A systematic methodology for industrial symbiosis approach development at a regional scale

L. Cutaia[1], G. Barberio[1], A. Luciano[1,*], E. Mancuso[1], S. Sbaffoni[1], M. La Monica[2], C. Scagliarino[3]

1 Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), IT
2 University "La Tuscia", IT
3 Environmental consultant

* Corresponding author antonella.luciano@enea.it

Abstract

Purpose. A systematic methodology for industrial symbiosis development at a regional scale is presented. The methodology was applied for the first time in Sicily as a pilot project with the aim of promoting productive development in southern Italy.
Methods. A platform is projected as an instrument to enable the transfer of resources and offer other services including a legal database, LCA and ecodesign tools and best practices guidelines specifically addressed to SMEs. Promotions activities and local stakeholders involvement were carried out during all the project duration. A database containing information on more than 2000 enterprises was firstly developed for group of heterogeneous companies selection in order to represent the most important productive sectors. Then operative meetings were organized for selected enterprises involvement in sharing information about resources fluxes and wastes and looking for potential synergies.
Results. During the meetings more than 80 SME were linked giving rise to almost 240 output resources and almost 190 input resources. More than 650 potential matches were found between the participating enterprises showing interesting opportunities both for substituting resources with waste products in real and virtual cases and for sharing waste management services and infrastructures.
Conclusions. The discussion occurred during the meeting has highlighted the significance and the consequences of the regulatory and control system on IS application, underlining the necessary participation of local stakeholders and control authorities and the needs of identify predominant productive activities in well-defined territorial contexts where to investigate the specific/local tangles involving legislative and technical-economic feasibility. Results also show that the used methodology for industrial symbiosis development is suitable for further implementations in other regions.

Keywords: industrial symbiosis, platform, input-output, companies, synergies, waste

Introduction

Efficiency and optimization of resources and energy and waste minimization represent an important strategy in a perspective of circular economy (Atasu 2008). The industrial ecology provides activities to close and optimize cycles of matter and energy (den Hond, 2000, Bringezu, 2003 and Korhonen, 2007) and the development of a systemic consideration of the industry (Graedel and Allenby, 2003). Industrial symbiosis, which represents one of the main features of industrial ecology, aims at the reduction of the wastes disposal into landfill and the maximization of their recovery potential through the development of regionally and locally based networks of companies factories and enterprises of similar or different business sectors. Links are encouraged between the companies so that resources such as materials, wastes, energy and water, and/or logistics, assets and expertise, from one company can be recovered, reprocessed and re-used by others (Chertow, 2004). Generating additional sales, attracting private investments, diverting waste from landfill, reducing CO_2 emission, creating and safeguarding jobs, are ones of the main benefits of the proposed approach. This method uses actual business opportunity as the mechanism for encouraging resource efficiency and its holistic approach has the potential to significantly reduce industrial and commercial waste and comprehensively lessen the adverse environmental impacts of business.
This approach reflects the recent European strategies of decoupling economic growth, environmental impacts and natural resource consumption through the promotion of a more sustainable circular economy as clearly identified in different programming and financing documents of the European Commission (EU COM, 2011, 2012, 2014).
Its application at local scale can contribute to the systematic reuse of waste and by-products, which minimizes the need to extract natural resources and the depletion of environment, according to the internationally recognized waste hierarchy (EU 2008).
The possibility for IS application is no longer limited in geographical proximity (Lombardi and Laybourn, 2012). There is no preferable spatial scale at which loop closing should be organized: loop closing is dominated by the spatial

economic logic of the transactions of the involved firms (Lyons, 2007). Location may be useful to create possibilities for firms to work collaboratively towards more environmentally friendly designs, more effective waste management, and beyond (Chertow and Ehrenfeld, 2012). However, the most important factor for developing IS relationships is collaboration amongst organizations (Bansal and McKnight, 2009). For this reason the presented project applied in Sicily, aimed to create a regional symbiosis platform with the idea of the active participation of both SMEs and local stakeholders.

Materials and Methods

Starting from 2011 ENEA began the development of the first Italian Industrial Symbiosis Platform addressed in particular to small medium enterprises (SMEs) and to other local operators to enable the transfer of resources (materials, energy products, water, services and expertise) and to offer other operational instruments (regulatory database, LCA and Ecodesign tools, Best practices database, etc.). The proposed Platform is based on a Manager (at the moment ENEA itself) and an integrated system of an ICT and DBs tools supporting and managing DBs, stakeholders' networks and meetings with companies. In parallel to the platform architecture design, described in previous works (Cutaia et al. 2014a,b), a systematic methodology for platform implementation and operation was developed and applied for the first time in Sicily. The methodology includes several activities for platform operation concerning database implementation, network activation, and operative meetings.

Considering that the first success factor in IS development is the establishment of the social network between companies and stakeholders and maintaining their continuous interest, mutual trust, and involvement (Sakr et al. 2011), several activities were launched for network activation. Initiatives were promoted for enterprises, authorities and stockholders involvement and sensitization on IS environmental and economic benefit, on project developments and so on, both at regional (in Sicily) and at national level. For sensitization and dissemination purposes in 2011 ENEA registered the domain www.industrialsymbiosis.it and other equivalents and more in general, the reference website for the promoted activities. At national level ENEA organized, starting from 2012, at Ecomondo Exhibition a series of national Conferences on the theme of industrial symbiosis aimed at collecting all the experience made on this topic by different institution and researchers and at sensitizing all political and institutional stakeholders in order to allow applications overcoming regulatory procedural barriers. In 2015 ENEA established the first Italian Industrial Symbiosis Network (SUN: Symbiosis Users Network; www.sunetwork.it). This network aims at being the Italian reference point in the field of Industrial Symbiosis through the support of scientific/research bodies as well as the participation of operative stakeholders (companies and institutions) and the cooperation with the General States of the Green Economy.

Local stakeholders' involvement is carried out through contacts with Sicilia Region (Regional waste Agency), meetings and specific framework agreement signed between ENEA and Confindustria Sicilia (Sicilian association of Industrials) and ENEA and University of Catania. The framework agreement signed with Confindustria Sicilia aimed at involving local productive sectors, enterprises and institutional partners, whereas the framework agreement signed with University of Catania aimed at collaborating in research activities in the field of eco-innovation strategies, with the perspective of mutual exchange of research experience and buildings and equipment provision.

In order to know and understand the Sicily's productive system, a database containing information on more than 2000 companies was developed collecting data from regional productive districts, chambers of commerce, universities, industrial associations and companies' web sites. The information collected into the database was: geographic localization, name of the enterprises, name of the owner, productive sector, number of employees. The productive sectors were represented by the classification of economic activities ATECO/NACE code. ATECO is a type of classification adopted by the Italian National Statistics Institute (Istat 2009), whereas NACE is a taxonomy developed by Eurostat, the statistical body of the European Commission (Eurostat, 2009). Starting from this comprehensive DB an analysis of regional productive sectors and an evaluation of quantity and dimension of enterprises were made to identify the most productive areas in the region more suitable for the organization of operative meetings to begin symbiosis paths. Then, considering sectors, employees and location, groups of heterogeneous companies were selected and invited to take part to operative meetings.

Two operative meeting (Fig. 1) were organized in most productive area of Sicily (East Sicily) with the main goal of involving companies in the project, get from them data and thus looking for potential synergies. The first meeting (Cutaia et. al, 2014b) held in Syracuse on March 28th 2014 with the support of the Chamber of Commerce. Sicilia Region gave their patronage to the workshop as Confindustria Sicilia did. The second operative meeting was held in Catania on October 24th 2014 with the support of Confindustria Catania and the collaboration of University of Catania (Department of Industrial Engineering).

a) b)

Fig. 1 Operative meetings in Syracuse (a) and Catania (b)

The meetings have been organized using both the ENEA methodology and the NISP one (the UK National Industrial Symbiosis Programme). For meeting organization invitation emails were sent to a selected number of companies, present in our database, with number of employees larger than 5 (in Sicily there are many small companies). For a more restricted group of companies we did finalized telephone calls in order to explain better the goal of the meeting. For a more capillary diffusion, invitations were made also by our local partners (Confindustria, Camera di Commercio and Department of Industrial Engineering of the University of Catania).

According to ENEA methodology before the meeting registered companies have been asked to fill in input-output tables about the resources they want to share within the project. These tables are organized as described below. The first two columns are two free text fields in which the company can specify the characteristics and a brief description of the resource, intended as a) materials; b) energy carriers (or sub-products in case of energy output); c) services; d) skills. "Services" means every kind of support resources such as transportation, available storage space, etc. that are not used entirely by the company and which can be shared with other participants, after proper agreements. The same applies to "skills", but in this case it refers to the skills and competences that can be shared if not fully used. The third column actually describes which of these four categories corresponds to the resource being described. In the "input" template, fourth and fifth columns presents drop-down boxes with specific codes that describe the resource using the codes normally used by companies. PRODCOM (Community Production) is the tool that the European Union has adopted to harmonize statistical observations about industrial production, and consists of a list of products (these are generally "goods", but also including some industrial services) grouped according to the economic sector of the manufacturer. NACE or ATECO are classifications of economic activities. In the fourth column is required to specify if the materials is a waste or a by-product because of the different legislations and administrative rules for those different typologies whereas the fifth column contains an identification code describing the resource: ERC (European Waste Catalogue) is the classification of waste types according to Directive 75/442 / EEC, PRODCOM (same as described above for "input" template) is used if the resource is a sub-product, NACE or ATECO (same as described above for "input" template) is used if it is a skill or service. The last three columns require to specify quantities, unit of measure and if the quantity is batch (available only at specific intervals) or annual (e.g. available continuously).

During the meeting, according to NISP methodology, almost five round tables, each containing 10 delegates were managed by ENEA facilitators. Delegates at each table shared their input-output resources using specifics slips, and then the compiled slips were sent to the other tables. Finally delegates' socialization was allowed during the lunch, prepared at the end of works, which represent, particularly in south Italy the best opportunity to get together and for proposals exchange.

The information shared by the enterprises before, during and after the meetings were included in the database, checked and loaded on the ENEA platform in order to search for further synergies.

The algorithm used in the platform to find synergies is represented by an "origin-destination" string. It uses the logic "one-to-many" to find relations between the main characteristics of a waste/by-product from one company and its potential as an input resource for another company. Following the opposite direction the same algorithm allows verifying which wastes, from different companies, can satisfy the quality specifications to allow the use, as an input resource, for a given company. The use of real case in the "origin-destination" string implementation increases the platform efficiency.

Results and discussion

On the basis of collected data, agriculture, followed by manufacturing, represents the mains sector of activities in Sicily (Fig. 3). In central zones (Enna and Caltanissetta) prevalently rural, agriculture is certainly the predominant sector with a greater number of companies and employees. Agriculture and particularly fishing are also well developed in the northern part of the island (Palermo, Messina and Trapani).

Industrial production in this region is characterized by a few but important industrial centers. Industrial poles, in particular petroleum and chemical industries, are concentrated in eastern Sicily (Catania and Syracuse) (Fig. 2) where the manufacturing sector represents an important percentage. Also in the south east (Ragusa) the manufacturing sector represents an important percentage together with numerous farms for breeding livestock.

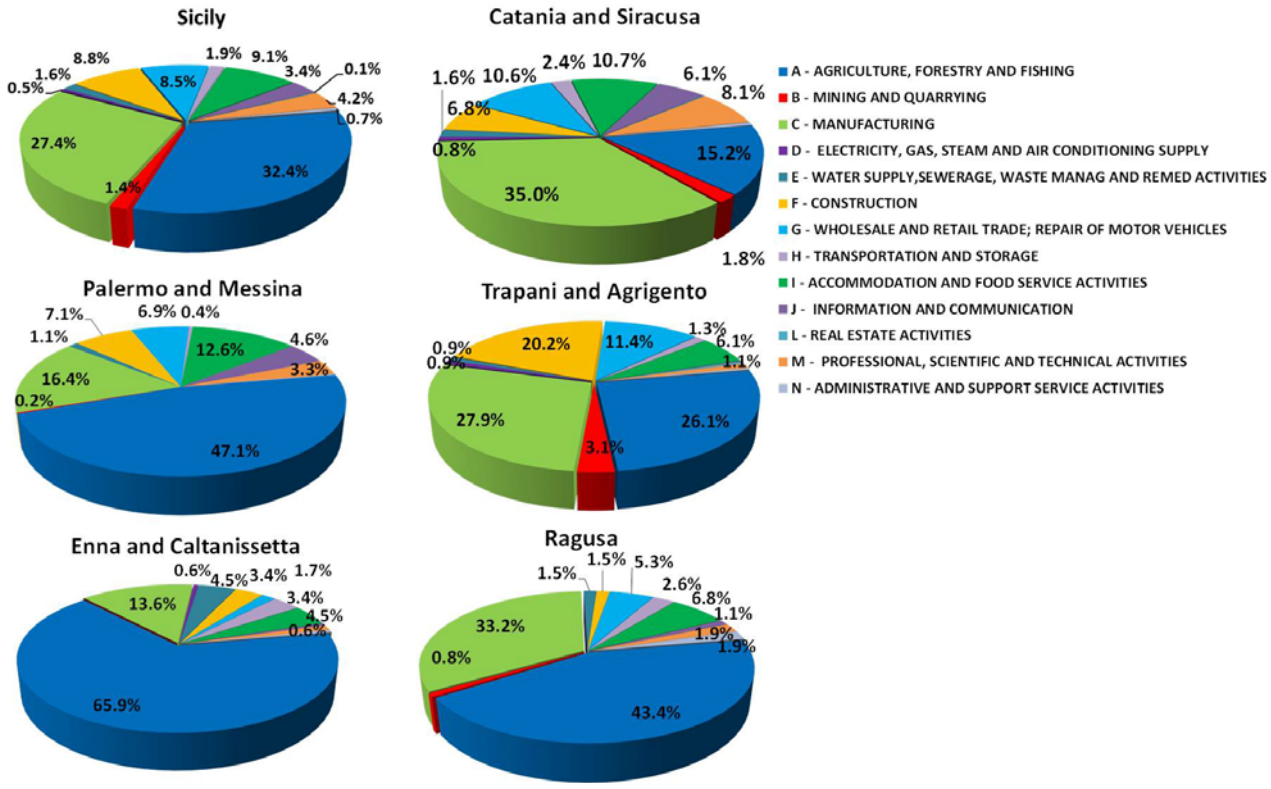

Fig. 2 Industrial sectors in Sicily (ENEA database)

The main interesting area for IS development is certainly represented by the east Sicily, in particular Catania and Siracusa districts, where the greatest number of companies with a greater number of employees is concentrated (Fig 3).

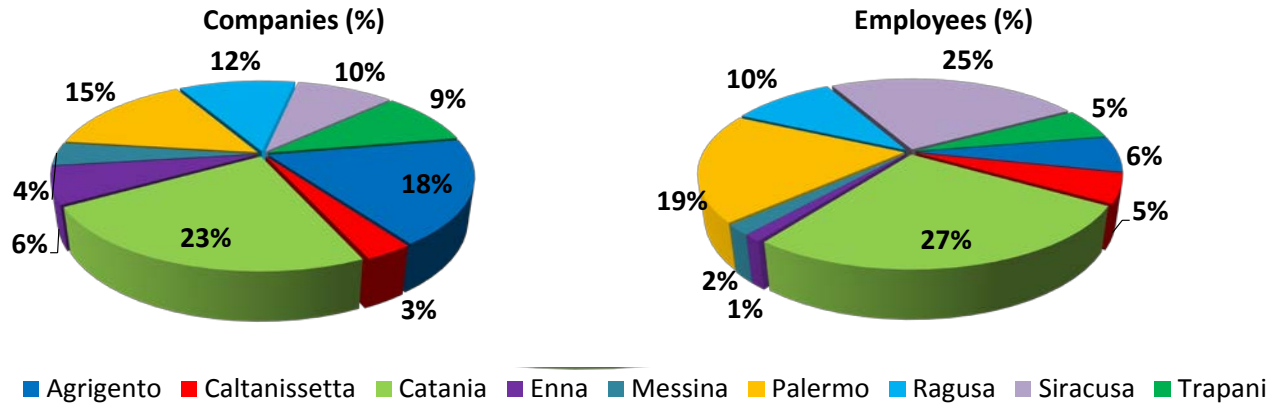

Fig. 3 Companies and employees.

A number of 44 delegates attended the Siracusa workshop, coming from 36 different companies prevalently from manufacturing and agriculture sectors (A) (37.1%) followed by water supply, sewerage waste management and remediation activities (E) (14.3%) and professional, scientific and technical activities (M) (14.3%) (Tab. 1).
Also in Catania meeting, where 37 companies with 42 delegates participated, the main sector was manufacturing with a higher percentage respect to Siracusa meeting (47.2%), followed by electricity sector (13.9%) and professional, scientific and technical activities (13.9%).
The lower participation in Catania meeting of delegates from sector as administrative and support service activities (N), human health and social work activities (Q), service activities and water supply, sewerage, waste management and remediation activities (E), resulted in a greater number of potential matches with almost the same number of declared resources (Tab. 2).
During Siracusa meeting more than 160 output resources and more than 50 input resources of different categories and 160 potential matches were found. The resources shared by the companies during the workshop were mainly "materials" (e.g. water, plastic, metals, chemicals etc. – 50% of the output resources and 42.1% of the input resources) and expertise, consultancy and services (42.1% of the output resources and 45.6% of the input resources).
From the workshop held in Catania good results have been achieved (Tab. 2): about 500 potential matches have been found starting from 133 outputs (63% materials, 25% expertise, consultancy and services) and 77 inputs (45% materials, 31% expertise, 12% equipment) shared during the workshop. 499 potential matchers were found (264 as materials, 41 as energy, 128 as skills and services, 7 as logistics and transports, 33 as available surfaces or volumes, 26 as equipment).
Starting from the analysis of prevalent interest of companies in sharing resources, three main groups of resources fluxes (wastes from processing stone materials, construction and the demolition waste; plastics and biowaste) have been individuated for further insights and technical dossiers elaboration.

Tab. 1 Delegates at the meetings for each industrial sector

	Siracusa meeting		**Catania meeting**	
NACE CODES	**Registered delegates (%)**	**Delegates to the meeting (%)**	**Registered delegates (%)**	**Delegates to the meeting (%)**
A - Agriculture, forestry and fishing	3.3%	5.7%	9.1%	8.3%
C - Manufacturing	36.1%	37.1%	37.9%	47.2%
D - Electricity, gas, steam and air conditioning supply	1.6%	2.9%	7.6%	13.9%
E - Water supply; sewerage; waste management and remediation activities	13.1%	14.3%	6.1%	2.8%
F - Construction	4.9%	2.9%	6.1%	5.6%
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	1.6%	0.0%	9.1%	8.3%
H - Transporting and storage	6.6%	8.6%	6.1%	8.3%
J - Information and communication	6.6%	2.9%	1.5%	0.0%
M - Professional, scientific and technical activities	13.1%	14.3%	16.7%	13.9%
N - Administrative and support service activities	3.3%	2.9%	0.0%	0.0%
O - Public administration and defense; compulsory social security	0.0%	0.0%	1.5%	0.0%
P - Education	0.0%	0.0%	1.5%	0.0%
Q - Human health and social work activities	1.6%	2.9%	0.0%	0.0%
S - Other services activities	8.2%	5.7%	6.1%	0.0%

Tab. 2 Resources shared during the meetings

	Siracusa meeting			Catania meeting		
Resources	**input**	**output**	**matches**	**input**	**output**	**matches**
Materials	24	82	88	84	33	264
Energy	5	4	7	1	7	41
Expertise, consultancy, services	26	69	62	33	23	128
Logistic, transportations	1	8	6	3	3	7
Land, capacity	1	1	1	10	2	33
Equipment				2	9	26
Total	**57**	**164**	**164**	**133**	**77**	**499**

Conclusions

ENEA developed the first Industrial Symbiosis Platform in Italy, actually in implementation phase at regional scale in Sicily. A systematic methodology was developed, applied and tested for platform operation with the perspective of further implementation in other regions. This methodology comprises network activation and promotion activities by means of stakeholders' involvement, analysis of productive sectors in the region and operative meetings organization finalized to involve companies in the project and looking for potential synergies.

As a follow up of the project, ENEA has registered till now, an huge interest from companies and local stakeholders in this methodology (and related tools) for its specific function in moving towards circular economy, save money and resources, if possible through the valorisation of those resources on to the local area which can be seen as a territorial benefit and not only a "personal" one.

Input-output data shared during, before and after workshops took, as first results, at identify more than 650 potential synergies for more than 410 resources shared. ENEA is still working with companies in the implementation of the pathways which carry from the idea till the actual implementation of potential matches.

One of the main results of the discussion occurred during the meeting was the significance and the consequences of the regulatory and control system. For this reason it was particularly important the presence and participation of local stakeholders and control authorities in all the phases of symbiosis implementation.

Results coming from organized meetings also highlighted the needs of identify predominant productive activities in well-defined territorial contexts where to investigate the specific/local tangles involving legislative and technical-economic feasibility. Predominant productive activities, in term of exchangeable fluxes, where therefore identified for further insights. Technical dossiers on three main resource streams (wastes from processing stone materials, construction and the demolition waste; plastics and biowaste), which may generate the more interesting potential synergies, are being implemented. These dossiers include European, Italian and regional regulations, guidelines, technical standards, logistic and economical aspects useful for supporting companies in synergies implementation. Results of this activity will also be used to improve the algorithm presents in the platform to find synergies.

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