Implementing circular economy in Umbria through an industrial symbiosis network model

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Abstract

Industrial symbiosis (IS) is a concept based on the idea of industrial ecosystems establishing symbiotic relationships between economically independent industries in order to make industry more sustainable and achieve collective benefits (the term "industrial" can also be extended to other anthropic systems). IS engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, water, energy and by-products. Development of IS depends on an enabling context of social, informational, technological, economic and political factors. The Umbria region is characterized by a highly competitive productive and economic industrial system with a very significant presence of manufacturing activities. IS is in line with the recent European strategies for decoupling economic growth from natural resource consumption through the promotion of more sustainable business models. This paper reports the activities developed by Sviluppumbria (Multi-functional Agency of the Umbria Regional Authority) and ENEA (Italian Agency for New technologies, Energy and Sustainable Economic Development) in the framework of the Innetwork project 2016/2017 2014-2020 ROP Umbria ERDF , Axis 1, Action 1.2.1) to support SMEs to individuate symbiosis opportunities at regional level in 2017. The project for an Industrial Symbiosis (IS) network in Umbria had the following objectives: (I) analysis of the productive sector in Umbria (II) local network activation with public and private actors (III) collection and processing of data (IV) development of handbooks for two most significant synergies and involvement of the interested companies to focus on specific solutions for resources valorization; handbooks has been developed with the collaboration of involved companies. Two workshops have been held in Terni (07.04.2017) and Assisi (09.06.2017), where more than 50 SMEs participated, and about 200 resources in output and about 80 resources in input have been shared among companies. More than 200 potential synergies were found among the participating companies, some of them found by ENEA with a specific data analysis. The resource streams and synergies have been studied to realise two technical handbooks: one handbook for the production of nutraceutical substances and the other one for energy production both from scraps coming from agro-industry. In the present paper the handbook for the nutraceutical substances production from scraps coming from agro-industry will be presented.

Keywords: Circular economy, Resource efficiency, By-products, Synergies, Network, Umbria.

1. Introduction

Industrial symbiosis (IS) is an emerging field of industrial ecology concerning the collaborative management of resource flows in business networks with the aim of achieving at the same time economic, environmental, and social advantages (Mirata, 2004). IS usually occurs between geographically proximate firms, e.g. firms co-located in clusters or industrial parks, as well as at regional level (Paquin and Howard-Grenville 2009). The fundamental principle of IS is the sharing of resources between firms. IS involves interconnections among industrial processes performed by traditionally separate industries, such as the physical exchange of materials, energy, water and by-product, to create mutual benefits (Boons et al. 2011; Chertow, 2000). In this way, the consumption of materials and energy is optimized, and by-products from one industry serve as raw materials for other industries, reducing disposal of waste and loss of resources (Frosch and Gallopoulos, 1989). The economic benefit associated with IS are in different dimensions. Economically, companies benefit by access to cheaper resource, avoiding disposal costs, and/or gaining extra profit from selling the by-products. The environmental advantages come from reducing resource consumption and mitigating environmental pollution (Erkman, 1997; Chertow and Lombardi, 2005). Finally, innovative business models can create a new relationship between companies and consumers (European Commission, 2014a).

Recent European policy documents have supported IS as an integral part of economic and environmental policy. IS is actually identified as a tool to implement circular economy in the last circular economy package of European Commission. In its Action Plan for Circular Economy, the European Commission targets a more sustainable and resource-efficient economy in Europe, identifies the need to promote IS and announces revised European regulation of waste in order "to clarify rules on by-products to facilitate industrial symbiosis and help create a level playing field across the EU" (European Commission, 2015). According to the

internationally recognized waste hierarchy IS application at local scale can contribute to the waste prevention and to the systematic reuse of waste and by-products minimizing in this way the need to extract natural resources and the depletion of environment (European Commission, 2008). ENEA (Italian Agency for New technologies, Energy and Sustainable Economic Development) and Sviluppumbria (Multi-functional Agency of the Umbria Regional Authority) cooperated to develop a IS network model among the companies in the Umbria region for the implementation of industrial symbiosis and new cooperative business models in the framework of the project Innetwork 2016/2017 (2014-2020 ROP Umbria ERDF , Axis 1, Action 1.2.1).

Sviluppumbria contacted about 100 companies in order to involve them in the IS working workshops. 50 companies participated at the Terni and Assisi workshops held in 2017 April 7th and 2017 June 9th respectively. They shared about 200 output resources and about 80 input resources. More than 200 potential synergies were identified. ENEA processed the data in order to list the potential synergies identified for each company participating to the workshops and to find more suitable potential synergies with an ex-post data analysis carried out by ENEA starting from data collected during workshops. According to the most significant synergies in terms of amount of involved resources and interest from companies in deepening the analysis, ENEA set up handbooks for describing in details the synergies for two particular cases: one handbook for the production of nutraceutical substances and the other one for energy production both from scraps coming from agro-industry. In the present paper the handbook for the nutraceutical substances production from scraps coming from agro-industry will be presented.

2. Methods

In 2011 ENEA started the development and the implementation of an IS network model thanks to three projects in three Italian regions: the “Eco-Innovation Sicily” project (Cutaia et al., 2015; 2014a; Luciano et al., 2016); the "Green Project - Industrial Symbiosis" in Emilia-Romagna (Cutaia et al., 2016; 2014b); and the "Industrial Park of Rieti-Cittaducale" project in Lazio (La Monica, 2016). The ENEA methodology used in all these projects to support companies in the realization of IS matches is the same applied in Umbria within the project presented in this paper. That consists of the following three phases.

A first organizational phase:

- analysis of the territorial context and, in particular, of its productive sectors;
- creation of a company database also geo-referenced;
- networking and promotion activities through more moments of contact with the selected companies located in the area and other stakeholders (e.g. public authorities, decision makers, institutions and associations of category) in order to illustrate the project and invite them to the workshops organized in order to get information on company inputs-outputs;
- sending emails to the companies taking in part in the workshops where are asked to fill in ENEA input–output table before the meeting so as to carry out a data collection on resources that they want to put in sharing within the project (those resources could be eventually updated and improved both during and after the workshops);
- organization of workshops in which ENEA identifies together with the companies the possible symbiotic synergies using input–output tables.

In the first phase it is interesting to underline that the ENEA input-output table is a data sheet to obtain information on resources that companies want to voluntarily share with others. That one foresees a taxonomy for the inventory of inputs or requested resources and of outputs or generated resources by companies (Figure 1), taking into account as resources “materials, energy, services, skills” and using code systems officially used in Italy (according EU regulation) for different kind of inventories (e.g. Nace codes, ATECO codes, ProdCom, EWC) with which companies normally deal with. Information asked in the input-output tables for collecting data are, in fact, the more simplified available in order to allow companies to fill the tables with the less possible effort, because information asked are those already used by the companies for their normal management.

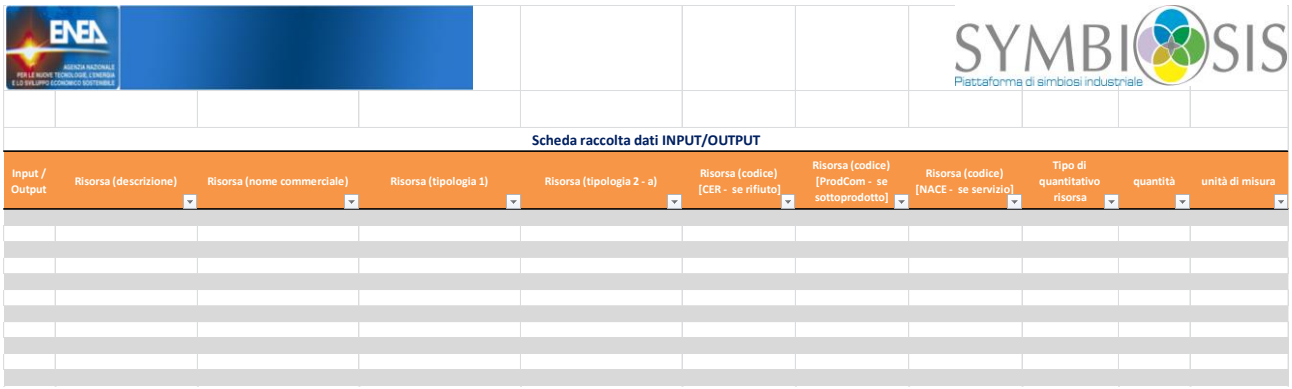


Figure 1. *ENEA input-output table (Cutaia L, at al., 2015)*

A second executive phase:

- carry out workshops with companies;
- a first moment of "data processing" during the workshops, i.e. the analysis of all the input-output data and identification of synergies with the companies;
- after the workshops, ENEA sends back an email to the companies with the list of shared resources by each company for their final control so that after information shared by companies through input-output tables are loaded on the ENEA platform;
- a second moment of "data processing" in which through the ENEA platform to identify further synergies compared to these ones found during the workshops;
- selection of the paths of IS to be proposed to companies;
- in-depth study of all issues to implement the pathway;
- first drafting of operating handbooks reporting selected IS paths.

Data elaboration and searching for synergies has also been realised with the help of the IS platform (www.industrialsymbiosis.it) developed by ENEA and used, with the same metrics and taxonomy in similar projects in Italy and abroad. The platform is based on the concept of IS which engages traditionally separate industries and other stakeholders in a network to foster eco-innovation strategies and a more sustainable use of resources (Chertow, 2000; Lombardi and Laybourn, 2012). It works through: 1) the interconnection (networking) among traditionally separated stakeholders (users) through matching between demand and supplyof resources shared by companies ; 2) existing databases and/or created by users that can be geo-referenced through Geographic Information System; 3) a central manager, that is ENEA.

The third final phase:

- carrying out a consultation meeting among the companies involved in the possible paths of selected IS, ENEA and other stakeholders where they discuss feasibility and different characteristics for implementation them;
- review of the handbooks based on feedbacks obtained during the consultation meeting with the companies and other stakeholders;
- final drafting of the handbooks;
- delivery of final handbooks to the companies involved.

In this last phase it is important to underlines that the handbook offers a systemic approach and knowledge base to support companies in the implementation of IS patterns found during or after the workshops, providing specific and tailored information for regulations, standards, logistical aspects, technical aspects, etc related to the specific synergy analysed. The handbook is organised in a first synthetic part (summary scheme) and a second containing all the useful documentation (technical dossier), citied in the first part. This useful tool aims to verify the feasibility of the synergies identified from a technical, logistics, economic and regulatory point of

view through a holistic approach that analyzes every single step of the path. The handbook allows identifying the issues to deepen/solve or barriers to overcome in order to implement synergies such as characterization and qualification of materials or administrative requirements. Moreover, this document can be a solid starting point for the setting up of an handbook, valid in an average way, and that allows the replication of the described IS pathways at similar cases.

The involvement of companies is based on a proximity criterion in the surrounding of the cities of Terni and Assisi, realised with the help of Sviluppumbria.

3. Results and Discussion

According to the proximity criterion, about 100 companies have been invited to take part to the workshops in Terni (07.04.2017 – Figure 2) and Assisi (9.06.2017) and, at the end, 24 companies participated at the workshops in Terni and 26 in Assisi. Table 1 shows the types of companies taking part to the workshops. It can be highlighted that the manufacturing sector was the most represented in both workshops followed by the agriculture sector.

Figure 2.*Terni Workshop 2017 April 7th*

Table 1. *Companies participating at workshops held in Terni (2017April 7th) and Assisi (2017 June 9th)*

Companies	Terni	Assisi	TOT
Agriculture	1	7	8
Manufacturing	18	15	33
Waste management activities	1	0	1
Construction	1	1	2
Wholesale	0	2	2
Financial activities	1	0	1
Professional, scientific and technical activities	2	1	3
TOTAL	24	26	**50**

The supply chain mainly represented in both workshops was the agro-industrial one with 18 companies: 8 from the Agriculture sector, 8 from the Manufacturing sector and 2 from Wholesale.

In Table 2 are reported the first results of both events. The resources shared during the workshops are 45 inputs (resources needed) and 201 outputs (resources offered). Wood and wood products are the most significant inputs, while agro-industrial waste and plastic, plastic products and rubber are the most significant ones for outputs.

As a whole about 250 resources were shared and about 260 potential synergies were identified, as reported respectively in Table 2 and Table 3.

Table 2. Resources shared during the Terni (2017April 7th) and Assisi (2017 June 9th) workshops (input, output)

Resource	INPUT		OUTPUT		Total	
	Terni	Assisi	Terni	Assisi	Input	Output
Energy	1	---	4	---	1	4
Service	2	1	1	14	3	15
Capacity	1	1	1	---	2	1
Paper and paper products	4	---	7	9	4	16
Chemical products	1	5	5	4	6	9
Metal and metal products	2	2	12	8	4	20
Wood and wood products	6	13	15	6	19	21
Agro-industrial waste	2	----	16	26	2	42
Construction and demolition waste	1	2	---	3	3	3
Plastic, plastic products and rubber	1	---	29	7	1	36
Exhausted oil			2	2	0	4
Mixed packings			2	6	0	8
Glass			---	1	0	1
Water and sewage sludge			8	4	0	12
Other			4	5	0	9
TOTAL	**21**	**24**	**106**	**95**	**45**	**201**

Resources shared in Terni and Assisi have been cross-checked for looking for more potential synergies and the results are shown in the column “mixed” in Table 3.

Table 3. Matches shared during the Terni (2017April 7th) and Assisi (2017 June 9th)Workshops

MATCHES	Terni	Assisi	“Mixed”	TOTAL
Energy	4	---	4	8
Service	5	---	---	5
Paper and paper products	6	16	17	39
Chemical products	4	---	---	4
Metal and metal products	6	16	17	39
Wood and wood products	20	7	8	35
Agro-industrial waste	19	36	15	70
Construction and demolition waste	4	1	1	6
Plastic, plastic products and rubber	19	2	13	34
Mixed packings	---	1	---	1
Water and sewage sludge	8	1	2	11
Other	5	2	---	7
TOTAL MATCHES	**100**	**82**	**77**	**259**

Resource streams and synergies have been deeply analysed to realise two technical handbooks: one handbook for the production of nutraceutical substances and the other one for energy production both from scraps coming from agro-industry. The specific issues on which focus the development of handbooks has been selected according to the most important streams, even in quantitative terms, and according to the availability of involved companies to provide more specific information both from the output side and from the input one. The following paragraph reports the handbook for the nutraceutical substances production from scraps coming from agro-industry.

3.1 Handbook for the nutraceutical substances production from scraps coming from agro-industry.

The companies involved in a possible path of IS aiming at the production of nutraceutical substances from agro-industrial scraps are four: one input-company (U015) that wants to have these resources and three output-companies (U024, U033, U055) that want to give them out (Table 4). Companies, as well as streams, are named with the code used in the project and not reported with its own name for privacy reasons.

Table 4. Companies involved in the handbook for the nutraceutical substances production from scraps coming from agro-industry.

Workshop	Company code	Legal form	Production site	Province	NACE Rev.2	Activity description
TERNI	U015	Limited liability company	Terni	Terni	M72.19	Other research and experimental development on natural sciences and engineering
TERNI	U024	Sole proprietorship	Terni	Terni	C10.41	Manufacture of oils and fats
ASSISI	U033	Sole proprietorship	Foligno	Perugia	A01.26	Growing of oleaginous fruits
ASSISI	U055	Limited liability company	Marsciano	Perugia	G46.33	Wholesale of dairy products, eggs and edible oils and fats

The input-company U015 is a company having his production site localized in the city of Terni. According to the NACE code this company carries out research and experimental development in the field of natural sciences and engineering. Its activity is mainly focused on obtaining products from the extraction of polyphenols of the olive.

The output-companies are as follows:

- U024 is a company whose production site is located in the city of Terni. According to the NACE code, it works in the manufacture of oils and fats. Its main activity concerns the collection and storage of olives and the extraction of oil through an olive-press and its storage and bottling.
- U033 is a company having his production site localized in Foligno in the province of Perugia. According to the NACE code this output-company mainly deals with the growing of oleaginous fruits. The farm cultivates olive trees following the principles of organic farming producing also an extra virgin organic olive oil thanks to an olive-press.
- U055 is a company whose production site is located in Marsciano in the province of Perugia. According to the NACE code, it works in wholesale of dairy products, eggs and edible oils and fats. This company mainly produces wines and olive oil and sells its products either through direct sales or through its online store.

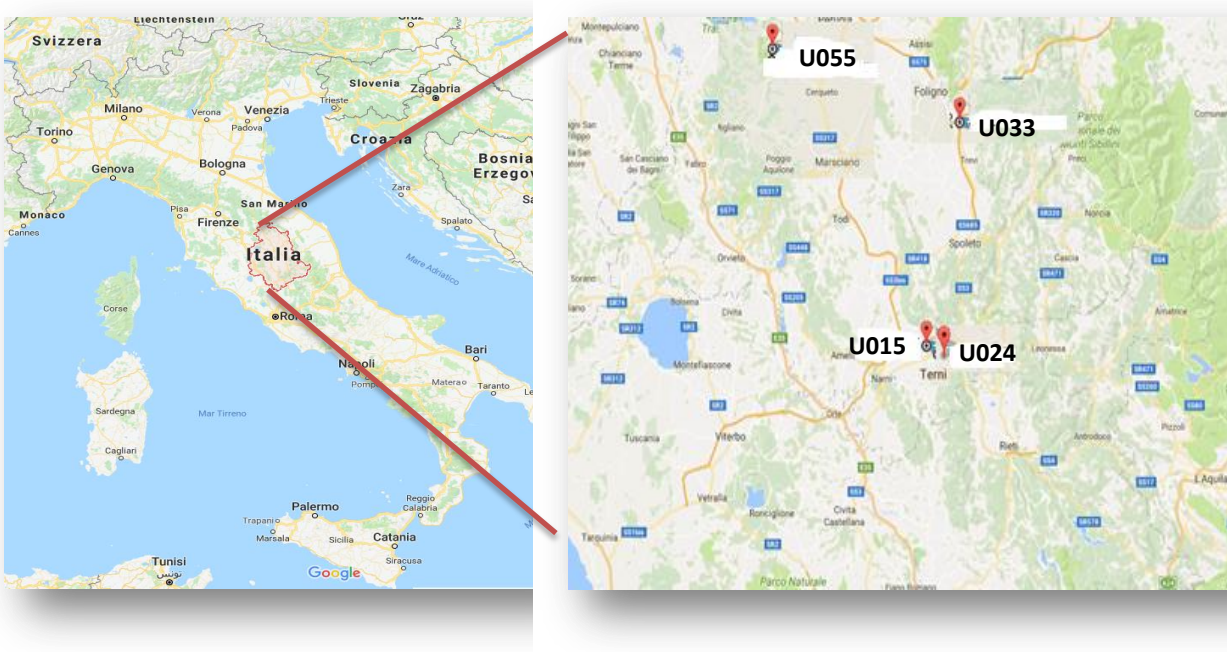


Figure 3. Geographical location of companies located in Umbria Region (Italy).

Handbook for the valorisation of waste from the processing of olives refers in particular to the reuse of the vegetation waters that come out from the mills. With regard to this synergy, four companies are involved: three companies share vegetation waters and a

company receives them. The receiving company is able to valorize these waters in a chemical production process that extracts useful substances for the nutraceutical sector. The term "Nutraceutical" derives from the union of "nutrition" and "pharmaceutical" and refers to those nutrient principles contained in foods that have beneficial effects on health. They are normally present in natural food but industrial transformation processes can affect its presence in final food products. Nutraceuticals can be extracted, synthesized and used as food integrative, or added to food. Company that receives these waters operates in the field of chemical extraction, in the research and innovation of new solutions to be put on the market. They produce natural raw materials with a high biochemical impact. Their production site has a plant for the extraction of polyphenols from the vegetation waters from the olive-oil production. Practically, first of all the waters are stored in large silos and then transferred to evaporators which concentrate the most reach part in substances. In this step the concentrated water is mixed with ethanol in a mixer at a temperature of 4°C. After 24 hours, allowing the most solid substances to settle, the concentrate goes to the distiller. The distiller extracts the ethanol that is expelled from the concentrate, and produces the rest as a gelatinous appearance. This final product is dark and gelatinous with a very high content of polyphenols, very interesting for the cosmetic industry. The Company produces a high quality anti-aging cream. The product can be sold in the form of a polyphenolic compound for different uses and sectors. This process represents a strategic opportunity because it could be applied to vegetation waters coming from several mills located in the area and can be applied to other similar situation, quite usual in Italy. The very strong point of this synergy is the very high added value of the final product (the concentrated polyphenol gelatine) that has several application potentials. Following figure shows the relations of the synergy related to the waste water streams from olive-oil valorisation for polyphenol extraction. With the red line are indicated the match identified during the workshops, with the blue ones the matches identified by ENEA.

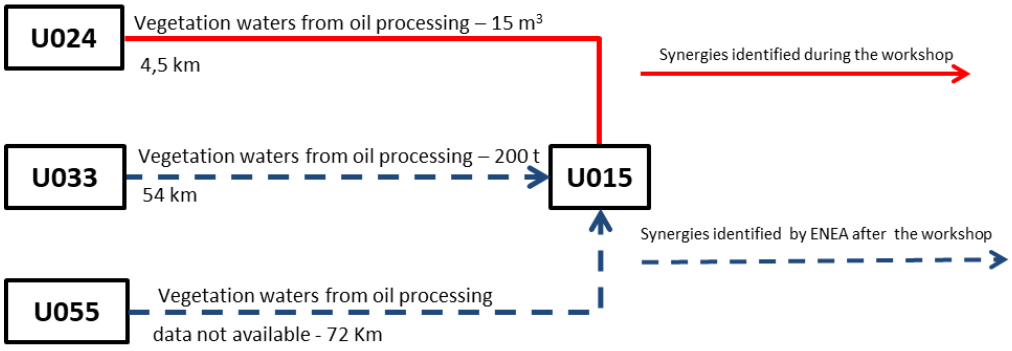
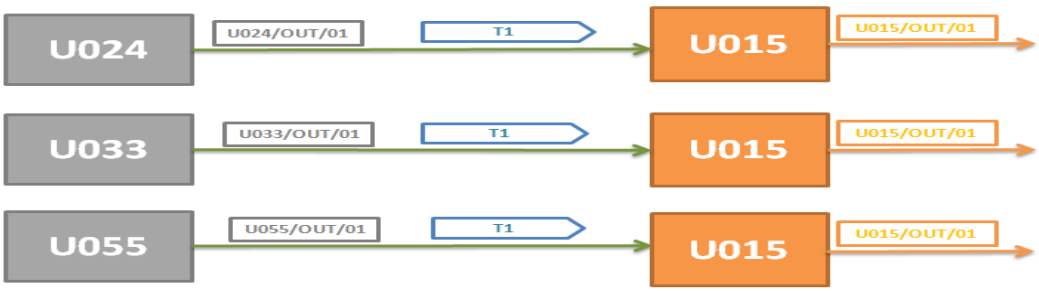


Figure 4. *Waste water streams from olive-oil for polyphenol extraction - Synergy layout*



Regulatory issues					
European	Directive 2008/98/EC			Regulation 432/2012	Regulation on the use of additives in food products: Reg.(EC) 178/2001 on food law
					Directive 88/388 and Decision 1999/217 on aromatizes; Directive 76/768 on cosmetic products
National	Legislative Decree 152/6 By-product: art.184	Decree by-product: 13 October 2016		Regulation on the use of additives in food products: Ministerial decree 209/96	
Technical issues					
Specific process: olive waste processing		Data sheet from Annex 2 of the DM by-products	Subscription to the demand exchange platform offered by DM by-products		
Logistical issues					
Authorization permission		Supply contract by-products	Transport documents		

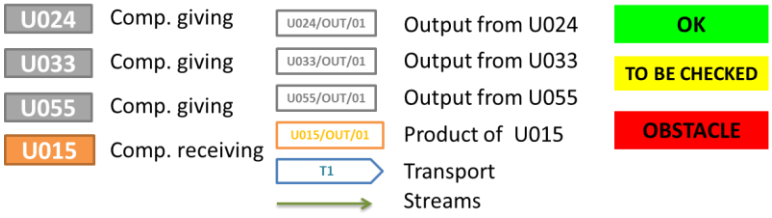


Figure 5. *Layout and summary table for the nutraceutical substances production waste water from olive-oil production.*

4. Conclusions

Based on the IS approach, the proposed methodology can be considered an interesting solution to facilitate the IS at a regional level and local level. The methodology helps to promote the efficient use of resources and new business models through the selection of the most promising synergies between companies, and the possibility of new opportunities for collaboration in the sharing of infrastructure and services. The methodology was tested in an industrialized area of Umbria region (Italy) that has many industries not strongly cooperating, at least from the point of view of enhancing circular economy through the IS. Most companies are SMEs with a high number of small different flows, in input and in output. The industrial symbiosis pilot project in the Umbria region is ended but ENEA is currently working to evaluate the economic feasibility of the synergies proposed in comparison to the existent scenario (BAU, Business as Usual). The results of the economic assessment will be integrated properly in the corresponding handbooks and delivered to the involved companies as well as presented to main stakeholders. The collaboration between ENEA and Sviluppumbria will probably continue, given the very positive feedback that the pilot project on industrial symbiosis had from companies and stakeholders.

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