical research about innovative networks [8].

This way different scenarios may be presented for IS relations in an industrial district and its surrounding environment (agricultural activities, municipalities, etc.) until reaching satisfying network parameters.

The Parameters for network analysis. Average shortest path length (ASPL) and density (D) were the values which were calculated for characterizing the network. Meanwhile between-ness centrality (BC) values were calculated for each individual node for assessing its effect in relating the other ones. This value uncovers the role of each company in controlling the whole system as the central point of contact. The analysis is possible to be performed in two different conditions. In one hand it is possible to consider equal weights (social importance) for all the collaborations (Edges) which is the approach previously undertaken by researchers [7]. However, in order to make the model much closer to real cases, different IS relations should be given specific weights. Coefficients were defined to give weight to each type of resource exchange (energy, byproduct, waste, water) based on the available estimations about the weights of various resource expenses in total costs of production for different sectors [9].

Results

Seven different scenarios were presented for the synergic relations in an industrial district with typical manufacturing activities of the southeastern zone of the province of Brescia. The scenarios include centralization, decentralization, the closure of supply chain loop or leaving it to some extent open, along with various types of resource exchanges such as energy, waste, and water. Moreover, different scenarios were analyzed for controlling or encouraging the activities of industrial and non-industrial players as the central actors in the network, specially, in two different conditions (1) considering same weight for relations and also (2) giving specific weights to each type of collaborations.

Conclusions

Social network analysis is a capable method for big data analyses for large networks such as regional industrial symbiosis. In the analyses, we also considered the potential contributions from non-manufacturing sectors such as agriculture and municipal waste management system as stakeholders of the networks. Industrial symbiosis is always more meaningful when it is considered in relation to the surrounding environment [10, 11]. It was shown that the analysis of social relations between different partners can be a proper measure for decision-making and defining regional policies. Although the SNA results can be useful in case of considering the same weights for all synergic collaborations, more significant results might be obtained by applying specific coefficients for weighing different types of resource exchange. However, due to the lack of a standard method for calculating proportional weights, it can be a proposal for further research in future to make the SNA applications more fruitful. This can provide the possibility of doing a multi-criteria analysis of IS potentials.

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EXPLORING CROSS-BORDER INTERMODAL MANAGEMENT OF CONSTRUCTION AND DEMOLITION WASTE BETWEEN ITALY AND SWITZERLAND

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ABSTRACT

The 2007 crisis had a negative lasting effect in the Lombardy's construction industry, driving first tier suppliers to look up north to Canton Ticino, located in the Swizz Alp. In Switzerland, the crisis did not have the same effect as in Italy, in fact since 2010 the construction industry registered a steady growth. The Swizz Alps are key for cross-border for international freight movement between Italy and Switzerland, especially for Aggregates and Construction and Demolition Waste (A&C&DW). The Canton of Ticino's geomorphological characteristics of narrow roads and short distances between aggregate production in Italy, construction sites in Switzerland, and environmental recovery or recycling sites in Italy where the C&DW is deposited, constrain logisticians and transportation managers in both sides of the border to choose exclusively road transportation to fulfil their operational needs. This paper shows that cross-border A&C&DW trade, transport, customs-clearance, and their associated emissions contribute to externality costs worth 13% of the total A&C&DW direct value. It also evaluates a cross-border intermodal strategy to reduce the emissions and transport externalities.

Keywords: *Construction and Demolition Waste, Cross-border, Intramodality, Emissions, Externalities*

Introduction

In Europe, the Industrial Symbiosis (IS) concept gained substantial traction after the European Commission set sustainable development as a goal for the European Union [1]. The reason for this is the worldwide perception of IS as a core strategy for the promotion of the circular economy (CE), a key element of the sustainable development goals [2]. 'IS' means that an organization's waste can be the input for production or ancillary services for another organization. In this sense, IS may turn negative environmental externalities into positive environmental externalities [3]. In addition, this addresses negative transport externalities.

However, one of the limit to the IS has been highlighted in Marcinkowski [4] consists on the trade-offs between the benefits of covering longer areas to gain diversity in the materials exchange among IS participants, and the negative externalities associated with the longer transportation distance, for instance in terms of road ware, maintenance, emissions, diesel consumption, etc.

The Italian and Swizz regions of Lombardy and Canton Ticino, respectively, have a symbiotic exchange of materials in the sense of Switzerland receives virgin aggregates from Italy, as a result of their insufficient extraction capacity for their construction industry, and Italy receives construction and demolition waste necessary for environmentally recover of quarries.

The material exchange is exclusively transported by road, with a series of externalities associated. Thus, this paper presents an examination of alternative transportation management strategies to extend the rage of material exchange to reduce environmental externalities and transport externalities at the same time.

Methods

This is paper belongs to an exploratory research which analyses the phenomenon in operational and managerial dimensions, just as complex social environments in case studies [5]. The research required data and information gathering from actors in the aggregates and construction and demolition waste supply network. The research process follows recommended practices for supply chain and operations management studies, case selection, data collection, data analysis, and validation [6]. This is an exemplary case study investigation, where the main guidelines and experience were acquired from the Lombardy and Canton Ticino's operational data and information may be informative to all other regions with similar materials flows. The instrument for data gathering consisted in all cases in in-depth face to face interviews with concept-indicator links to guide the interviews as suggested in [7].

In addition, primary data was also obtained from public authorities at four governmental levels, i.e. communal, provincial, regional and national. Moreover, secondary data from public sources about operational information regarding the specific industry activities reinforced the analytical process, as a way to triangulate information to converge towards a validation of the research findings, as strategies in [8].

Cross-border materials flow. According of material exchange within the region was 1.8 million tons in 2018. This corresponds to a flow of virgin aggregates from Italy to Switzerland was 1.2 million tons, whilst the flow of C&DW from Switzerland to Italy reached 576 thousand tons (see Table 1). This shows a balanced growth in volume of exchange of aggregates to Cantone Ticino and C&DW to Lombardy.

*Road transport emissions and externality cost*s. The current cross-border management of materials flows is a rather simple process (see Figure 1), yet the implications in terms of emissions and externalities of the exclusive use of road transportation is unveiled in this study. There were 36 active transportation companies in the year 2018 registered with a total 317 trucks; of which 14% are rigid trucks and 86% semi-trailers. The average load for these transportation means is 25 tons per truck, depending on the type of C&DW [9,10].

The estimated transportation emissions associated to this cross-border management of A&C&DW, the estimates are as high as 8,042 tons of CO_2e; 7,919 tons of CO_2; 1.41 tons of CH_4; 122 tons of N_2O, and 3,191 tons of diesel equivalent.

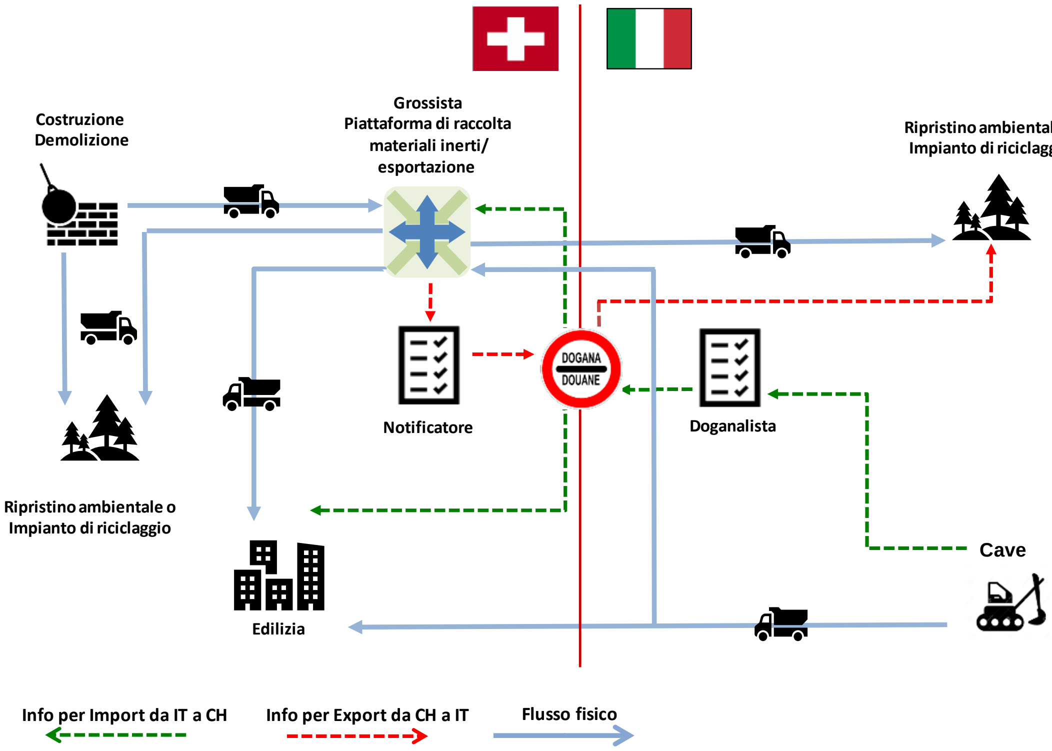

Figure 1. Cross-border management of virgin aggregates and C&DW between Canton Ticino (CH) and Lombardy (IT)
Source: Own elaboration

Scenarios for cross-border intermodal transportation management of A&C&DW. It was found that the mean distance of material exchange within of the IS Canton Ticino-Lombardy region is 50 km, with a maximum of 70 km. Beyond this distance, the transportation become unfeasible, both in terms of costs and operationally. For instance, the cost of transportation would be much higher than the cost of the material itself. Also, operationally, the transportation services are usually hired per day, and the transport provider is expected to perform at least 3 or four trips per day in order to meet demand of the construction industry and the narrow streets through where trucks need to circulate in Canton Ticino. Extending the transportation range reduces the likelihood of performing 3 or 4 round trips in a single day. This would lead transport service to use larger trucks and transport more volume per truck, however the geomorphological characteristics do not permit.

Alternative transportation strategies to address the cross-border intermodal management of materials exchange, include the balancing of trade of transportation, that is, trucks travelling full to Switzerland with Aggregates come back filled up with C&DW to Italy. That is full balanced transportation. Another alternative is the intermodal transportation management of materials exchange, where aggregates are transported in short distances to an intermodal platform in Italy, and C&DW are transported in short distances to an intermodal platform in Switzerland. The emission generated under different scenarios all based on 50 km distance are shown in Table 1.

In Table 1, Scenario 1 (S1), describes the equivalent emissions for transporting by road from Italy to Switzerland 1.2 million tons of virgin aggregates, and for transporting by road from Switzerland to Italy 576 thousand tons of C&DW. These are full load trucks on 25 tons and empty return trips.

Table 1. Scenarios for cross-border intermodal transportation management of A&C&DW, 2018 based scenarios

Scenarios	Scenario's trips codes*				ton CO_2e	ton CO_2	ton CH_4	ton N_2O	Diesel equivalent
S1	XAR	XER	IWR	IER	8,042	7,919	1.41	122	3,191
S2	XAT	XET	IWT	IET	3,220	3,187	2.90	30	1,284
S3	XAR		IWR	IER	6,484	6,394	1.11	89	2,576
S4	XAT		IWT	IET	3,142	3,110	2.83	29	1,253

Source: Own elaboration
**X (Export from Italy to Switzerland); I (Import from Switzerland to Italy); A(Aggregates); W (Waste); E (Empty truck); R (Road); and T (Train)*

Scenario 2 (S2), describes the equivalent emissions for transporting by road from Italy to Switzerland 1.2 million tons of virgin aggregates, and for transporting by road from Switzerland to Italy 576 thousand tons of C&DW. In this case, the trucks arriving to Switzerland are loaded with C&DW and transported back to Italy. The rest of the trucks of return empty to Italy. Scenario 3 (S3), describes the equivalent emissions for transporting by train from Italy to Switzerland 1.2 million tons of virgin aggregates, and for transporting by train from Switzerland to Italy 576 thousand tons of C&DW. These are also full loads and empty return trips. Scenario 4 (S4), describes the equivalent emissions for transporting by train from Italy to Switzerland 1.2 million tons of virgin aggregates, and for transporting by train from Switzerland to Italy 576 thousand tons of C&DW. In this case, the trains arriving to Switzerland are loaded with C&DW and transported back to Italy. The rest of the trains return empty to Italy (See Table 1).

Results and discussion

The scenarios clearly show several potential strategies to address the limitations posed by the cross-border road transportation of A&C&DW. One possibility for cross-border management strategy is that of coordinating the logistics operations for balancing trade with re-utilization of trucks for both, import and export, this could potentially reduce CO_2e emissions by about 18%. Another potential strategy would be that of cross-border transportation by train, which may potentially reduce emissions by around 60% with respect to the S1 scenario. It is expected that S3 scenarios may also be applicable to other cross-border regions exchanging materials in IS fashion, provided the rail infrastructure is available and intermodal platforms for the management of aggregates and C&DW are available. Given the financial cost of the transport externalities are 13& of the total value of the industry, intermodal scenarios may allow to reduce the equivalence of transport externalities from 13% to 8%.

The limitations of the work is the estimations of emissions and externalities from intermodal platform to intermodal platform, whilst future steps will include the estimations of the first and last mile distribution/transportation, i.e. from quarries to intermodal platforms in Italy, and from C&DW sites production to intermodal platforms in Switzerland.

In sum, an IS strategy that considers the use of trains transportation other than allowing the reduction of transport externalities, it allows to increase the IS catchment area for the exchange of material.

Acknowledgments

This is paper is part of the research project GeTRI (Gestione Transfrontaliera del Trasporto di Rifiuti Inerti e degli Inerti Vergini Intermodale) funded by the Programme Interreg Italy-Switzerland.

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CIRCULAR ECONOMY STRATEGIES AND ROADMAPS IN EUROPE

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The abstract and executive summary of the report published by the European Economic and Social Committee [1] are hereby reported.

ABSTRACT

The report reviews circular economy strategies in support to the European Circular Economy Stakeholder Platform (ECESP). Circular economy strategies have been under development in European cities, regions, and countries in the last few years. 33 strategies have been adopted since 2014, and at least 29 more are under development. Existing strategies were reviewed to identify similarities and differences, assess the involvement of civil society organisations, and potential for collaboration. The documents reflect a period of defining and understanding the circular economy concept and its possibilities. In this evolving context, strategies are valuable endeavours which draw attention to the topic, kickstart initiatives and bring stakeholders together. The report argues that documents developed in the future should put more focus on including broader sections of value chains, and on ensuring inclusive partnership approaches in all phases of the strategy's cycle. To date, circular economy strategies show different degrees of inclusiveness in terms of value chains and partner involvement. Limited inclusive approaches can be explained by the exploratory nature of most documents. This includes a stronger involvement of civil society organisations in earlier phases of strategy development, and not just for dissemination and citizen involvement. The report highlights the ECESP's role in gathering and sharing civil society's knowledge and making sure it's fed into the policy cycle for circular economy.

Keywords: *Circular Economy, Strategy, Inclusive Value Chains, Local Development Strategy, Material Efficiency, Stakeholder Engagement*

Introduction

The report reviews circular economy strategies in support to the European Circular Economy Stakeholder Platform (ECESP). Similarities and differences between circular economy strategies are reviewed to assist the ECESP in becoming more effective, particularly through collaboration and the involvement of civil society organisations.

Methods

33 documents have been reviewed for the study: 13 cover national levels, 9 regional, and 12 local levels. A higher number of strategies was found in areas where there were early strategy development activities, such as Belgium, Finland, the UK, and the Netherlands. The number of strategies at all levels is growing and the pace at which they are adopted is increasing (9 were approved in 2017, 12 in 2018). At least 29 new strategies are under development, which will bring the total number of strategies to over 60 at the end of 2019. Most new initiatives are at regional level in Spain, Portugal, and France, and at national level in central and eastern Europe. Upcoming strategies at regional and local level will improve the relative low number of documents at this level when compared to the national level.

Results

Strategies are more effective when they address the circular economy comprehensively and include broad partnerships.

Different approaches to inclusive circular economy models and thematic focus. To date, circular economy strategies show different degrees of inclusiveness in terms of horizontal tools and policies, sectors approached and partner involvement. Limited inclusive approaches can be explained by the exploratory nature of most documents: the circular economy approach and understanding is being tested, and broad, all-encompassing inclusive approaches are intended as subsequent steps of these developments. All strategies aim to further the transition to a circular economy, with slight differences depending on the territorial context. Strategies follow different approaches, either aiming to close material loops in specific value chains, or focusing on integrated, horizontal approaches.

Following this differentiation, the reviewed strategies are categorised in three types:

- Integrated strategies, like the ones for Päijat-Häme, France, Paris, Greece, Italy, Oslo, Poland, and Catalonia, largely focus on horizontal tools and policies. They aim at steering the public opinion toward the concept of circular economy;
- Strategies with a restricted sector focus, like Luxembourg, Amsterdam, Glasgow and London do not address a broad range of sectors. Including a large stakeholder base is also not a major concern, as normally only stakeholders directly linked to the selected loops are targeted;
- All-encompassing strategies with a clear setting of priorities, like strategies for Brussels, Denmark, and Scotland, keep a balance of the two approaches. Strategies of this kind most directly ensure the inclusion of both the broadest possible material loops and inclusive partnerships.

Strategies describe the economic sectors of manufacturing, food and feed and water processing in the most inclusive way. The most common economic sectors addressed are: manufacturing, construction, waste processing, and food and feed. The evolution of sectoral focus across geographies and time is analysed in the report. For instance, whereas early adopted strategies tend to focus on waste strategies and recycling, more aspects of value chains are increasingly considered in more recent strategies.

Horizontal topics introduce innovative concepts and practices that enhance circularity in multiple sectors. The implementation of horizontal sectors is closely linked to the capacity of strategies to be inclusive, both in terms of the comprehensiveness of value chains, and in stakeholder involvement. The most recurring horizontal sectors are: repairing reusing, and refurbishing; public procurement; design and eco-design; urban planning and development.

Partnerships supporting circular economy strategies. Circular economy strategies benefit from inclusive partnerships. Different players capable of providing the knowledge, funding or improving the regulation need to work together to bring about a paradigm shift. Strategies consider partner involvement in different ways. Public authorities have a key role in the strategies. In most cases they draft the strategies and have important roles in implementation. Civil society organisations have diverse roles in the reviewed strategies. Not every strategy specifically addresses this type of player, and their role is often behind the scenes, and not always explicitly reflected in the strategies. Civil society involvement is currently higher during strategy implementation than during strategy development. Although civil society organisations perceive themselves as co-developers and co-creators of strategies, they often have a role limited to implementation and dissemination. Civil society organisations can initiate grassroots movements in support of a circular economy, encourage their development and build links between different movements to scale up the initiatives. They can also provide knowledge on which strategies can be based.

Current state of play of inclusiveness and potential for future collaboration. All-encompassing strategies with a clear priority setting of sectors show the most inclusive thematic approaches. The most inclusive strategies are those considering balanced partnerships, involving all types of partners in different roles across the different stages of strategy development, and using different instruments for coordinating partner engagement. Combining these two aspects shows that the strategies for Flanders, Maribor, Finland, Porto and Denmark are the most inclusive. The strategies for Greece, Italy, and Paris have less inclusive approaches. There is a need for strategies to further develop inclusive approaches. Different ways forward are proposed following the review of strategies, encouraging collaboration between strategies and providing guidance in the form of an adaptable model strategy.

Civil society engagement has proven to be a valuable asset for policy makers; however, most strategies fail to include the civil society's point of view at the onset of strategy development. The ECESP acts as an aggregation point, and it should continue doing so by highlighting the potential for improved quality of circular economy strategies when knowledge from civil society actors is taken full advantage of. The ECESP coordination group members can support increasing inclusive approaches, for instance by further developing the opportunities for collaboration proposed in this study, by promoting the model strategy, and by liaising with EU institutions to provide technical assistance.

Model strategy illustrating ways to enhance inclusiveness. To provide guidance to strategy developers willing to develop new strategies, or updating existing strategies, the report outlines an adaptable model strategy illustrating the key elements and needs of circular economy strategies, and collecting learnings from existing strategies that can be used to develop new documents in a comprehensive way. Policy makers are invited to reflect on six elements of documents: rationale of the strategy; experience and links to other policies and strategies; strategy objectives; implementation measures; governance; and a monitoring and evaluation plan.

The use of the model strategy as a reference framework has the potential to improve the quality and consistency of strategies, contributing to a convergence toward a common understanding of the circular economy concept, eventually enabling a greater scope for collaboration between experiences in different territorial contexts. A convergence toward a more comprehensive and inclusive model strategy could also make for an enabling condition for more common tools and approaches at EU level.

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GOOD PRACTICES OF INDUSTRIAL SYMBIOSIS: CAP GROUP CASE STUDY

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ABSTRACT

Promoting a company culture oriented towards sustainability means sharing the value produced with the local communities through our industrial activity. The most interesting challenges are currently posed in the field of wastewater treatment. This case study describes the implementation by Gruppo CAP of an innovative project in the municipality of Sesto San Giovanni, focused on industrial symbiosis between the organic waste management industry and the sewage sludge treatment industry. The biorefinery concept will be applied on two different existing infrastructures merged for the project implementation: a wastewater treatment plant and a solid waste incinerator. The objective is to treat Gruppo CAP' sewage sludge - which is not valorized in agriculture - in a new fluidized bed incinerator suitable for the extraction of phosphorus from the residual ashes and to treat the organic fraction of municipal waste produced by the municipalities (shareholders of the existing companies) into the existing anaerobic digesters. The infrastructures, under public control, will allow to recover materials, biofuels and nutrients from the sludge and wastewater, but also to share the technological solutions through the construction of a research centre.

Keywords: *Shared Value. Sustainability. İnfrastructure. Biomethane, Biorefinery. Phosphorus*

Introduction

Protocol for the environment, infrastructure and territory. Among the 5 priorities of the Regional Development Program, "sustainability as a distinctive element of administrative action and as an opportunity to improve the life of citizens, reconciling the needs of productive growth and involving all the actors of the territory, from businesses, to citizens, from schools to public administrations" is a key aspect to pursue, and the present project goes towards this direction.

Regional waste plan. The circular economy package sets new and more stringent objectives for resource use efficiency and waste management, recycling and reuse and landfill disposal.

Regional energy and climate plan. The transition to a low carbon economy, as a response to climate change, has triggered a progressive re-launch of the goals of decarbonization and energy evolution at all institutional levels. The new regional energy climate plan, synergistic with these objectives, will define the framework for the actions of orientation and implementation of this transition, responding to the logic of environmental and social sustainability and technological innovation.

Research, innovation and technology transfer program. The Program is the governance tool with which we intend to trace the lines of development for the future of research and innovation. The objective is to point out that innovation is the main key to fulfil organic and sustainable growth, with the support of new methods and systems capable of increasing the efficiency of governmental choices.

Methods

This is the framework we used, starting from 2016, in order to redefine our approach on sewage and wastewater operations, analysing in detail the performance of each plant and the general process organization, to optimize the treatment processes and to make significant changes moving towards a resource recovery approach. Within the scope of this activity, we drew up a roadmap and a detailed Master Plan towards the Circular Economy for CAP Group.

The entire process reorganization is inspired by circular economy principles. Following the European Commission circular economy package, we started discussing and reasoning, within the company and with our stakeholders, over the role of the water sector in helping to radically change our production and consumption models, so as to obtain a truly sustainable development of the country and a rational use of the end resources that we deal with every day.

With these premises in mind, and considering that the revolution of our sector from a linear to a circular process will not be based only on technology development but also on the organization of our work processes, communication and industrial symbiosis with other markets, we have implemented our Master Plan. Its goal is to enhance the value of what we already have: treated wastewater and excess sludge.

Quantitative data, on which the entire project is based, are depicted in the following tables and figures.

In Table 1 are reported the trend of the different destination for the dewatered sludge of Gruppo CAP in last years and in Table 2 the quantity produced with a clear indication of the increasing disposal cost (+65% in 3 years). The sludge line of the future plant will treat 65.000 ton/years of dewatered sludge.

Table 1. Destination of the sewage sludges produced by Gruppo CAP wastewater treatment plants

DESTINATION	2015	2016	2017	2018	2019 estimate
AGRICOLTURE	56,00%	77,40%	69,70%	38,50%	32,12%
LANDFILL	40,00%	16,20%	1,10%	3,50%	9,33%
CEMENT INDUSTRY	4,00%	2,30%	4,70%	3,30%	2,98%
FERTILIZERS	0,00%	0,00%	5,00%	23,30%	23,37%
CO-INCINERATION	0,00%	4,10%	19,40%	31,40%	32,21%

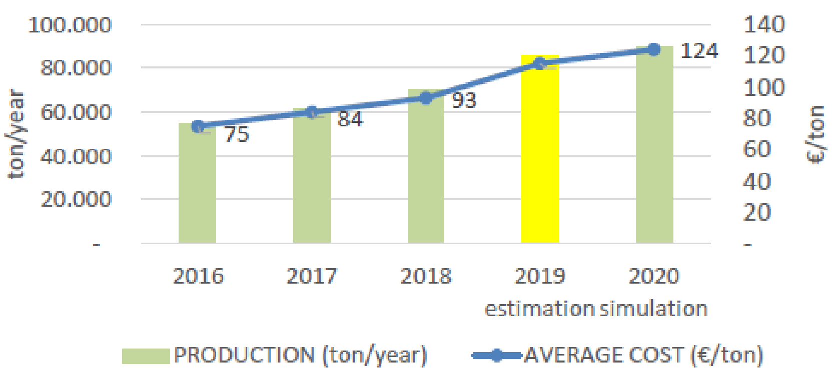

Figure 1. Costs

In Table 2 are reported the quantity of the organic fraction municipal solid waste produced the 5 municipalities owners of the Waste-to-Energy plant that will be converted within the project. The overall treatment capacity will be 30.000 ton/years of organic waste.
In Figure 2 is reported the timeline of the project.

today

Fonte Arpa Lombardia 2016

UNDIFFERENTIATED MUNICIPAL WASTE		ORGANIC FRACTION OF MUNICIPAL WASTE	
COMUNE	t/a	t/a	Kg/ab a
CORMANO	2.383,69	1.830,94	91,41
COLOGNO MONZESE	7.457,50	4.089,64	85,66
PIOLTELLO	5.636,17	2.991,97	81,06
SEGRATE	8.370,34	3.557,34	100,96
SESTO SAN GIOVANNI	19.195,95	1.713,02	20,94
TOTAL	43.043,652	14.182,91	76,00

To the existing incinerator — To external plants

tomorrow

To external «big» incinerators (with a reduction of 15.000) — **To the biorefinery (up to 30.000 t/year)**

Table 2. Municipal waste destination

Figure 2. Time schedule

Results

Sludge: diversified activities. Regarding the aspects of circular economy and the recovery of value, the focus is the excess sludge. Changing the traditional perspective, WWTP sludge is and no longer a waste but a potential source of several nutrients, and the treatment process has great potential from the point of view of the production of energy and biofuels (biogas and biomethane).
Some of the activities are already fully operative, some are getting under way and others are at the study and analysis stage. The aim is to perform the operations organically on all our treatment plants, that is, a distributed regional platform of competence and innovation. In every situation, we try to apply solutions that can be replicated in a modular manner on other plants of the Group.

Thanks to anaerobic digestion we already produce biogas, which is used in CHP (Combined Heat and Power) units, while from other processes is possible to obtain fertilizers (calcium carbonate and mixed compost amendment), volatile fatty acids (that will be initially used as C-source to replace some chemical reagents used in the water treatment line). VFAs are also chemicals on which we will subsequently start experiments aimed to the production of bioplastic.

Moreover, at the treatment plant of Bresso-Niguarda, in the northern outskirts of Milan, we have produced the first filling station of methane produced from sewage.

*From treatment plant to biorefinery***.** In this setting, the CAP Group has established relationships with universities specialized in the sector, which coordinate or participate in vast European innovation projects for selecting, developing and implementing innovative and reliable strategies and techniques that culminate in the transformation of the existing treatment plants into biorefineries, within the scope of a transition from a linear economy to a circular economy. This is the setting of the latest innovative project of CAP Group in Sesto San Giovanni, centred on industrial symbiosis between the waste sector and the wastewater treatment sector.

The biorefinery concept of the new treatment plants would apply to the existing infrastructure, consisting of a treatment plant and a waste-to-energy plant, and would entail creating a centre of excellence and innovation under entirely public control that can be used not only to recover materials, biofuels and nutrients from the sludge and wastewater, but also to share the technological solutions through the construction of a research centre where experts, operating also on an international level, can validate the best environmental technologies on a pilot or demo scale, sharing the results obtained with the public and other stakeholders.

The CAP Group's proposal therefore consists in enhancing the value, through industrial symbiosis, of the public assets, that is: the waste-to-energy plant (with the hypothesis of establishing a single line rather than the three existing ones) and the WWTP plant for treating the sludge and the growing volumes of OFMSW (an effect of increasing the separate waste). The idea is to recovery materials and energy, and to treat with monoincineration the sludge non-recoverable in agriculture, in addition to the organic fraction of municipal solid waste from door-to-door collection.

The creation of a centre of innovation in the circular economy – connected on a network with the other treatment plants managed by CAP – will enable us to experiment with and implement the continually developing technological innovations, sharing the technological decisions with the local community.

Finally, alongside the plant, a wetland will be set up together with a nature trail for the public, which adds new naturalistic quality and ecosystem elements to the area, as well as forming an environmental filter between the outlet of the treatment plant and the receptor watercourse.

Discussion and conclusion

In this way, the area would have a certain future, maintaining its current industrial vocation but regenerating itself also as an innovative research centre dedicated to an entirely publicly-owned circular economy. A truly green innovation centre, the first in Italy, which represents the core of the metropolitan network of all the treatment plants managed by the CAP Group for experimentation on wastewater, also through collaboration with its partners in the Smart Plant Project (financed by the EU within the scope of the Horizon 2020 targets), University di Verona, Politecnico di Milano, University Bicocca and the CNR.

The area, completely renovated, will host researchers and start-up companies committed to developing new eco-friendly solutions to transform what used to be waste into products with high added value.

A fully-fledged green biorefinery that will produce biomethane and heat, recover nutrients and produce compost, bioplastic and phosphorus. The availability of treated water would enable it not only to be reinjected into the nearby Lambro river, as currently done, but also to be used to irrigate neighbouring countryside areas, including the parks of the Adriano district of Milan.

WHY COMPANIES DO NOT IMPLEMENT INDUSTRIAL SYMBIOSIS?

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ABSTRACT

This paper is aimed at highlighting the main barriers hampering the development of the industrial symbiosis (IS) practice. The study is divided into two parts. First, a systematic literature review was conducted, in order to identify the barriers mentioned in the literature. 77 papers published by scientific international journals were analyzed and the barriers to IS were classified according to their nature (i.e., technical, economic, legal, and strategic) and according to five steps of IS (i.e., awareness, feasibility assessment, partner identification, implementation, and operation over time). Then, a survey was designed, in order to collect feedback from IS experts on the extent to which the barriers identified by the literature review are perceived as significant.

Keywords: *Industrial Symbiosis, Barriers, Systematic Literature Review, Survey*

Introduction

Industrial symbiosis (IS) is a subfield of industrial ecology that engages separate industries in a collective approach to competitive advantage, involving physical exchanges of materials, energy, and services [1,2]. Through IS, companies can replace production inputs with wastes and by-products generated by other companies. As a result, companies can reduce their production costs and contribute to generate environmental and social advantages for the overall collectivity. Nevertheless, the adoption of the IS approach is not largely spread across companies. A recent work by Mortensen and Kørnov [3] highlights the critical factors impacting on the initial phase of creating symbiotic relationships. However, a comprehensive view on all the barriers that companies face when operating IS, not limited to the emergence phase but addressing also the implementation and operation phases, is lacking in the literature. Furthermore, there are no studies ranking these barriers according to their perceived importance. This paper aims at filling these two gaps. First, through a systematic review of the available literature, we identified the barriers for companies and categorized them according to their nature, as well as according to the steps of IS adoption. Then, we designed a survey, aimed at collecting information on the extent to which these barriers are perceived as relevant by experts of IS. The rest of the paper is structured as follows: Section 2 presents the methodology, Section 3 presents and discusses the results, and Section 4 describes the conclusions.

Methods

The study is based on a systematic literature review started on July 2019. The first step was to collect papers. The data were retrieved from Scopus, an academic citation indexing and search service of Elsevier. The following research keywords have been applied to title, abstract, and keywords of papers to cover the largest possible selection: ("industrial symbiosis" OR "industrial symbiotic network*" OR "eco-industrial park*") AND "barrier", limiting the research to papers published in English in international scientific journals. As a result of the research, 77 papers were collected. For each of them, we analyzed the full text, aimed at collecting relevant information on the IS barriers mentioned. The main barriers to IS described in the analyzed papers were identified and categorized according to their nature (i.e., technical, economic, legal, and strategic), as well as according to five steps of IS (i.e., awareness, feasibility assessment, partner identification, implementation, and operation over time). Then, based on the barriers identified, a survey has been designed, aimed at collecting feedback from IS experts on the extent to which the above-mentioned barriers are perceived as significant. The survey is made by several statements: for each of them, respondents were required to select the extent to which they agreed or disagreed with that statement, according to a 5-points Likert scale (1 = full disagreement, 5 = full agreement). Ten respondents were selected, five academics and five company managers. Results were collected between September and October 2019.

Results and discussion

Table 1 shows the main barriers identified, categorized according to their nature (rows) and the IS step to which they belong (columns). It can be noted that, in the awareness phase, companies face barriers related to the strategic nature.
Legal barriers hamper the feasibility assessment phase. Finally, technical and economic barriers impact on the partner identification, implementation, and operation over time.

Table 1. IS barriers categorized according to their nature and the IS step to which they belong

		Awareness	Feasibility assessment	Partner identification	Implementation	Operation over time
Technical	Barriers related to the waste-to-input conversion		✓			
	Mismatch between demand and supply of wastes			✓		
	Lack of information			✓		
	Lack of space to stock wastes				✓	
	Fluctuations in the demand and supply of wastes					✓
Economic	Lack of economic incentives		✓			
	Investments required		✓			
	High transitions costs			✓	✓	
	Benefits not fairly shared among the involved companies				✓	
	High transportation costs				✓	
	Fluctuations in the waste disposal and input purchase costs					✓
Legal	Legal requirements and bureaucratic procedures		✓			
Strategic	Lack of awareness on the potential benefits of IS	✓				
	Lack of awareness of the IS basic concepts	✓				
	Low propensity to innovation	✓				
	IS is far from the core business	✓				
	Lack of trust among companies	✓				
	Lack of willingness to cooperate	✓				

Table 2. Main results from the survey (T = technical, E = economic, L = legal, S = strategic)

T	E	L	S	Statement	Average value
	✓			Companies are willing to implement IS synergies only if they are economically convenient	4.25
	✓			Low waste disposal costs drive companies to dispose of their wastes without implementing alternative solutions	4.25
			✓	Companies are focused on their core business and IS is not perceived as a strategical activity	4.25
	✓			IS synergies have to be convenient enough for all the involved companies. Hence, the benefits created by the synergy should be fairly shared among the involved companies	4.17
	✓			When companies are not close-by, waste transportation costs are too high in comparison to the potential benefits	4.17
	✓			Economic benefits from IS might fluctuate over time	4.08
✓				The mismatch between potential demand and supply of wastes is affected by the lack of information and communication among companies	4.08
✓				There are relevant operational problems, e.g., concerning quantity and quality of wastes, as well as transportation time and mode	4.08
		✓		Some legal requirements ruling waste exchanges are old and hamper the establishment of IS synergies	4.08
		✓		Some bureaucratic procedures ruling waste exchanges are too complex and hamper the establishment of IS synergies	4.08
			✓	Companies do not implement IS because they face difficulties when integrating this practice into their current business models	4
		✓		The lack of a clear legislation on waste exchanges hampers the establishment of IS synergies	4
			✓	If companies do not take into account the need of their symbiotic partner(s), the risk of failure of IS relationships is high	4

Table 2 shows the main results of the survey. In particular, the statements characterized by average score higher than or equal to four are shown. Each statement is categorized according to the nature of the related barrier. Statements are ordered by decreasing value of average score.

It can be noted that five of the first six statements concern economic barriers. In this regard, companies would like to implement only IS relationships economically convenient and, in some cases, the low waste disposal costs and input purchase costs are perceived as strong barriers. In fact, the higher these costs, the higher the economic benefits coming from IS, and therefore higher the economic convenience of IS will be, ceteris paribus [4]. Furthermore, all the involved companies have to gain sufficient benefits from the relationship, otherwise they are not interested to cooperate. This means that the overall economic benefits created by IS should be fairly shared among the involved companies.

Finally, the transportation costs limit the geographic scale of IS relationships. This means that, for companies located not close-by, the IS relationship might be not convenient enough because transportation costs erode the economic benefits created by IS.

Concerning the technical barriers, two operational problems are perceived as strongly relevant, i.e., the mismatch between demand and supply of wastes and issues related to the waste quality. From the strategic perspective, companies are focused on their business and IS is not perceived as a strategic activity.

However, even companies able to overcome this barrier might face problems when integrating the IS practices into their current business models. Finally, from the legal perspective, the respondents to the survey agree on the fact that legal requirements and bureaucratic procedures are, in some cases, too complex to deal with, or the legislation concerning waste disposal is not clear enough with reference to the IS practice.

Conclusions

This paper was aimed at identifying the main barriers hampering the creation of IS relationships among different companies and clarifying the extent to which these barriers are perceived as relevant by experts of IS. According to the findings, economic and technical barriers are perceived as the most significant. Overcoming these barriers is fundamental in order to promote the development of IS. Policymakers can have an important role in such direction. For instance, they can design economic incentives for companies adopting IS, with the aim to increase the economic profitability of investments in IS [5]. Furthermore, they are in charge for reducing the legal barriers to IS, in particular by making the legislation ruling the waste exchanges clearer and less complex. Technical barriers are more difficult to address. In this regard, future research should address how to tackle the operational problems of IS, aimed at providing solutions able to ensure the match between demand and supply of wastes, as well as to solve logistic issues. Furthermore, further analysis is required to verify whether different perceptions of the same barrier might arise when considering experts from different geographic areas.

Acknowledgements

This study has been funded by Sapienza University of Rome within the project "Critical factors for the development of industrial symbiosis in Italy: accelerating the transition towards the circular economy".

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LIMITS AND OPPORTUNITIES OF MUD DATA FOR THE DEVELOPMENT OF CIRCULAR ECONOMY STRATEGIES IN AN INDUSTRIAL AREA

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ABSTRACT

In the last years, the strategies developed in response to the growing production of waste have been oriented towards a circular economy approach, starting from minimizing the waste generation up to increasing its recycling and its energy recovery. This research focuses on waste produced in an industrial area located in Trieste, that aims to increase its level of sustainability. The output is a database that combines the list of companies settled with the related waste data, obtained from MUD (Modello Unico di Dichiarazione Ambientale, a mandatory companies waste assessment) and a series of information relating to the company balance, its activity sectors and its dimension (Innovation Intelligence). The analysis of the results permits to identify limits and opportunities of this methodology based on the MUD, replicable in similar contests. Moreover, the data collected are included in GIS, made available to the stakeholders to identify feasible circular strategies as industrial symbiosis.

Keywords: *Waste, Circular Economy, MUD Data, İndustrial Area*

Introduction

The European Union's approach to waste management is based on the “waste hierarchy” which sets the following priority order: prevention of waste production, maximization of reuse and recycle, recovery of waste energy value, and as the last option the disposal in landfill. In this scenario, Italy occupies the first place among the European countries in the matter of the circularity of the material: in 2017, 65% of the total industrial waste produced (about 139 million tons) was applied to recovery, mainly of material [1]. Despite this primacy, the challenges on the “circularity” of the production processes are several as for the implementation of industrial symbiosis interventions. The knowledge and monitoring of waste generated within a defined area represent an indispensable tool for planning waste management systems intended to promote the sustainable development of industrial areas and symbiosis practices.

This study fits into this context. Area Science Park[1], with the project ARGO[2] supports the industrial consortium CoSELAG[3] in the creation of a database of waste produced by the belonging companies and in its inclusion in a geographic information system (GIS), using MUD data and other business information. The goal is to experiment in the industrial area of Trieste a methodology that can be replicated in other similar territorial contests, aimed at outlining

[1] The Scientific and Technological Research Area of Trieste - Area Science Park is a national public research body supervised by the Ministry of Education, University and Research (www.areasciencepark.it)

[2] The Argo system is the result of an agreement between MIUR, MISE and the Autonomous Region of FVG. The coordination of the activities is carried out by Area Science Park (www.sistemaargo.it)

[3] Consorzio di Sviluppo Economico Locale dell’Area Giuliana (www.coselag.it)

strategies in accordance with the principles of the circular economy and a low environmental impact.

Methods

The MUD (Modello Unico di Dichiarazione ambientale), established with Law n. 70/1994, is the model by which the waste produced by economic activities must be reported to the Chamber of Commerce, Industry and Crafts and Agriculture (C.C.I.A.A.) of the territory. The chamber system is the collector of MUD declarations, while the system of Environmental Protection Agencies plays the role of data manager.

The MUD declaration models are issued by Decree of the President of the Council of Ministers; the last one has been issued in December 2017.

The subjects required to submit MUD are those identified in art. 189, subsection 3 and 4 of Legislative Decree 152/2006, in addition to those referred to the art. 4 of Legislative Decree 182/2003 and art. 220 of Legislative Decree 152/2006. In the case of companies with more than one local unit, the declaration must be submitted for each local unit if required by the articles mentioned above.

This model is a valuable information source for the creation of a database of waste flows, concerning types (EWC, European Waste Codes) and quantities.

It can be utilized for several goals also by public administrations, as the planning and monitoring of industrial waste management [2], and by the academic literature reviews [3, 4]. In terms of industrial symbiosis, defined as a form of organization of inter-company relations with the aim of generating mutual benefits and optimizing their own material flows utilization through the exchange of matter, energy and infrastructure [5], the knowledge of the types and quantity of waste produced and the producer companies, represent the starting point for creating a network and identifying possible synergies within an area.

This research is based on data from MUD of the year 2017, made available by ARPA, to analyze the production and management of industrial waste within the limited COSELAG area. This consortium spreads over three municipalities (Trieste, Muggia and San Dorligo della Valle-Dolina) for a total of 810 ha, of which about 300 ha fall on the Site of National Interest of Trieste.

The data on waste have been crossed with the ones related to companies involved. The business data for societies of capital were derived from the platform Innovation Intelligence developed by Area Science Park in collaboration with the University of Trieste. Innovation Intelligence is a Business Analytics tool that collects, integrates and processes data of all capital companies in Friuli Venezia Giulia (FVG), with a focus on innovation. The platform is updated on an annual basis and it is divided into 14 sections as registry and locations, activities sector (ATECO, Classification of economic activities by Istat), structure (including the number of employees), economic and financial performance, budget controls, certifications, regional and European research, patents, innovation, and internationalization level.

Among these data, the number of employees and the sector of economic activity (ATECO) were fundamental in identifying the subjects with the obligation to submit the MUD declaration.

Results and discussion

The output of the research consists in a database with information on the typologies (EWC) and quantities of waste generated within the industrial area, the companies involved in waste production, their sector of activity and other business information as companies size, innovation level, and turnover. The analysis of data can be developed in several directions as planning a more circular waste management, identifying possible industrial symbiosis between companies, and monitoring the most impactful waste flows and sectors of activity.

The industrial waste generated within the industrial area is over 287.000 tons. The types of waste with higher production are those of the EWC 17 – waste from construction and demolition operations (54% of the total) and 19 – waste from waste treatment plants, wastewater treatment plants off-site, drinking water plants (34% of the total), followed by the EWC 20 – municipal waste - and 13 – spent oils and liquid fuel residues (both around 7.000 tons) (Figure 1).

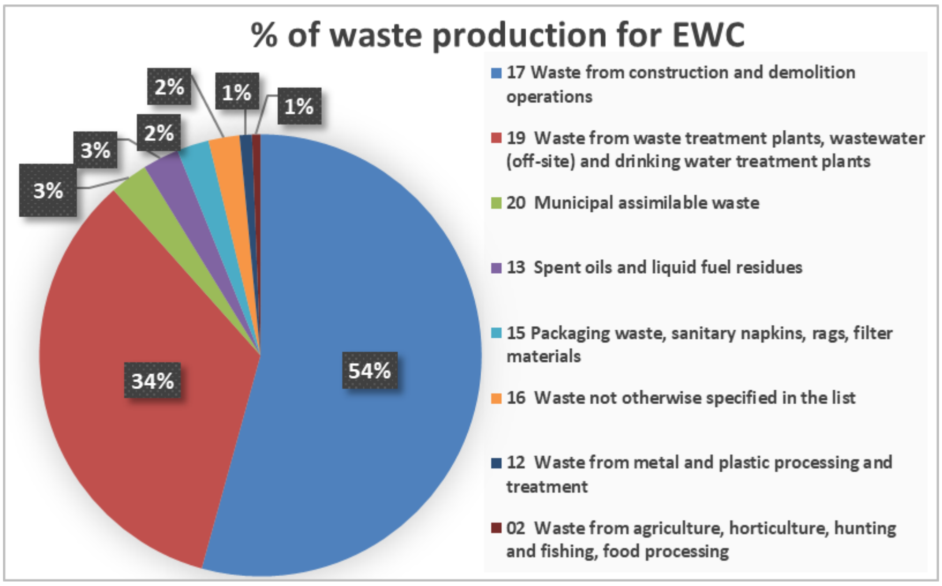

Figure 1. Percentage of industrial waste counted in the study area classified by EWC

Out of the total MUD declared, 55% contained at least one hazardous waste code but the results show that less than 6% of the total waste produced in that area is classified as hazardous. This percentage is in line with the one presented in the Regional Plan for the management of industrial waste for FVG [2].

It should be noted that 94% of registered waste is produced by capital companies. For the latter, the waste data was crossed with their business sectors, to identify which are the most impactful sectors (ATECO) in terms of waste production, but, at the same time, the most interesting in terms of possible synergies for industrial symbiosis development.

In the following analysis, it was chosen not to consider the waste referred to the EWC 19, which is the waste produced by waste treatment plants, replicating the methodology set out in the Regional Plan for the management of industrial waste for FVG [2]. That choice is dictated by the need to describe the real impact of the production activities that operate within the area of competence of CoSELAG. Considering production data also those from waste treatment plants could lead to a double accounting of the same waste, before and after the treatment, and therefore oversize the real production. However, it should be specified that the waste treatment plants could also treat waste produced outside the CoSELAG area; not having enough data to be able to divide the two flows, it was chosen, as a precaution, to exclude the mentioned waste.

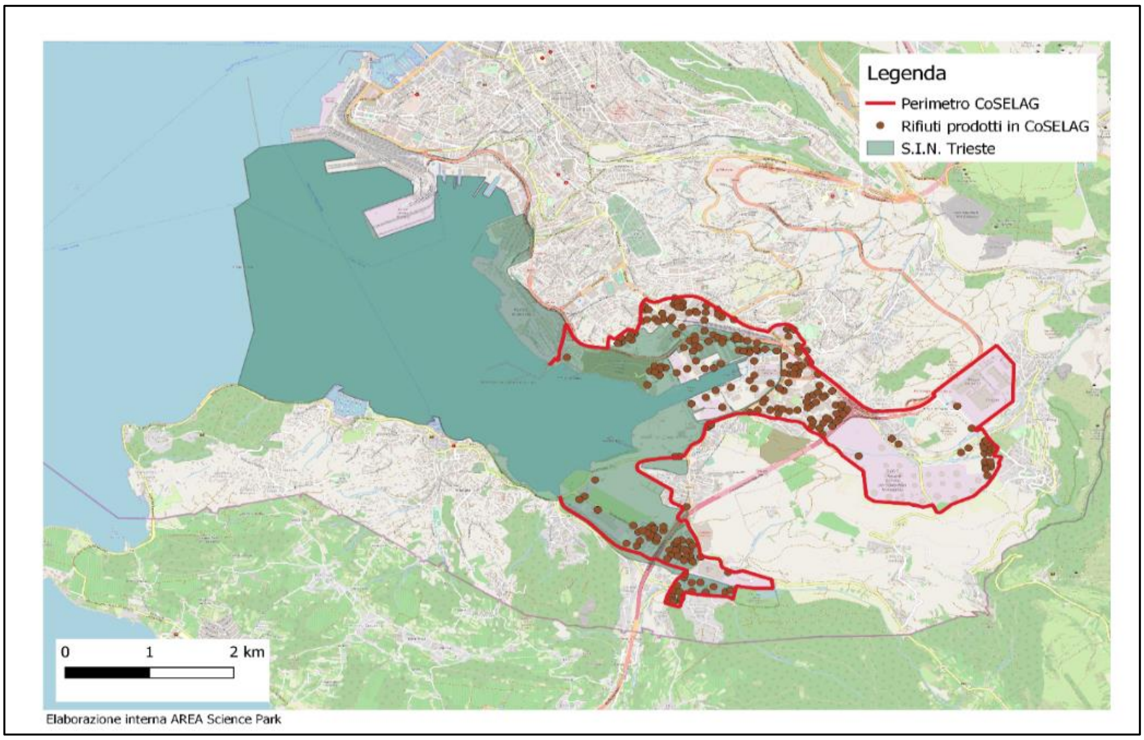

Figure 2. The boundary of the area belonging to CoSELAG and location of the waste-producing companies identified by MUD

Another important aspect of the described methodology is the geographical representation and IT management of information concerning the production of waste. The database created was included in a GIS application (Geographic Information System), containing the location of each company analyzed and, consequently, the georeferencing of the waste produced in the industrial area (Figure 2).

The developed GIS is therefore configured as a means of planning and analyzing territorial data to simulate sustainable development scenarios and strategies, making it accessible to all stakeholders through a dedicated web infrastructure.

Conclusions

The analysis of the results allows to identify limits and opportunities related to a methodology relying on MUD data.

The main limit, intrinsic to the non-mandatory nature of the MUD for certain categories of firms, concerns the lack of data on the not hazardous industrial waste referred to the activities mentioned in the points c), d), g) of the art. 184 c. 3 of Legislative Decree 152/2006 (with less than 10 employees) and in the points a), b), e), f), h) of the art. 184 c. 3 of Legislative Decree 152/2006, reducing the coverage rate on the settled realities. Of the total local units present in CoSELAG, 35% declared MUD; for the remainder not obliged (companies with less than 10 employees or with activities in the sectors mentioned in points a), b), e), f), h) of the article 184 c. 3 of Legislative Decree 152/2006), data on waste are not available. This limit can be resolved through indirect sector analysis or direct interviews with companies.

The presented methodology can be replicated nationally in other similar industrial areas and it can be a useful tool for three different types of subjects:

- Local and regional policymaker, with the aim of monitoring industrial waste and process management plans;
- Industrial consortia, with the aim, in addition to those of the previous point, to evaluate feasible projects of industrial symbiosis, with a top-down development approach; in this case, however, MUD data should be accompanied by information related to the production inputs of the companies involved;
- Private stakeholders, which could use a database of this type, together with the georeferencing of produced waste, to assess the extent of certain flows and the location of their production plants, whether they are recovery/disposal plants or aimed to exploit synergies with the neighboring subjects.

Finally, it should be noted that the presented methodology can be further developed by analyzing the waste streams destination, determining the percentage recovered and/or disposed of inside and outside the area under study.

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BEST PRACTIES ON INDUSTRIAL SYMBIOSIS IN BOLOGNA (ITALY) AND CONTRIBUTION TO REGIONAL POLICIES

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ABSTRACT

Overexploitation and competitiveness over shared freshwater resources are some of the growing problems that affect many regions of Italy, especially Emilia Romagna. Private and public sectors are driven to find alternative strategies to conserve the water resource and guarantee a future use to all. The Italian affiliate of Philip Morris Manufacturing and Technology Bologna (MTB), with support of the INOGEN International Alliance and environmental consultants Denkstatt and HPC, implemented the Alliance for Water Stewardship (AWS) in order to promote a sustainable water use in Emilia-Romagna as the second certified AWS site in Italy.

***Keywords**: Water Use, Innovation, Sustainability*

Introduction

Water is a key resource and most essential element of life, yet less than 1% of Earth's fresh water is usable [1]. In 2019 the World Economic Forum listed water scarcity, the lack of sufficient available water for usage demands, as one of the largest global risks of the 21st century. Overuse, increasing demands, pollution, unsustainable management and changes in weather patterns due to global warming are key stressors that are affecting water availability and triggering water scarcity. The United Nations foresee two-thirds of the world's population living in water-stressed environments by 2030 [2]. The potential impact on the environment and humanity could lead to a water crisis that would face over 6 billion people, in conflict over water for basic needs. The sustainable management and conservation of this fundamental resource is a shared responsibility and a rapidly growing worldwide demand that faces every single country. Italy, as most Mediterranean countries, is dominated by a temperate climate but with an uneven distribution of rainfall between north and southern regions, which does not allow a uniform water use or reserve. According to the Water Risk Filter, the Italian regions of Sicily, Puglia, Molise, Campagna, Toscana, and Emilia-Romagna are amongst those most subjected to high water depletion risk [3].

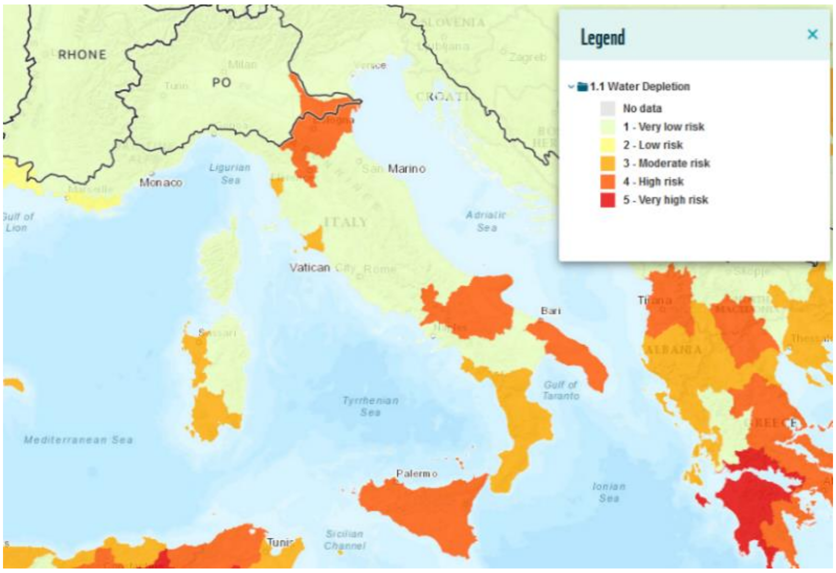

Figure 1. Water depletion in Italy according to the Water Risk Filter

Methods

The Alliance for Water Stewardship (AWS) is the first globally acclaimed standard that assesses water-use across a 5-step certification procedure [4]. With the aim to sustainably manage the water resource, AWS is proving to be an innovative certification adopted by a wide range of multinational companies such Nestlè in order to reduce their water footprint. The AWS standard promotes water management by considering a variety of social, economic and environmental criteria, with the scope to reduce water consumption on-site and spread good water use practices throughout the entire catchment area.

Philip Morris International (PMI) has always adopted ambitious sustainability initiatives as core of their business strategy and is ranked by the Carbon Disclose Project (CDP) amongst the top companies for sustainability programs. PMI firmly believes that working efficiently goes hand in hand with helping and managing the environment. In 2017 PMI's environmental milestones included an active commitment to responsible and sustainable water management by piloting the AWS standard. After the success of the Brazilian facility of Santa Cruz do Sul, the AWS certification was launched to all PMI affiliates world-wide, with a target of certifying ten facilities by 2020 and all operations by 2025. PMI is assisted and aided in the certification procedure by the environmental consultants Denkstatt and HPC of the INOGEN International Alliance.

Philip Morris Manufacturing & Technology Bologna (MTB), located in the Italian region of Emilia-Romagna, is a global lead site for the large-scale production of HeatSticks, reduced risk products (RRP) used in the IQOS tobacco heating system. MTB is certified AWS since July 2019, is the second to be certified in Italy after the Sicilian affiliate of Nestlé and the first ever RRP site in the world to be certified AWS.

Results and discussion

MTB is transforming their business and their commitment towards a best-practice water management [5]. The AWS standard abled MTB to not only follow the 5-step wheel towards a Core-Level certification but also become a water steward, a sustainable water-user with the scope of reducing water consumption and impact on the territory [6].

Figure 2. The AWS 5-step wheel

The AWS Standard allowed MTB to identify and implement several AWS principles:

- Catchment area delimitation, the area of land that MTB affects and is reliant upon;
- Water-related risks identification: MTB is subjected to a high baseline water stress and high-water depletion risk, due to the presence of many water-demanding industries and an estimated increase in drought occurrence in the area;
- Identification of important water related areas, sensitive areas of high conservational value in the catchment area;
- Active outreach to stakeholders and active participation in catchment governance: MTB created mutual collaborations with stakeholders such as the local community, environmental authorities, water service providers, local manufacturing facilities and industrial federations;
- Reduction of water use within the catchment: MTB implemented various strategies in order to reduce potable water consumption on-site and consequently remove less water from the catchment area. By recycling wastewater, implementing water-saving settings and introducing innovative technologies such as Electrodialysis Reversal and Cold Plasma, MTB has obtained outstanding results in 2019: a 20% water saving and a water efficiency index of 12 m^3 per million of HeatSticks produced;
- Increase awareness of water issues and disclose best-practice performance: MTB strongly believes in effective communication and the AWS philosophy has been actively disclosed through awareness activities. MTB's AWS experience was presented at the Ecomondo international exhibition for innovative and sustainable developments.

Conclusion

The AWS standard certifies PMI's commitment to responsible water management and sustainable innovation for the wellbeing of the environment and future generations. The AWS journey abled MTB to minimize its water footprint by understanding water use impacts and working collaboratively with local stakeholders for sustainable within a catchment context.

By implementing the steps and guidance of the AWS standard, MTB contributed to good water stewardship practices that not only improved onsite water performance but contributed to wider sustainability goals. The path is still ongoing, but MTB and PMI are proudly transforming their business towards a sustainable future with the hope that their commitment towards the environment with be followed by other water stewards world-wide.

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SUSTAINABLE SUPPLY CHAINS WITH THE CIRCULAR ECONOMY OF END OF LIFE TECHNOLOGIES FOR INDUSTRIAL SYMBIOSIS

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ABSTRACT

The use of "new circular models" towards sustainable production chains, capable of managing the process and identifying it, in all its relationships in size and shared platform for its innovative phases of ecodesign, exemplifies the potential to any mission of those working in the industrial sector. A challenge not only for the innovation of process and product that move its overall objectives, but also for the activated business model, from the transition from centralized and linear logistics to a circular economy chain, capable of activating among others processes an "industrial symbiosis" of a sectoral type, absolutely sustainable, to achieve the most advanced model of "product as a service". In the scenario of technology adoption life cycle, actors working within these supply chains, contributing to the qualification of "innovators" as "early adopters", are identifiable as those who adopt radical innovations characterized by originality and design complexity.

Keywords: *Sustainability, Circular Chain, Upcycling, De-Manufacturing, Re-Manufacturing*

Introduction

It's obvious that the transition from a linear to a circular economy model is not simple and immediate and although there are now cases and good practices in the industrial policy sector in the literature, the processes and products that are identical and unique, require an activated production chain. by the company every time "made to measure" in order to change its business model and environmental management. Therefore, it is necessary to reconstruct the chain of operations and the operations of the circular model phases, case by case, with reference to the chain triggering sector, the recipients of the service and the type referring to the new life cycle of the product, coming from the recycling and with reference to the joint model of industrial symbiosis. Starting what has been described often means "expanding the technical and economic scale" of the supply chains to activate and innovate the processes even before the products. The cycle of resources, connected to the demand for raw materials for increasingly performing productions, can no longer be sustained with a linear model, with the production of waste and only with a model that assumes recycling as the possibility of transforming waste. It is necessary to adopt a model of "circular economy", capable of making scraps and wastes [1], raw material-second according to a process that allows to activate also products coming from their "upcycling". Cycles capable of producing from the raw-second material, products of higher quality than those involved in a simple recycling process [2]. This scenario is based on the most urgent demand to decrease the impact of industrial processes on the environment and to avoid the enormous landfilling of waste, with the consequent need to manage landfills, incinerators, etc. (policy waste objectives European 2020-2030) [3] (Figure 1).

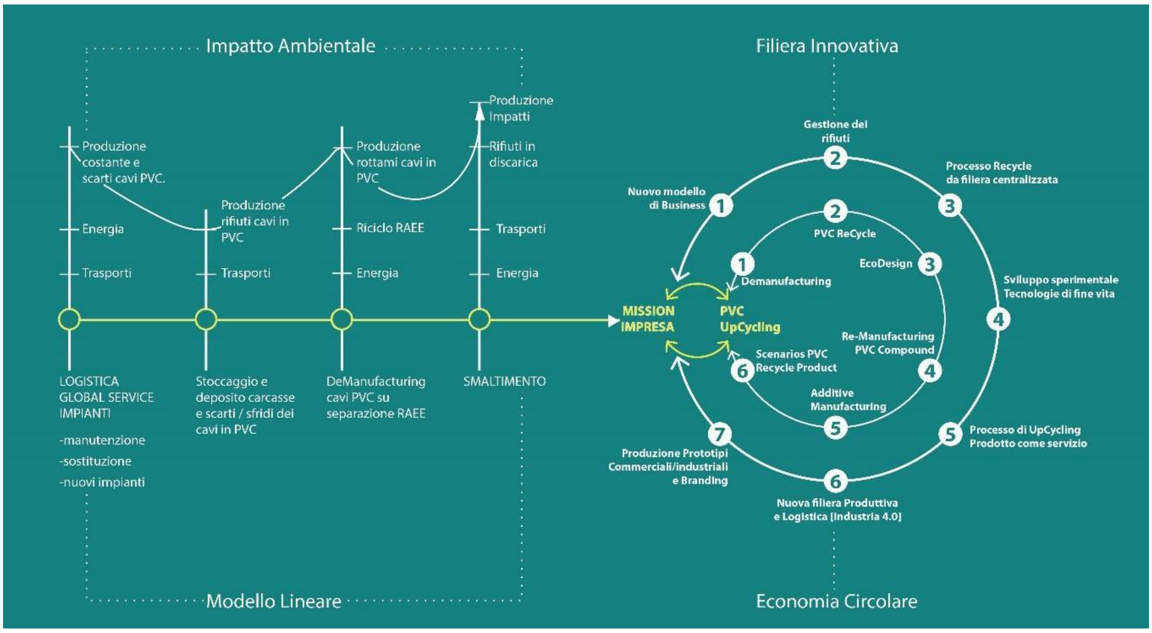

Figure 1. From the Linear Management of PVC Cable Waste to the Circular Model of Multiple PVCupcycling Chains (C.Nava, D.Lucanto, 2018)

Methods

For these circular economy processes, models of different profiles are developed, through technical-scientific circularity, economic-financial circularity, technical-productive circularity. All three profiles are self-sustaining for the effects produced by as many models or strategies, which are punctually verified, evaluated and implemented according to the flows of information, data, technologies, supply chains, products, networks in order to guarantee the rules themselves, fundamental for continuous circular processes.

For “scientific development”[4] with:

- the implementation of policies for the exchange and mobility of capital between the research system and the company, with the attraction and commitment of particularly necessary human resources;
- the objective of improving the technological and managerial skills of the company, directing regional support actions on specific needs;
- the organization of a joint project which is able to promote the company’s participation in the majority of scientific and industrial research specialist networks, for the purpose of sharing knowledge; - facilitating access from a medium enterprise for scientific and technological knowledge of industrial interest and for experimental system development;
- the availability of “specialized services” with a higher added value both for the project and the interests of the external sector to promote and encourage suitable praise for the subjects participating in the project.

For “technical and industrial development” [5] with:

- the convergence of investments in new developments trajectories for innovative products and services (S3) with the intersectoral transfer of technological knowledge;

- access to EU resources in research, development and innovation sectors for medium-sized businesses;
- entrepreneurships based on specialized subjects, such as the strengthening of new structures, are made possible thanks to the modern market that is triggered by the experimental and innovative processes on this commercial prototype;
- foreseen promotions and product marketing will include attracting productive investments in regional and national territories, as well as starting the internationalization processes for the company;
- the strengthening of required resources for “placement in production scenarios of the sector” and the structure of the company's R&D, which should go beyond the years of financing directly for programs in which one participates for the following two years;
- the transposition and translation of new technologies into general protocols, which will be made available to companies that are also moving towards “a circular economy” and the chain of industrial recycling for the production of zero waste: this addresses those in the sector who aim for significant technological assets and whose actions support innovation development and research policies competitively;
- the shared use of spaces, devices, laboratory equipment and general research infrastructures, experiments, programs, platforms and certifications, as well as intangible innovation assets.

The indicators for the quantification of expected results follow the logical structure of the referable outputs:

- the general objectives for the PVCupcycling project are de-manufacturing and re-manufacturing;
- the outputs which relate to new processes, technological solutions, and prototypes are summarized as follows: Outputs Innovative Processes, Output Technological Solutions, Output Prototypes.

Therefore below, with reference to the results, is a description of the outputs which monitor the level of achievement, as well as referencing what is described in the project’s different operational and technical criteria for achieving the objectives. The monitoring will have many levels and can be classified into: 1) financial realization indicators which are on the project to quantify the execution of actions implemented by the joint project’s U.O.; 2) procedural implementation indicators will monitor the project management throughout, focussing on the quality of the coordinating subjects, therefore implementing the conclusion of the WPs and of the project itself; physical implementation indicators on the WPs; result indicators on the outputs; 3) indicators of effectiveness and efficiency.

Application: the PVCupcycling proposal. The proposal for the PVCupcycling project calls for an innovative circular chain inserted into an energetic and chemically dynamic environment. From which there is a feed of raw material which consequently has new resources. The company is placed directly into the innovative life cycle of technology contributing to endorsers being labeled as “innovators”. The main objective of the PVCupcycling project is to facilitate the transition of R.ED.EL.’s current production chain, from an economically linear model to a circular type. This is achieved through actions that aim to recycle PVC from electrical cables (“de-manufacturing”) to upcycling the same PVC into new products with a low environmental impact (“re-manufacturing”). The project’s specific innovative objectives adhere to experimental developments and industrial research, to which a circular production chain is complimentary. With this project R.ED.EL. aim to reach new possibilities, such as advantageous technical solutions to reuse the so-called waste material and place it into the manufacturing chain. They should also expect to gain leadership in an accelerating market, and so pursuing a real innovation strategy based on three dimensions of sustainability: environmental, economic and social. In the first experience the strategy will trigger "the transition from a linear to a circular economic model", increasing the performance level of new products and services, and enhancing skills for the operators who are involved in the process. By implementing a new design we change the organization and function of the current model, which is centralised and therefore the project's methods are easy to apply. Thanks to this new design the company is able to control the quality of service in their "end of life cycle". In favourable terms, the following scenarios are implemented for the company: investments in technology with a higher performance rating; significant improvements to the consequential processes of a recycling chain; integration of present machinery and the "additive" digital printing technologies necessary for prototyping a typical eco-design. Such early adopters are identifiable as those who embrace new technologies, and whose radical inventions are characterized by originality and design complexity (Figure 2).

Figure 2. Ecodesign hybridization, with upcycling components- pvc recycling electrical cables and prototypes in pla printing systems in additive manufacturing (PMopenlab for PVCupcycling, 2019)

Results and discussion

Is observing the criteria and activities specific to circular economy models sufficient to evaluate a process to recognize it as sustainable? This is the question that arose in the aftermath of the dissemination of circular economy cases and its good practices. To strengthen the work and purposes of such an investigation of assessment tools, it is important to consider the traceability and scalability of the environmental issue on three scenarios, that of development, that of strategy and that of application to specific production sectors. In this macro-scenario, the assessment tools must always be calibrated to the need to respond, in addition to the qualitative and quantitative dimension provided by the indicators, to a practicable operational dimension. This is in order to implement the policies and methods necessary to achieve the objectives of interest, for the entire chain of stakeholders involved, but also to satisfy the three known dimensions of sustainability, social, economic, environmental [6].

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ECO-DESIGN AND MANUFACTURING IN THE DESIGN PROCESS FOR THE VALORIZATION OF WASTE FOR PVC UP-CYCLING

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ABSTRACT

PVCUpCycling with R.ED.EL., an innovative project funded by POR Calabria 14-20, Axis 1 - Action 1.2.2, deals with waste management and waste derived from electrical cable management processes within the current production line of the company R.ED.EL. The treatment of waste coming from the waste of electrical plants finds the greatest number of critical issues in its disassembly phase, this question becomes even more sensitive if we consider that from this passage depends the supply of precious materials such as Copper and Aluminum. With the first “de-manufacturing phase”, the technical characteristics of the PVC belonging to the “electric cable” component were verified. In the subsequent “re-manufacturing” phase, these materials will be re-used for the production of industrial eco-innovation products/components. The building sector and the reference market regard sustainable supply chains that use eco-compatible and multi-functional materials. The authors of the text conducted the experimental research activities within the innovative startup laboratory PMopenlab, project research consultant.

Keywords: Ecodesign, Circular Economy, Design For Manufacturing, Upcycling Process, Design Driven Innovation

Introduction

The case study presented describes the EcoDesign and Manufacturing processes in the enhancement of plastics from the disposal of PVC electrical cables, with reference to the research project PVCUpCycling [1]. The document highlights the relationships put in the field in EcoDesign and Digital Manufacturing processes, adopting a complex system of enabling technologies.
In the smart manufacturing/smart materials - smart solutions phase, performance control and the technical qualities of the final products is implemented through the formulation of a model that verifies sustainability criteria and performance, through energy-type check-lists environmental, which build the performance framework in the technical data sheets on the scenarios tested in the construction site-laboratory and with the comparison with market products competitive.

Methods

The Ecodesign model used of the “hybrid” type aims to reform and innovate the “system-product “and is therefore formulated on market-driven innovation on that governed by technology (technology push).

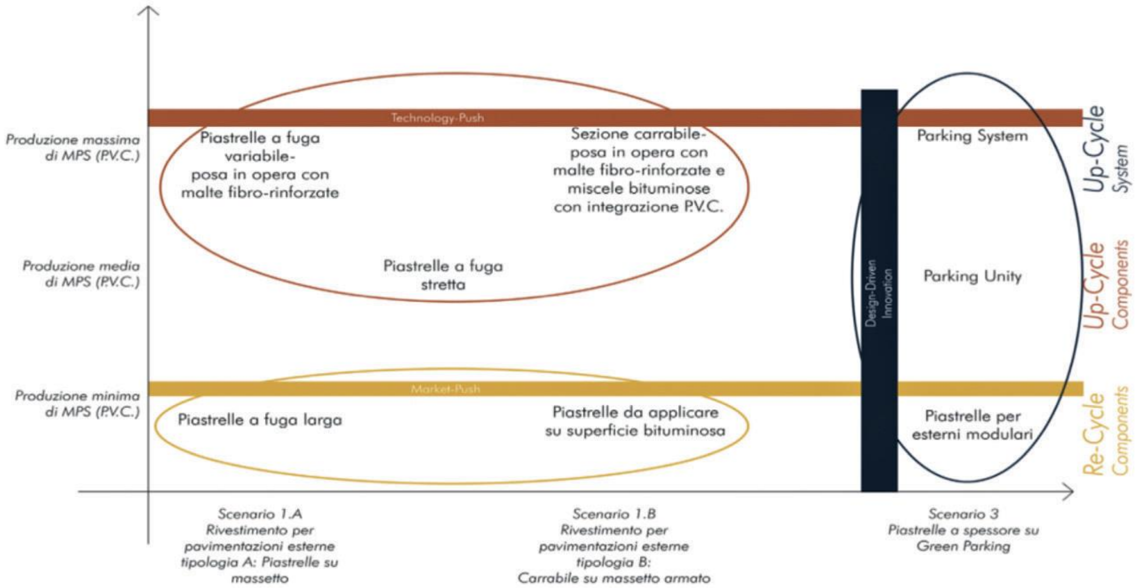

Figure 1. Design Driven Innovation Scheme for PVC Upcylcling (Domenico Lucanto)

This model is tested on scenarios in the three dimensions referring to the minimum, average and maximum production of PVC in the Upcycling process (Figure 1).

Design Driven Innovation. Pursuing a type of experimental innovation of the Design-Driven type means in the case of PVCUpCycling take advantage of a conceptual asset of processes/products that can guide the realization of the testing scenarios sustainably, both in terms of supply of Second Raw Materials (MPS) [2], consistently with the primary objective of formulating scenarios that progressively manage to use the best energy-environmental profile. Specifically, the items in Figure 1 refer according to the Design-Driven Innovation model by R. Verganti to three qualitatively different types of innovation: Linked innovation market push (a), technological innovation (b), design-driven innovation (c). (a) The reference to innovation supported by the market push is triggered in the case of PVCUpCycling, starting an experimental phase in which the choice of the testing object it is linked to a type of product that can be easily placed on the relevant market. The case in question concerns the experimentation which refers to the first output relating to the first phase of PVCUpCycling, i.e. the realization of the 4,9x7cm tile, creating a type of external flooring coating. The second phase of experimentation concerns technological innovation during which, taking into account the results of the market experimentation, the technology system is used enablers (KET) systematized in the drafting of the PVCUpCycling project, to guide experimentation towards increasing performance from a competitive perspective. At this point, the application of the same output (tile 4.9x7cm) is implemented with another type of output, or the PVC powder, which obtained from the de-manufacturing phase, is the basis for the creation of tiles for the pedestrian cladding system. In this case, the component is hybridized with the mortar to make joints, creating a type of mortar for “high-strength joints”, and a hybrid of PVC powder and cement mortar for the construction of a screed reinforced with a type of mortar which, at this point, can be said fiber-reinforced. (c) The last experimental step concerns the construction of a theoretical plant for construction experimentation with the Design Driven type [2].

Experimentation scenarios/Testing in situ. Specifically, the experimentation, referring to the theoretical system built in the previous paragraph, concerns the realization of three different scenarios. They are carried out on site-laboratory c/o R.ED.EL. the 3scenarios that use components of Hybrid PVC such as MPS in different consistencies: loose powder, powder printed on multiple formats. The goal is to account for the amount of recyclable PVC material on a functional unit and also define an energy-environmental profile for the reduction of CO_2 correspondings to the system created. It is, therefore, a matter of pursuing two other objectives ai purposes of the pre-prototype phase: evaluate which pre-commercial product it can find in the triggering of the industrial chain an available sector, for the technologies already available in the company and with which impact on the business model and innovative recovery-recycling chain for an economy circulate with zero-waste; evaluate which competitive markets can accommodate higher products and with which technologies to be activated with an expansion of the company's technical and economic scale (scenario so be realized) [3].

Scenario 1: pedestrian pavement. The first phase of experimentation concerns the construction of a pedestrian pavement, using the recycled PVC tile, laid on an existing reinforced screed, as a coating for outdoors. The implementation concerns the construction of a 120x55cm mat (Figure 2) in which it is placed has had the opportunity to test both the painting phase (post-installation) and the hybridization of the grout for filling joints with MPS granules. To have a diversified production chain based on the number of MPS available in the company, or in the period of the year in which there is a minor energy supply from renewable sources. IMPACTS: kg of PVC per square meter of set up: 3,5 kg PVC; kg of CO_2 saved per square meter of scenario implemented: 7 kg of CO_2. Processing hours required for installation: 6 h.

Figure 2. Realization phase scenario 1 (PMopenlab S.l.r.s.)

Scenario 2: Realization of a driveway for handling Small vehicles. In the second phase, the attention was paid specifically to the hybridization techniques of the materials, the installation of a screed of concrete mixed with PVC, for the construction of a driveway for handling small loads. On a functional unit of one square meter for 18 cm of thickness (Figure 3), our dough used 24 kg of recycled PVC, 25 kg of cement, 50 kg of inert recycled from construction site works. On the 50 sq. m. Experimentation square, we brought out of the factory and not transferred landfill 1200 kg of PVC powder. Environmental savings in CO_2 and impact from plastics and economic of about 400 euros for the company. IMPACTS: kg of PVC form 2 of scenario installed: 24 kg PVC; kg of CO_2 saved per square meter of scenario in operation: 50 kg of CO_2; Working hours required for installation: 16 h for 5 m^2.

Figure 3. Realization phase scenario 2 (PMopenlab S.l.r.s.)

Scenario 3: Green Parking. Green Parking (Figure 4) consists of a road section with draining and block asphalt thickness in recycled PVC - Hybrid system with additive technologies - printing of components in 3D and molded MPS PVC blocks. The experimentation accomplishes what is expected in the additive manufacturing project and creation of a scenario with components hybrid and from ecodesign processes. The creation of a functional unit of measurement 280 * 450 cm, of a highly resilient green parking, with an integrated absorption system of water for the functioning of the permeable and semi-permeable vegetable surface and gravel, with an already tested completion screed (scenario 1) and with a system printed and modular to size, for the disposal of rainwater, which carries out the channel and joint function. The loading surface is reinforced by the alveolar mesh in Printed PLA, which houses the thick blocks of recycled PVC and the permeable filling and semi permeable and allows the coupling of the modules-components to the disposal system of the waters. The latter thus sized and made in the functional unit responds with capacity in case of overload in a short time of impact from rain washout (water bombs), with a system capacity of approximately 1.61 cubic meters. The water conveyed can be recovered and reused to water the same permeable surface o maintenance activities of the waterproof part of the green parking. Also the realization in 3D printing the components can be used in prototype form as a mold for production with other more performing materials and in line with industrialized processes. The use of additive technologies has triggered an Ecodesign and engineering process of the components that are described in the annex to this report in all its phases. IMPACTS: kg of PVC for m^2 of scenario installed: 24 kg PVC; kg of CO_2 saved per square meter of scenario on-site: 50 kg of CO_2.

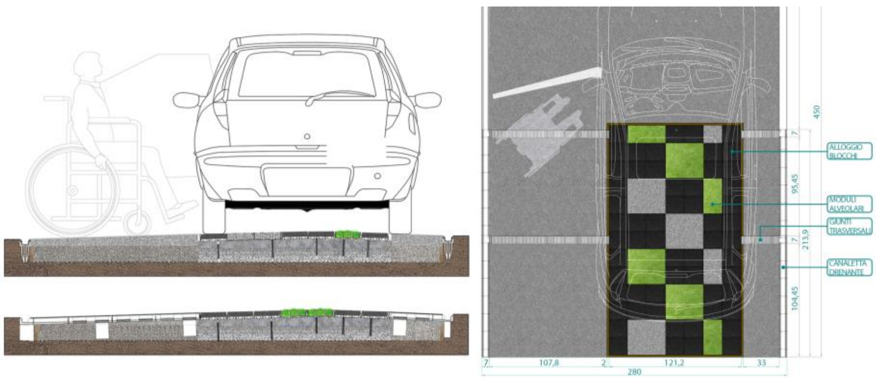

Figure 4. Scenario 3 Design (PMopenlab S.l.r.s.)

Conclusions

In conclusion, we can assert that the goal was achieved thanks to the "cradle to cradle" eco-design model operated on two different levels [4]:

- The first, which we can define addressed to "capacity building", or through a "dedicated" laboratory of the "design-driven innovation" type, founded on the creation of relational assets, to build capacity and exchange on four activities: I. strategies; II. development and renovation; III. process of interpreting the progress of research, acquisition and improvement of methodologies and instruments in a workshop system that develops concepts of products/prototypes; IV. a graft of the discourse design, to increase reputation of the company and attract new competitors and markets;
- The second level of "smart manufacturing" in the phase of identifying smart solutions, with the prototyping of products and components made for the use of unconventional and high productivity technologies.

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OPEN PLATFORM AND COLLABORATIVE DESIGN FOR SUSTAINABLE PROCESS MANAGEMENT OF UP CYCLE FOR THE ENHANCEMENT OF PVC SCRAPS FROM THE PROCESSES MANAGEMENT OF ELECTRICAL SYSTEMS

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ABSTRACT

Concerning the PVC UpCycling research project, the "adaptive" environmental accounting system is described for experimenting and building sustainable management models of the process/product chain, which measure the impact of the project, describing different types of information to describe its phases relations, nodes, issues, tangents, operational spaces (Figure 1). In this sense, the model concerns the possibility of starting recycling chains, capable of self-management in terms of energy, to reduce CO_2 emissions. Among the objectives of the circular system result, those of designing the innovative industrial symbiosis supply chain model on PVC-MPS scenarios and the Collaborative Platform for open source eco-design products. From the de-manufacturing phase to the re-manufacturing phase, the circular models activated by the new innovative PVC-MPS supply chain through which it is possible to build a collaborative platform for information exchange, intercept the ecodesign phase, transferring the possibility of intervening on the production of PVC-Upcycling prototypes.

Keywords: *Open platform, Circular economy, Upcycling, Sustainable process, Zero-waste, Ecodesign*

Introduction

Addressing issues concerning the Open Platform and Collaborative Design, for management sustainable process of UpCycling, we intend to investigate the issues relating to the construction of open platforms and tools that encourage collaborative design, with a view to sustainable management. UpCycling processes for the enhancement of PVC scraps from the management processes of electrical systems, but also leads sustainable design, prototyping, and evaluation with application to the markets identified products/components, made for use and integration with Technologies additive manufacturing / 3D printing enablers [1].

Methods

The methodological approach allows identifying the processes projects and their accessible models (Open Platform), capable of involving in co-design users, to produce low maintenance and high flexibility components. In this sense it is necessary to consider a type of platform that can transfer the accounting of impacts to the quantities of PVC MPS used, dimensioning, therefore, the activities capable of triggering the production of "zero waste" in the process circular, model to which the company to which the PVC UP Cycling project refers. Another level of information provided is that relating to the sector with which symbiosis can be implemented industrial and in the case of experimentation implemented, with the sustainable construction sector and the production of low environmental impact systems with a good performance during use [2].

PVC UpCycling Impact Map. The concepts of circular economy with a view to recycling, to improve metabolism industrial and industrial symbiosis, are reflected in the phases of experimentation of PVC Upcycling (Figure 1). The process tested with PVC UpCycling covers all the receiving systems that enter competition in the linear model of disposal of PVC cables, from their supply system and storage to the disposal system, thus affecting the transport system, the quality of the air, energy flows, soil, material and energy flows related to logistics and production services necessary to manage the post-consumption and pre-consumption phases. Model of the circular economy to which the R.ED.EL. company tends involves a system of actors, who given sharing make the various project partners available to the Partners title knowledge, competitiveness, and know-how to increase the meanings and skills of Project [3].

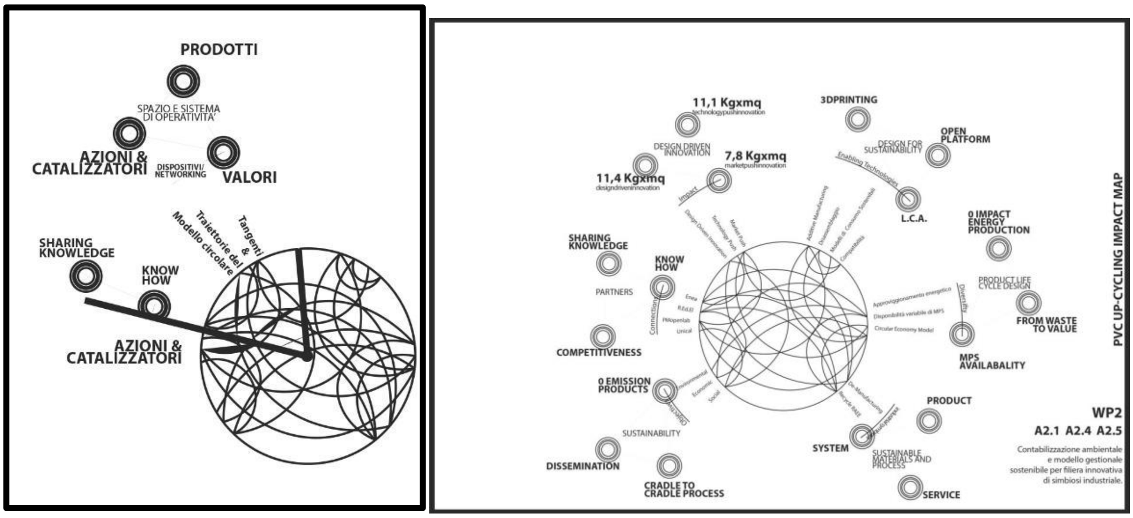

Figure 1. PVC UpCycling Impact Map

PVC UpCycling Innovative product chain. The construction of an innovative supply chain model in a circular perspective allows us to describe fully the outputs and conditions that arise throughout the production process of the material-charge MPS from the de-manufacturing to the re-manufacturing phase (Figure 2). Circular models activated by the new supply chain innovative PVC-MPS in this sense activate the experimental phase, also thorough construction of the experimentation scenarios illustrated, returned in collaborative form, thanks to the construction of a digital enabling technology plant returned to an open platform (Open Platform).

It intercepts the eco-design phase transferring the possibility of intervening on the production of PVC-Upcycling prototypes. [4] This platform also investigates all the accounting of impacts concerning quantities of PVC MPS used, thus sizing the activities capable of triggering the production with the "zero waste" objective, a model to which the company tends. The sector with which the industrial symbiosis can be implemented with the sustainable construction sector and the production of low environmental impact systems with a good performance during use.

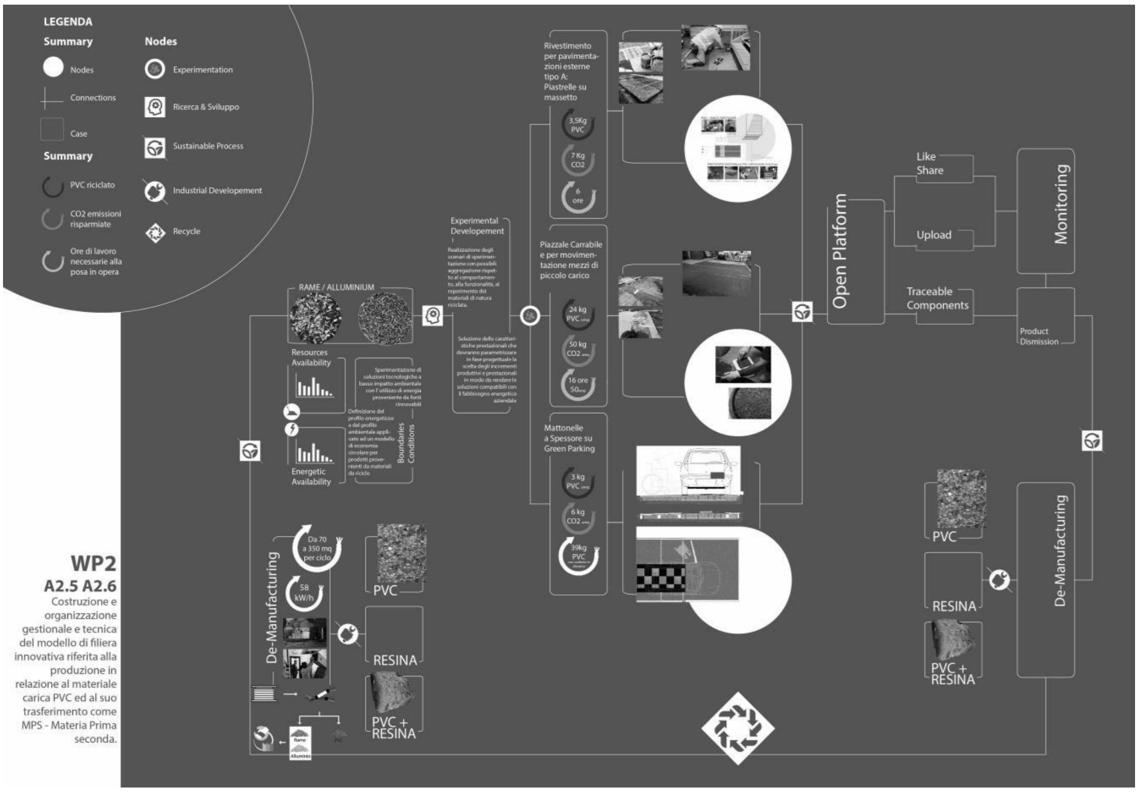

Figure 2. PVC UpCycling Innovative product chain

*PVC UpCycling Circular process map.*The PVC Upcycling project aims to consolidate a series of practices (know-how) for the development of products that manage to meet sustainability requirements environmental, according to the LCA environmental impact assessment rules, applied to the treatment-specific types of waste, in the design processes of products, services, and systems applied to a sustainable circular chain management model for the treatment of MPS obtained from PVC recycled from WEEE type waste (Figure 3). This creates the “Industrial Symbiosis” [5], or that sectoral cooperation that allows reintroducing, as MPS (second raw material), waste into the production cycle and their by-products, interfering with other processes and value chains.

A type of approach that interfaces with the L.C.A. it is necessary to define the characteristics of the tools which must be used in the industrial sector to develop a system of innovative solutions. The priority becomes to declare the function of the system that in the case of PVC UpCycling concerns the ability to adapt the production cycle and modify it according to two parameters concerning the energy supply and the availability of MPS. [6] The functional unit refers to the variables that consider the functioning of the system, in which the risk for which incentivizing the production of low materials must be taken into account emissions derived from waste materials, can favor consumer policies “use and throws” which in any case are inconsistent with the set global sustainability objectives from the SDGs 2030 Agenda.

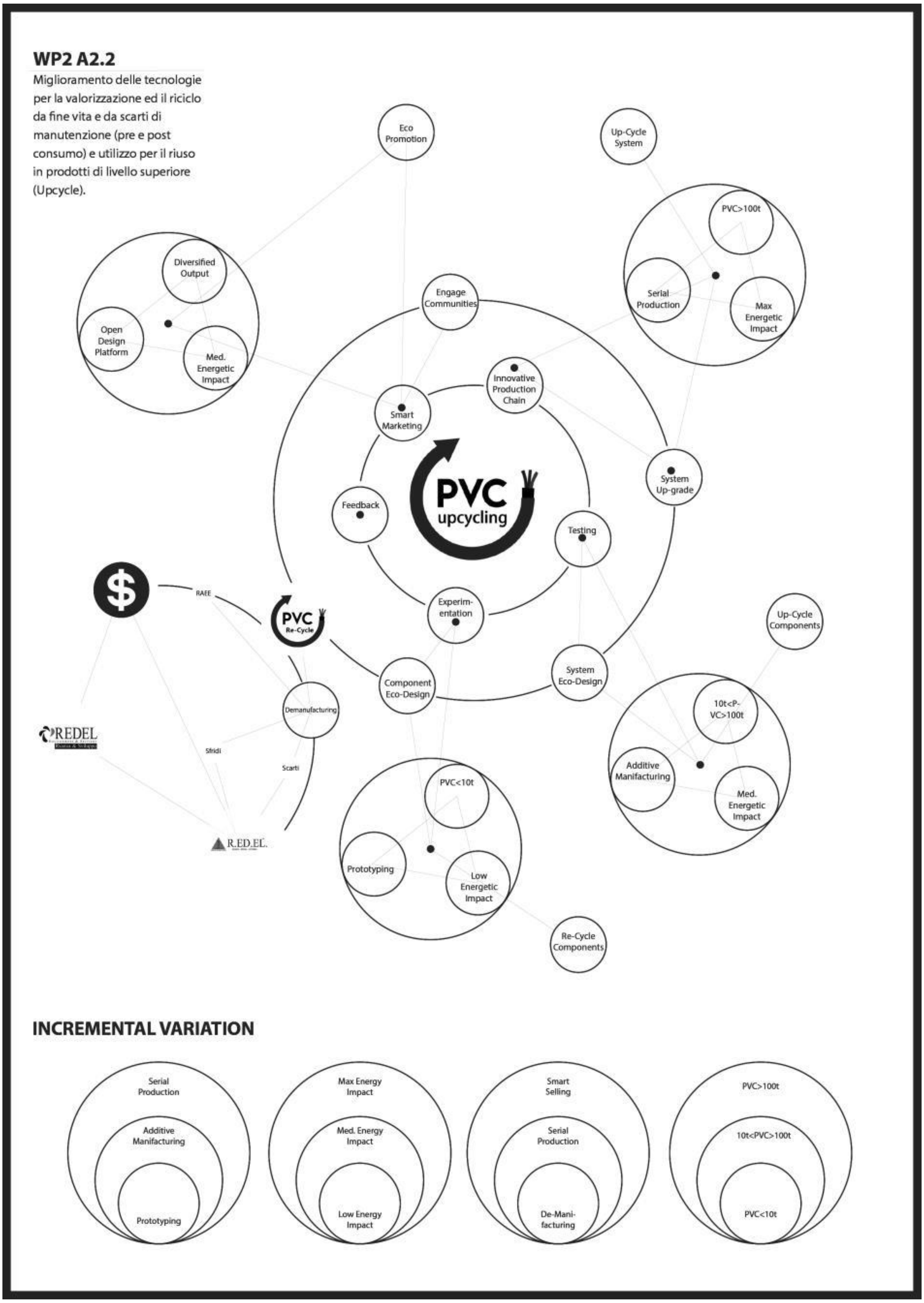

Figure 3. PVC UpCycling Circular process map

Results and discussion

Building graphic models made it possible to make accessible in the case of PVC UpCycling the theoretical system necessary for the design of a sustainable testing model of such complexity. In addition to the scalability of the concepts, of return in graphic form what is called the three moments of Eco-Design [7]:

- Identification of low impact materials and processes. In the production cycle of PVC UpCycling It is possible to propose a sustainable model for the recycling and reuse of materials deriving from WEEE components, which are currently the fastest growing waste in the countries of European Community.
- Design of the Life Cycle of the products. Convert the company's production cycle from a traditional linear system to a model circular allows you to abandon the old process based on a consumption model “Take, make, use, dispose” carrying out a product-system UpCycling, succeeding in hybridization with additive manufacturing to decline industry 4.0 paradigms according to one circular scheme.
- Design for sustainability. To start designing according to the compatibility rules for recycling UpCycling means take into account a product by qualifying all its components to facilitate the disassembly of the various materials.

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GOOD SYMBIOSIS PRACTICES IN CIRCULAR ECONOMY

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ABSTRACT

Decarbonization and a broad concept of efficiency that includes continuous evolution with a view to growth are structurally integrated into Eni strategy. The company response to a global energetic and climate challenge is oriented towards a new paradigm of development that shifts from linear to circular growth to reduce waste, transform them and give new life to products and assets by researching innovative solutions. This ground-breaking approach exploits the synergy between stakeholders, industrial symbiosis and cultural change as pillars of change. Eni conceives the circular economy as a key driver and a powerful tool for sustainable growth towards a low carbon future. During the four-year-plan (19-22), Eni will invest more than €950 million (to reach €3 billion considering also decarbonization and renewables projects), and additional €220 million in research and development activities to develop industrial circular solutions. New projects are focused on waste to fuel transformation thanks to innovative processes and plants which are under evaluation and will came into operation.

Keywords: *Circular Economy, Decarbonization, Synergy, Symbiosis, Partnership*

Introduction

The world in which we live needs more and more energy and this need, although with different trends and solutions, affects all countries, including Italy. In the global scenario this request is accompanied by a necessary and irreproachable reduction of greenhouse gas (GHG) emissions.

Aware of this ambivalence and as a decision maker in the energy field, Eni has chosen to contribute to identifying solutions that favor the energy transition supporting the aims of the Paris Agreement on climate. We definitely live in a world where dependence on fossil fuels and the uncontested existence of a linear economy are not sustainable. Providing sustainable energy sources for more than 9 billion people – according to projections to 2050 – is an outstanding and historic challenge. To meet this challenge, renewable energy sources in terms of both traditional (e.g., hydroelectric, biomass) and modern (e.g., wind, solar) ones, would need to be a quite large part of the energy mix. However, according to estimates by IEA (International Energy Agency) to 2040, the energy mix will not be very different from the current one, with the contribution of oil and gas remaining central, continuing to represent around half of the energy mix [1] – with a significant reduction of the share of coal – despite the announcements and commitments made to address the energy transition.

The current development model has also lead to the generation of gaps, some of which are related to social and demographic trends, e.g. population growth will be mainly driven by non-OECD countries[4], though the gap on per capita GDP (gross domestic product) with the

[4] OECD (Organisation for Economic Co-operation and Development) countries are: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia,

OECD economies will increase, just because the GDP growth of non-OECD economies will be partly displaced by their demographic increase. Since an increasing number of people will globally move from rural to urban areas – it is foreseen that 2 on 3, and even more in OECD countries, will live in cities at 2050 [2] – the high concentration of people in areas that are often not adequate to accommodate them can contribute to exacerbating the limits of the current development model. It impacts negatively on the quality of life of such populations and contributes to increase the most varied forms of pollution, from waste management to mobility problems and greenhouse gas emissions.

Indeed, an interesting aspect to analyze is the global production of solid urban waste, in 2012 equal to 2 billion tons, a volume that will almost double to 3.4 billion tons by 2050 [3]. Such amount of wastes accounted for around 1.5 billion tons of CO_2 equivalent emitted in 2012 which could almost double in 2050. It is also estimated that around half of waste disposed goes to landfills, while 20% of waste is recycled, with the remainder treated with other methods. As a matter of fact, the future challenge is a new and more efficient waste management, through reduction, re-use and recycling of materials, in order to reduce the amount of waste produced and contribute to the reduction of GHG emissions and terrestrial and marine pollution.

Methods

According to Eni, efficiency is a broad concept that includes continuous evolution with a view to growth, in line with the new perspectives that the future shapes, as well as the ability to self-sustain minimizing wastes and losses. This is a transversal concept of Eni's strategy and is transversal for the company, both for all its divisions and in terms of application to processes, products, assets.

Moreover, decarbonization has a fundamental role in our business model and implies ensuring long-term sustainability by working towards a low-carbon future. In this sense, we already have designed concrete programs and implemented actions not only to be an efficient company from an economic, environmental and technical-operational point of view but also to apply circular economy principles in our country. Furthermore, scientific research and technological innovation are Eni's boosters for launching new circular economy projects.

The pillars of Eni circularity strategy are three main ones, consisiting in sustainable raw materials (fewer and fewer virgin inputs), reuse, recycling and recovery (by developing recycling technologies, recovering raw materials from waste products and reusing resources such as water and soils), and extension of useful life (giving new life to assets and land in a sustainable perspective). All of this is clearly oriented to the reduction of waste, the sustainable management of natural resources, mitigation and adaptation to climate change, innovation, employment and increase in competitiveness respecting the environmental matrices.

Through its downstream platform, Eni is constantly committed to study new processes which exploit the circular model thanks to its conversion plants, consolidated skills, technologies, innovative research and the geographical distribution of its assets.

Eni owns assets throughout the national territory: through its business units it has 4 refineries, 2 bio-refineries, 9 chemical factories, 5 thermoelectric power plants, 4,500 gas stations and about 4,000 hectares of reclaimed or already reclaimed land. They represent real transformation platforms, which are an opportunity to welcome new circular economy activities.

Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom.

The assets have the strength to have the necessary connections already in place and operational, without creating any impact on the territory, to which they are integrated with their own logistics and utilities system. Furthermore, Eni already has the internal expertise to manage complex plants and conversion of existing assets.

Through this transformative attitude and this platform of circularity, Eni is set on triggering a change based on long-term relationships with local stakeholders, on the attention to the specificity of local communities and on their inclusion in advancing the new development model.

Indeed, Eni has built its positioning on circularity through three drivers. Synergy is the first one, relevant to encourage the convergence of skills and partnership through a system that rewards proximity, respect for territorial vocation and participation. Here, collaborations are intended with public and private subjects from different sectors and centers of excellence on a scientific and technological level. Then, industrial symbiosis is declined on two fronts, the internal one activating integrated projects among the various corporate industrial realities and that external one through collaboration involving different industrial sectors, with a focus on the supply chain and the cross industry, thus creating a model that allows to glimpse a development opportunity in the waste of an industry sector, to encourage processes of technological transformation, and, last but not least, to raise quality standards of services and products. Eventually, Eni intends to develop new products (bio-fuels or products chemicals and intermediates) through eco-design, the third driver: believing in the intrinsic value of a product or service along its life cycle, Eni, in collaboration with a specific partner, intends to facilitate the transition from the concept of consumer to that of circularity facilitator.

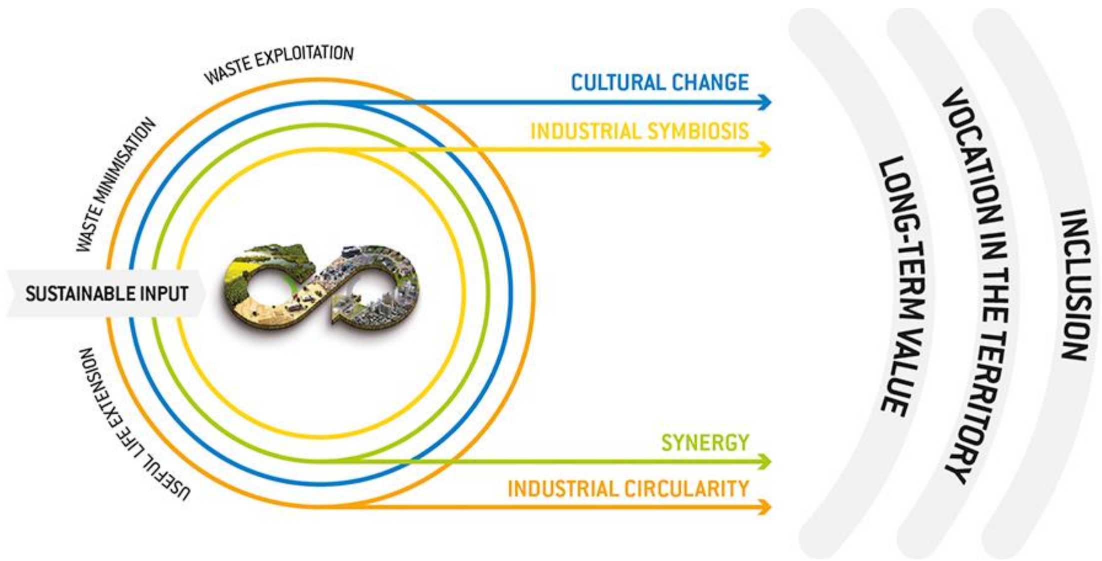

Figure 1. Circular economy sketch to represent the meaning of the concept in Eni's view

Eni's transformation started from Italy and the investments we have seen in these last years are a concrete demonstration of this. Then, also towards the future the same determination is present, as the above presented manifesto is supported by an important investment plan: in the four-year period 2019-2022 Eni has planned to invest around 3 billion euros in decarbonization projects, circular economy and renewables. To the circular economy, in particular, the financial commitment correspond to projects for over 950 million euros and additional 220 million euros in R&D to develop circular solutions for industry.

Projects and partnerships. Eni's circular economy applications aim on the one hand to find sustainable and innovative technological solutions, which have the objective of reusing and enhancing wastes or renewable materials, aiming to make the economic system more efficient and minimizing at the same time the use of resources and energy. On the other hand, they aim at enhancing existing assets, transforming those that are no longer profitable or being disposed of and giving them new life in industrial areas, plants, human and social capital.

Eni intends to convert biomass and waste material, namely organic waste and not recyclable mixed plastics in energetic products or biofuels, bio-methane to support the strategy of sustainable mobility and at the same time develops sharing services, such as Enjoy for vehicles.

In our bio-refineries, which hydrotreat vegetable oils to produce biofuels by the proprietary Ecofining process, we will process waste and biomasses, not in competition with food, also contributing to transforming and extending life of assets. Indeed, Venice bio-refinery, in Porto Marghera, is the world's first conventional refinery that has been converted into a bio-refinery, operative since 2014. A pre-treatment plant came online in June 2018, enabling the import of crude – rather than refined – vegetable oils and a significant increase in the amount of used cooking oils (UCOs) and animal fats processed. The use of vegetable oils as fuel in diesel engines is not a new idea but in our bio-refineries the focus has shifted to used cooking oils, i.e. exhausted frying oils, an approach largely in line with the current European Community orientation which is directed towards the gradually increasing limitation of use of raw materials in competition with the agro-food market (in some contexts the so called "first generation oil") in favor of alternative feedstocks.

In a couple of years, a further upgrade to the plant is set to boost the processing capacity of the bio-refinery, with increasing levels of raw materials or intermediates from waste. A second bio-refinery has been launched by Eni in August 2019 in Gela (Sicily), with a processing capacity of up to 750,000 tonnes a year of vegetable oils and advanced raw/waste materials.

To leverage on our assets and our facilities, as a driving force for the growth of the circular economy, it is essential to create synergies along the entire supply chain. This happens through the creation of public and private partnerships. In the field of bio-refineries, as early as December 2017, Eni signed an agreement with a national consortium for the collection and treatment of exhausted vegetable and animal oils and fats, which undertook to provide Eni with the collected UCO; others have followed this first agreement, such as those ones signed with another consortium or multiutilities or sector operators (September 2018, February 2019 and following), to increase the collection of UCOs as well as to carry out information and environmental education campaigns on the advantages of using exhausted vegetable oils for the production of alternative fuels to fossil fuels and awareness-raising projects of trade associations, consumers and environmentalists.

Every citizen who consumes oils in the kitchen, from those used for frying to those for conservation of various types, can help avoiding their dispersion in the environment through their recovery and collection, for which it is suggested to use dedicated channels such as the ecological platforms. Eni encourages not to disperse what can become a value, namely a new product like a biofuel. The collected UCO is in fact purified ("regenerated") by a third party and sent to the Eni bio-refinery in Venice, at present.

From the environmental point of view, the contamination capacity of such oils is incredibly high: a single litre of edible oils thrown into domestic waste makes one million litres of water unfit for drinking [4], corresponding to a person's need for 14 years. UCOs then cause malfunctions in water purification plants, as well as pollution of the soil, rivers, seas and reservoirs, with a consequent increase in overall costs for water purification plants.

According to CONOE estimates, in 2018 260,000 tons of waste oils were produced, of which 94,000 coming from the professional sectors and the remaining part from domestic activities, an interesting but not easily interceptable share (to date, indeed, almost entirely dispersed).

CONOE collected 78 thousand tons of waste oils, mainly deriving from the restaurant industry and also produced by commercial and industrial activities (fryers, laboratories rotisserie, industrial catering). So far only a quarter of domestic waste reaches the bio-refineries. Everything else is dispersed in the environment or thrown into the sinks [5]. Eni already uses almost half of the quantity collected on national scale and the increase margin is large precisely due to the potential of the domestic sector.

Thanks to the Oilà project, Eni has boosted and favored the recovery of UCOs produced by employees in their homes to multiple locations – places of work – throughout Italy (from Porto Marghera to Rome, Taranto and Sannazzaro de' Burgondi).

Eni is studying the feasibility of projects to produce hydrogen and high-quality fuels that can be considered "renewable"[5] from the gasification of non-recyclable plastic wastes. In this regard, Eni signed an agreement with a national consortium for plastics collection and recycling, in March 2019. The agreement defined the establishment of a joint working group to evaluate the projects and analyze the developments that the market for non-mechanically recyclable packaging will undergo in the coming years. Such packaging is not the only type of waste that can be used to develop a virtuous and innovative circular economy process and maximize recovery, in line with the new European directives: in addition to the so-called plasmix, a mix of post-consumer packaging consisting of heterogeneous plastics that today have no outlet in the recycling market, also the so called secondary solid fuel can be considered proper feedstock to the gasification plants that Eni has under study. Eni is studying initiatives to produce methanol from solid urban waste via gasification. Through the signing of further agreements, such as those with local multiutilities, Eni is studying the possibility of realizing gasification plants in two areas where a (bio)refinery is already present to increase the production of hydrogen, in one case, and for the production of around 100,000 tons/year of methanol starting from 200,000 tons/year of plastic feedstock, in the other case. Such methanol produced from waste can be a socially acceptable fuel thanks to the absence of emissions harmful to human health (dioxin, furans) and the launch of a circular and economically sustainable economy project thanks to the value of the final product, which can be used as a component in gasoline.

With these and other agreements, mostly memorandum of understanding and cooperation agreements, for a total of over 40 ones signed, Eni strengthens and develops its strategic path of application of the principles of the circular economy to business.

Conclusion

Circular economy is conceived by Eni as a "choral" process that requires a behavioral and technological change and the ability to favor industrial symbiosis and synergies.

All collaborations Eni established aim to contribute towards reaching the SDGs' (Sustainable Development Goals) targets through strategic cooperation focused on areas of common interest such as renewable energy and energy efficiency, agriculture value chains, preservation of our planet, wide access to energy resources, innovation, recognition of diversity, creation of long-

[5] The RED (Renewable Energy Directive) II states that 'recycled carbon fuels' means liquid and gaseous fuels that are produced from liquid or solid waste streams of nonrenewable origin which are not suitable for material recovery in accordance with Article 4 of Directive 2008/98/EC, or from waste processing gas and exhaust gas of non-renewable origin which are produced as an unavoidable and unintentional consequence of the production process in industrial installations. As a part of the transport target of energy from renewable sources, Member States may choose to include "recycled carbon fuels".

term shared value, also crossing national borders, especially towards specific countries where Eni operates.

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Printed in May 2020 at the ENEA Technographic Laboratory – Frascati

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ISBN 978-88-8286-394-4