Industrial Symbiosis Guideline.

AIDIMME: Processes and Sustainability Management.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 870037.

Presentation/Objective of the guideline

The objective of this guide is to introduce the concept of industrial symbiosis to SMEs.

Industrial Symbiosis is a key tool to materialize the concept of circular economy.

With industrial symbiosis, resources are kept in productive use for longer, making the transition from the linear economy model to one of circular economy a reality.

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1.What is Industrial Symbiosis

1.1. Industrial Symbiosis.

From an etymological point of view, symbiosis refers to any **association in which its members benefit from each other**. It is a concept that comes from Greek and can be translated as "means of subsistence".

In Biology, symbiosis consists of an associative bond developed by specimens of different species. The term is used mainly when the organisms involved (known as symbionts) derive a benefit from this common existence, for example lichens (union of fungi and algae).

Following this argument, Industrial Symbiosis can be considered as an **organization model** that promotes the establishment of **synergies between industries** in such a way that a beneficial exchange takes place for the industries involved.

1.1. Industrial Symbiosis.

Industrial Symbiosis is based on a **cooperative model** that seeks to optimize the flows of resources to obtain a collective benefit greater than the sum of the benefits that can be obtained individually.

Through Industrial Symbiosis, it is possible to detect which resources are underused and become waste prematurely. These resources could be used as raw materials in industries in another sector to re-enter the value chain.

Industrial symbiosis involves the search for interaction among industrial activity and its environmental and urban environment. In this new connection production processes become dependent and interrelated elements. Thus, the symbiosis between human activities located in a given area is enhanced, through the exchange of materials and energy, the use of localized knowledge in various activities, the development of facilities or shared initiatives.

1.1. Industrial Symbiosis.

Industrial Symbiosis **implies collaboration between two or more companies through the exchange of material, energy or other flows that are residual or not usable by one company, to be used as a resource by another**. Industrial Symbiosis also can imply other types of collaborations such as the sharing of **information, infrastructures or services, logistical means, experience, etc. that provide a benefit to companies involved**.

Industrial symbiosis can lead to a reduction in environmental impact through the optimization of the use of resources and the reduction of waste streams, and a potential economic benefit due to the reduction of waste management costs, purchase of primary raw materials, etc. This is **directly linked to the concept of circular economy**, since it contributes to closing the material cycle in the production phase, and optimizing the efficiency of the use of resources, creating value in products, materials and resources and ensuring that the resources remain in the system as long as possible.

1.2. Introduction to the environmental problem, relationship with circular economy.

The **traditional linear economy model** based on “produce-use-throw away” is based on the premise that resources are abundant, available, easily accessible and cheap to manage when they become waste. But this model is not feasible when it’s viewed from a long-term perspective.

Every year Europe loses around 600 million tones of valuable materials in the form of waste that could potentially be recycled or reused. Directives about waste are a powerful tool for reducing waste generation and optimizing its management through a series of hierarchical actions, but more efforts are required to “close the loop”.

1.2. Introduction to the environmental problem, relationship with circular economy.

Industrial Symbiosis involves the search for interactions between industrial activity and its natural and urban environment, where production processes are dependent and interrelated elements. In this way, the symbiosis between human activities located in a given area is enhanced, through the exchange of materials and energy, the use of knowledge and the development of facilities or shared initiatives. In this context, the term "waste" is not considered as worthless or useless matter, but rather imitates natural ecosystems in which nothing is disposable and all materials are reused with great efficiency.

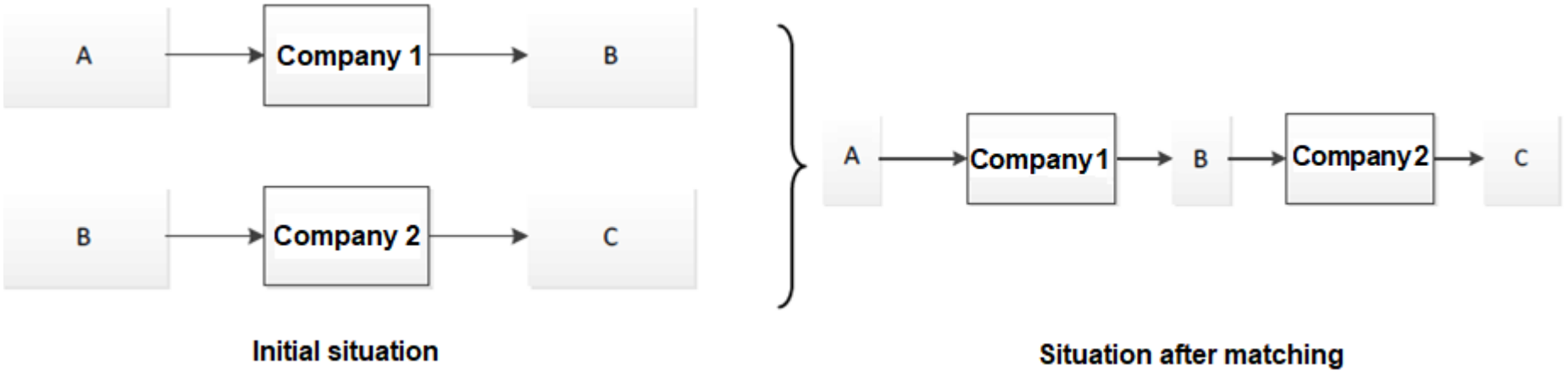
Likewise, the by-products and waste of one industry are used as raw material for others, producing at the same time economic and environmental benefits, since the saving of resources is added to the minimization of waste and the reduction of polluting loads. In this way, companies and other entities establish a relationship and collaboration within the industrial sector with the social and natural environment.

1.2. Introduction to the environmental problem, relationship with circular economy.

Industries should be the driving force behind the change that the circular economy implies. And this means collaborating with each other, sharing resources, establishing new relationships between competitors, suppliers, consumers, and other stakeholders in order to promote regenerative industrial growth. Industrial symbiosis is the way to apply all the concepts of circular economy in the productive network.

1.3. Types of industrial symbiosis

Symbiosis involves a transaction in the participating companies so that the outputs are used as inputs. This is known as "establishment of synergies“, since the global benefits of this transaction are greater than the sum of individual benefits separately, giving rise to great competitive advantages.



1.3. Types of industrial symbiosis

Synergies that can arise within a process of industrial symbiosis are classified according to three main types:

- **Mutuality synergies:** These opportunities consist of the use / shared use of common services, facilities or infrastructures by the participating companies. (For example, energy supply or waste treatment, cooperation on issues of common interest such as emergency planning, training or sustainable planning, logistics and transport).

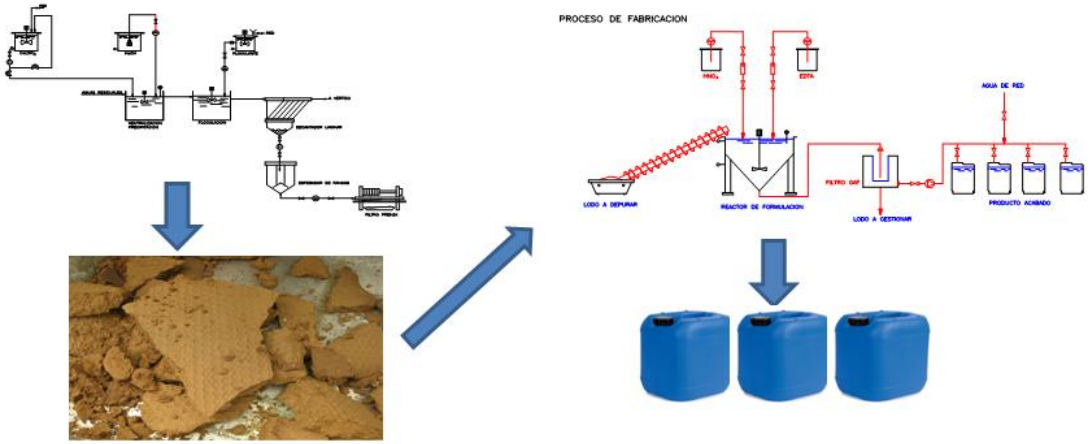
- **Substitution synergies:** These opportunities mean that residual flows from one company become inflows in another. (For example, exchange of by-products, waste, residual heat etc.) In this way the useful life of raw materials is optimized

- **Genesis synergies:** These opportunities are related to the creation of a new activity to satisfy the need for reuse of any flow.

1.3. Types of industrial symbiosis

For practical purposes, substitution synergy is the most visible in reference to industrial symbiosis, since it provides opportunities for reducing the input costs of resources or the cost of treating waste streams.

* SOURCE: Iniciativas empresariales de economía circular en el País Vasco. Ihobe



* SOURCE: AIMME. use of iron-rich sewage sludge for compost

2. Benefits of implantation Industrial Symbiosis models.

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The exchange of underused resources implies the possibility of:

- Reusing material resources,
- Share infrastructure or services such as energy, water, wastewater
- Access services together: transport, purchase, provisioning, etc.

The implementation of symbiosis models can lead to a global reduction of the environmental impact through both the inputs, or the resources used (raw materials, energy ...) and the outputs generated: emissions, waste, discharges, by-products, etc.

Linking directly with the concept of circular economy, as it contributes to closing the material cycle in the production phase and optimizing the efficiency of the use of resources.

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ECONOMIC BENEFITS

- RESOURCE SAVING
- WASTE MINIMIZATION
- REDUCTION OF POLLUTANT LOADS
- IMPROVEMENT OF THE ENVIRONMENTAL IMAGE
- INCREASED COLLABORATION IN THE INDUSTRIAL SECTOR

ENVIRONMENTAL BENEFITS

- Entreprises
- Local entities

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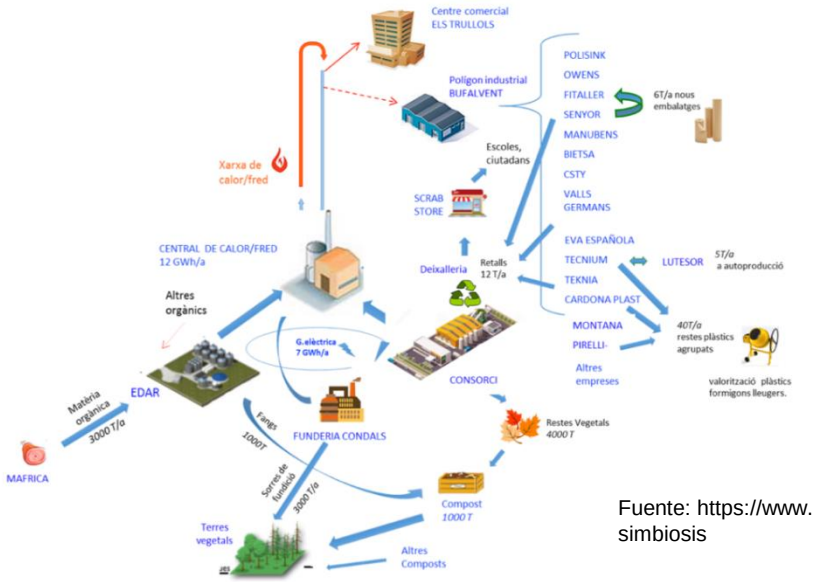
As an example, cooperation between nearby companies has tangible economic and environmental benefits, since the cost of transportation is practically zero, the rest of the benefits are also increasing.

The implementation of symbiosis models in a given industrial zone will allow the inflow and outflows to be used in the same zone, keeping the resources in productive use for a longer time. Also avoiding that the environmental impacts are dispersed.



Fuente: https://www.simbiosy.com/post/presentaci%C3%B3n-de-los-primeros-resultados-del-proyecto-manresa-en-simbiosis

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However, although geographic proximity is frequently associated with industrial symbiosis, it is neither essential nor sufficient, since it is not based solely on a physical exchange of resources.

In practice, the concept of industrial symbiosis is applied to commercial operations in which the use, recovery, and redirection of resources for reuse causes them to remain within the economic system for longer, **creating new business opportunities and reducing the pressure on resources and natural systems.**

Industrial symbiosis is another tool to achieve a circular economy model

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With industrial symbiosis, **an overall profit is obtained that is greater than the sum of the individual profits of the company**.

The aspects that favor the implementation of industrial symbiosis models are:

-the existence of a tractor company around which the symbiotic industrial nucleus is generated.

-the existence of flows and exchange of materials and energy between companies in the area.

- the existence of an association or network of companies with common needs.

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The economic benefits obtained by companies will be variable, but these cost savings will contribute to obtaining a **competitive advantage in the market.**

The economic benefits include savings in the purchase of raw materials, waste management costs and the sale of waste as by-products.

The reduction of the environmental impact of production, translated into a reduction in the generation of environmental aspects (waste, emissions, discharges ...) and its consequent polluting effects in the industry has **a positive effect on the quality of the environment and therefore, on the health and quality of life of citizens**.

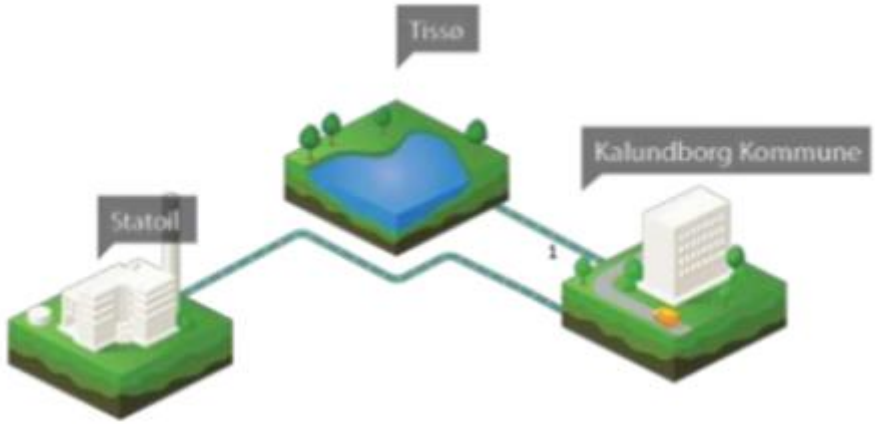
Industrial Symbiosis represents a great opportunity for economic growth and for the creation of jobs, decoupling the consumption of non-renewable resources that can have really positive impacts on a socio-economic and environmental level.

3. Good practices and succesful stories

KALUNDBORG

Kalundborg is a Danish port city that has become the flagship model of industrial symbiosis.

It consists of a network of interconnected companies that share input and output streams, just like a natural ecosystem.



Source: http://www.symbiosis.dk/en/

The system started in 1961 with 2 companies: A power station and a refinery.
The plant supplied energy to the refinery and the refinery supplied gas to the plant.
The results were 2 companies connected and 2 flows

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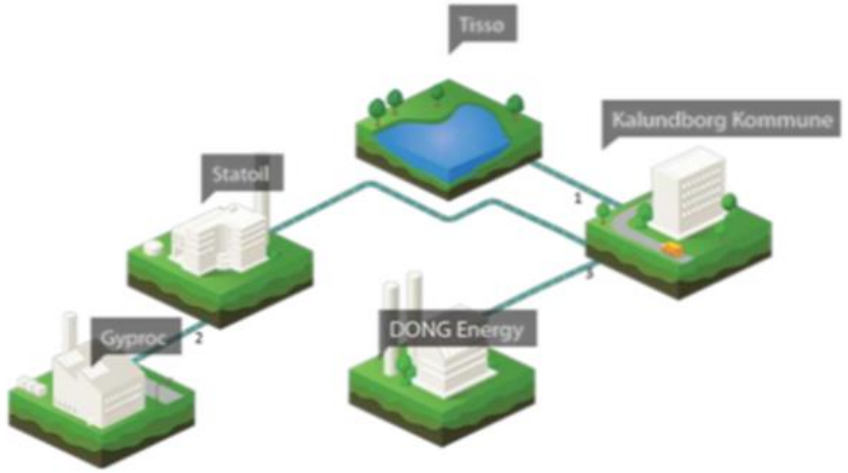
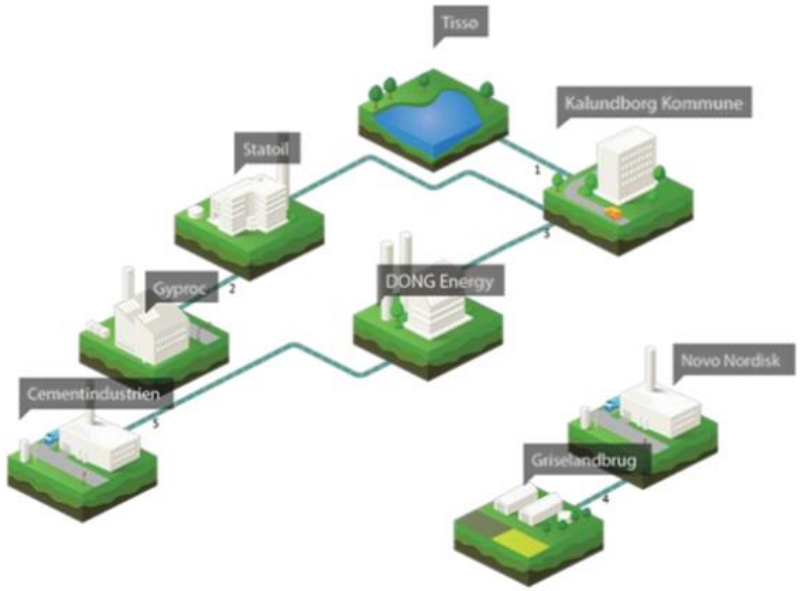


In 1972 the refinery signed an agreement with a plaster company in order to pass the excess gas.
As a result, 4 companies are connected and there were 4 connection flows.

In 1973 a new company was connected to the water pipe of the refinery.



Over time the network grows, and in 1979 there are 8 companies connected and 6 connection flows

Source: http://www.symbiosis.dk/en/

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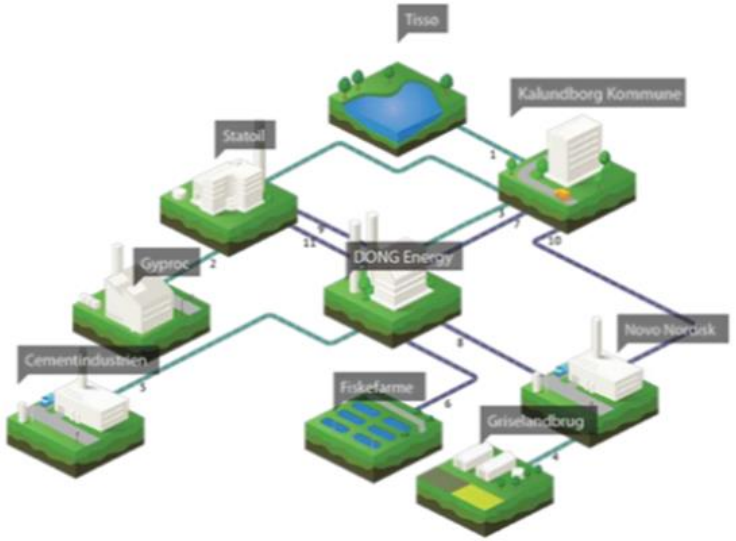
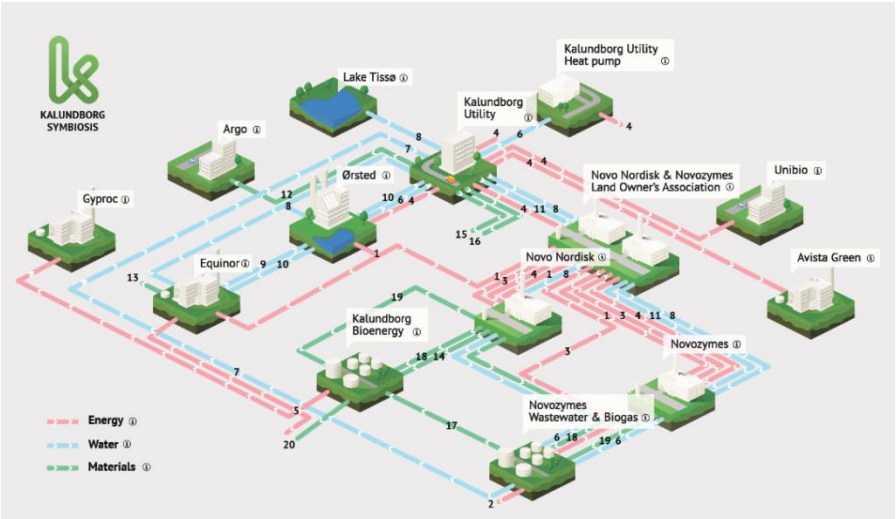


20 years after the first link in 1980-1989 there are 9 companies connected and 12 exchange flows



Currently, Kalundborg has more than 14 connected companies and 20 flows divided into three groups:
-Water
- Energy
- Materials

Source: http://www.symbiosis.dk/en/

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The main symbiotic flows of Kalundborg are:

-Water
- *-Waste water*
- *-Treated waste water*
- *-Used cooling water*
- *-Deionized water*
- *-Surface water*

-Energy
- *-Heat*
- *-Heat condensates*
- *-Natural gas*

-Materials
- *-Sulfides*
- *-Gypsum*
- *-Sand*
- *-Ethanol waste*
- *-Biomass*

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Cooperation among companies makes exchanges possible, as if it were a biological system, where everything is used and there is no waste.

For more than 50 years, Kalundborg has become a global reference for industrial symbiosis processes, constituting an efficient model of production and consumption.

These kind of systems are based on the imitation of natural cycles, transforming conventional industrial linear cycles into closed ones.

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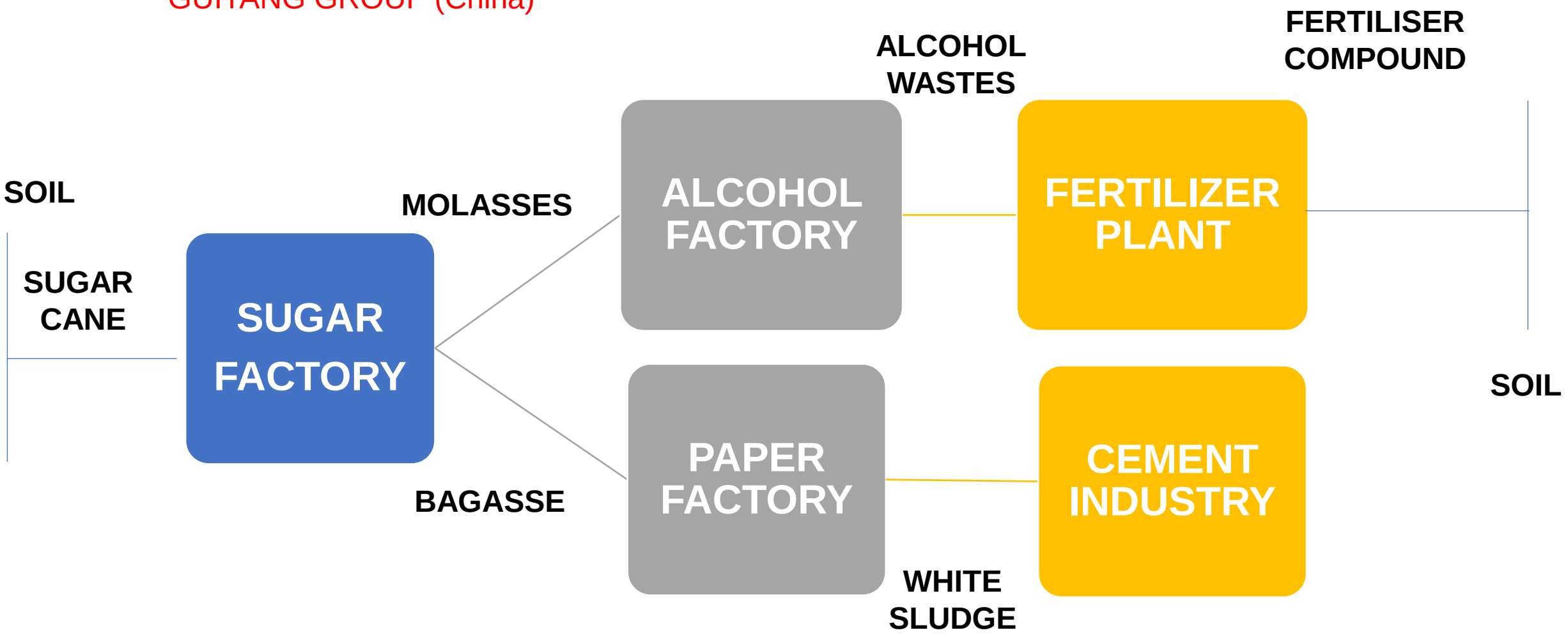
GUITANG GROUP (China)



Source: adapted from Universidad técnica de Cotopaxi

GUITANG GROUP (China)

This is a good example of chain symbiosis. The source company produces sugar from sugar cane and has two main byproducts: molasses and bagasse (molasses is a semisolid stream with a high sugar content, while bagasse is a fibrous like).

Molasses is used as a raw material in an alcohol manufacturing company, while bagasse is used as a raw material in a paper factory. The alcohol factory produces alcohol wastes that are transformed into fertilizers in a third company. On the other hand, white sludges are obtained from the paper factory, and they are used in a third company for cement production.

In this network there are 5 companies connected by industrial symbiosis and 5 flows of raw materials.

Industrial Symbiosis Guideline

FOOD INDUSTRY

In the wine industry, by-products are generated such as vine shoots, pruning remains.

Use in pharmaceutical and cosmetic products, food and chemical industry.

https://www.ainia.es/proyectos-idi/valorizacion-de-subproductos-de-la-industria-vitivinicola-el-reto-de-la-biorrefineria/

TEXTILE SECTOR

The waste generated in the textile industry is fabric and fiber trimmings, spent dyes, dye and reagent containers, acidic and basic solutions. etc

Use as a building material (acoustic absorbent panels). Insulating material for vehicles. Polyester recycling for new fibers. Recycling of cotton for the generation of new fibers, rags, filling material, etc.

WOOD SECTOR. WOOD AND FURNITURE INDUSTRY

Wood chips, sawdust and shavings, pallets, wooden containers (boxes); furniture, doors, construction and demolition debris, pruning debris, wood spools and treated wood

Manufacture of particle board.
Obtaining energy, making compost…

AUTOMOBILE SECTOR

The waste generated in industries and companies related to the automobile sector mainly correspond to the part of the automobile that is manufactured, plastic, metal, textile scraps, packaging, sludge from aqueous suspensions, etc.

Reuse of textile trimmings to manufacture shock absorbers and other insulation material.
Use of recycled plastic as fibers for seats.
Reuse of windows for other applications such as storage shelves for shops.
Use of tires for the manufacture of footwear, bags, backpacks, etc.
Use of sludge for the cement industry.

4. Implementation of industrial symbiosis. Tools.

Industrial Symbiosis Guideline

4.1. To get start on Industrial Symbiosis

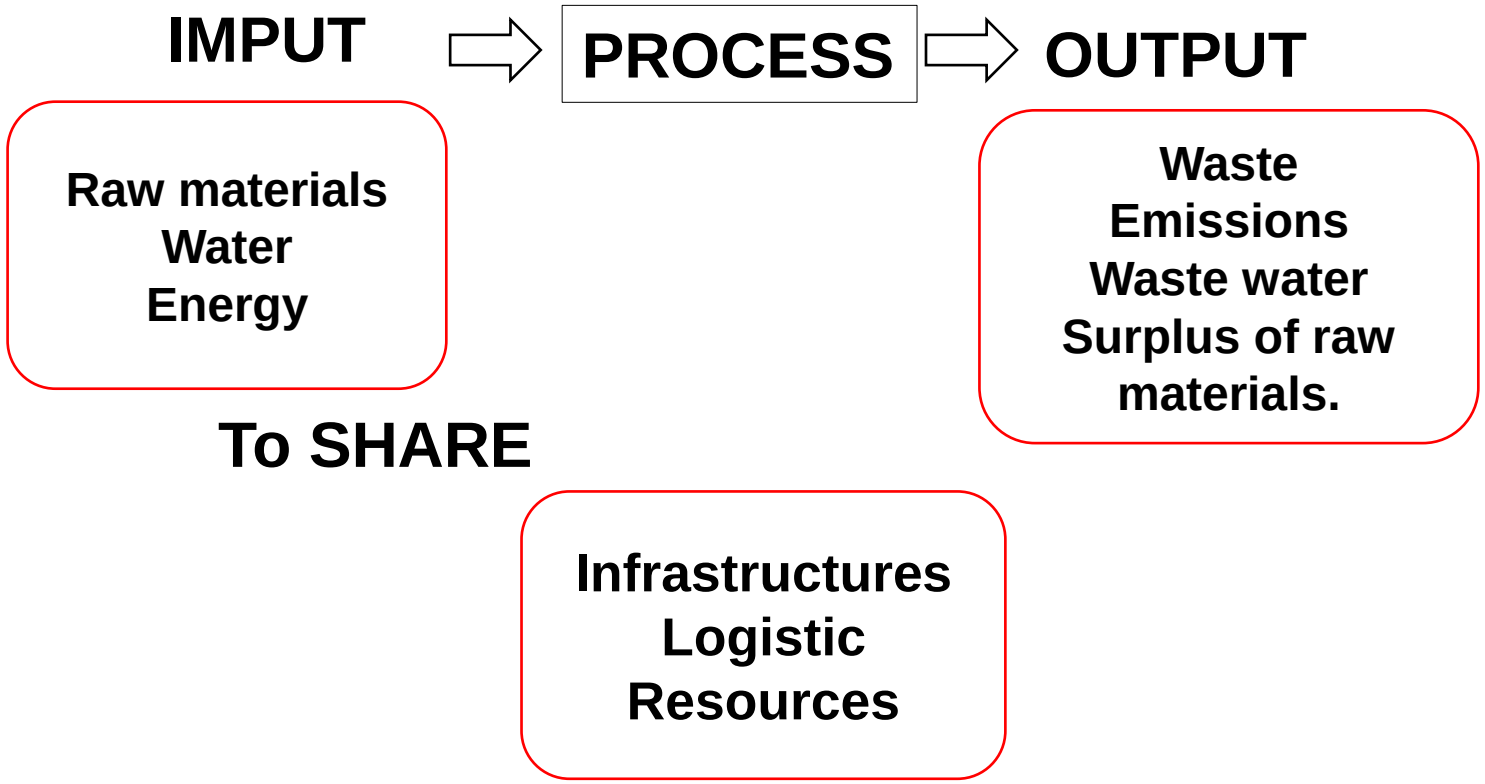
- Three steps to establish industrial symbiosis synergies:

STEP 1	• DEFINITION OF INPUT AND OUTPUT FLOWS
STEP 2	• OFFER OR DEMAND UNDERUTILIZED RESOURCES
STEP 3	• TO ESTABLISH SYNERGIES

To establish synergies: Relate offers and demands with other companies and establish common ground

STEP 1. DEFINITION OF INPUT AND OUTPUT FLOWS

The company must determine what the input and output flows of its processes are. It is important that you not only think about materials, but you have to take into account experience, knowledge, logistics, water and energy.



STEP 2. OFFER AND DEMAND UNDERUTILIZED RESOURCES

After analyzing the flows, the company must reflect on its needs by filling in templates for offers and demands.

In the template “offers”. It explains what resources each company can offer: remains of raw materials, waste, empty warehouses, reverse logistics, etc.

The "demand" template, explains what resources each company wants / needs: raw material, storage spaces, transport, etc.

It is important to fill in the quantity of the resource and if its production is continuous or discontinuous. As well as include other aspects that can provide information on the characterization of the resource.

How to fill in the offers and demands?

In order to establish synergies between companies, it is necessary to bring together companies interested in the implementation of industrial symbiosis, for this, it uses dynamic workshops or use of developed ICT tools. These tools will be able organized automatically synergies. Based on the development of predictive algorithms.

Tools.

There are some web platforms that make it easy for companies to establish symbiotic exchanges. These tools give them a greater capacity to find synergies between the companies that use the platform.

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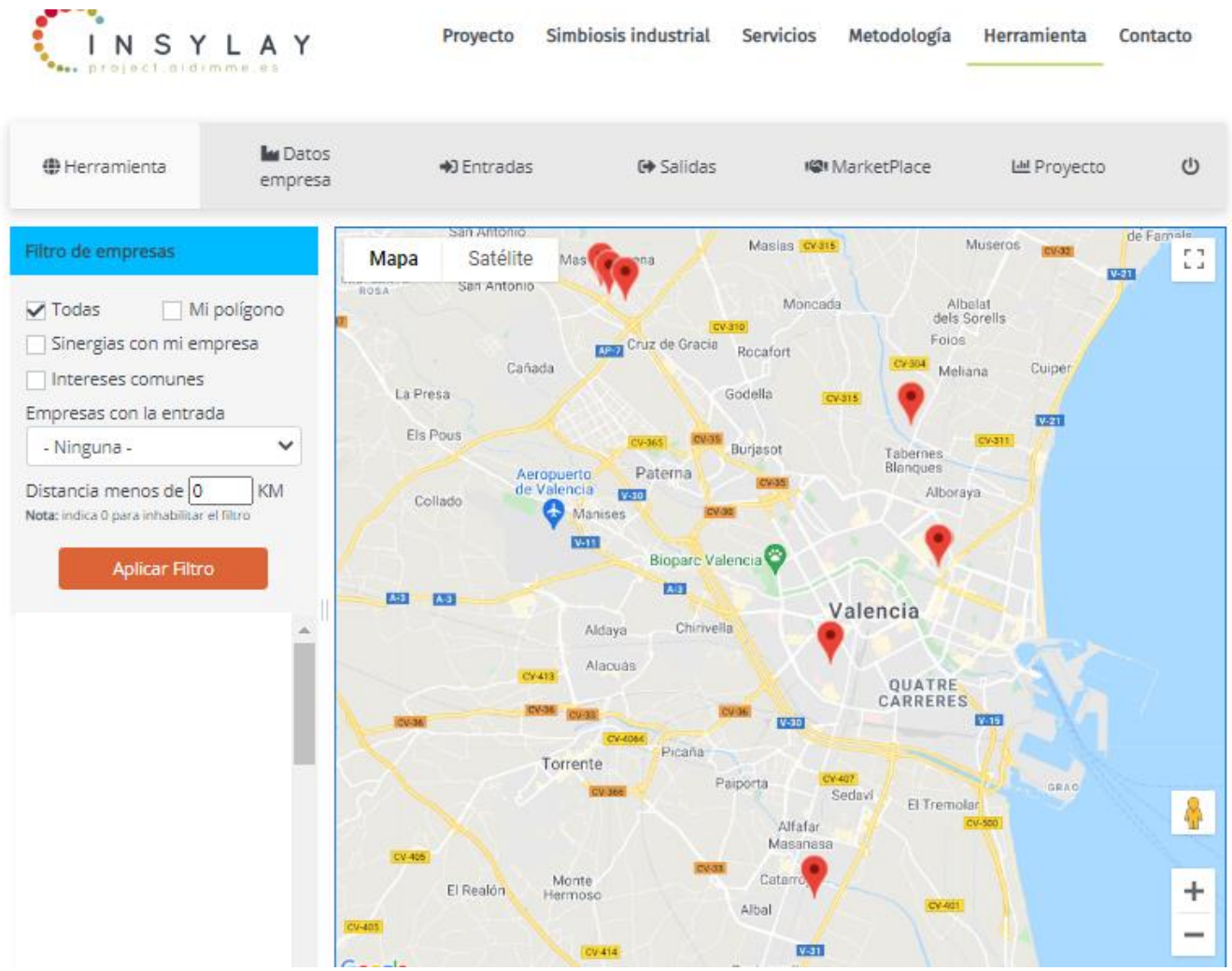
TOOL: INSYLAY. http://simbiosisindustrial.aidimme.es/



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INSYLAY

How can you use INSYLAY?

STEP 1. Insert data enterprise

STEP 2. Insert outputs/inputs (offers and demands)

STEP 3. Insert offers/demands

STEP 4. Automatic find ofs sinergies

STEP 5. Analysis of the feasibility of industrial symbiosis actions

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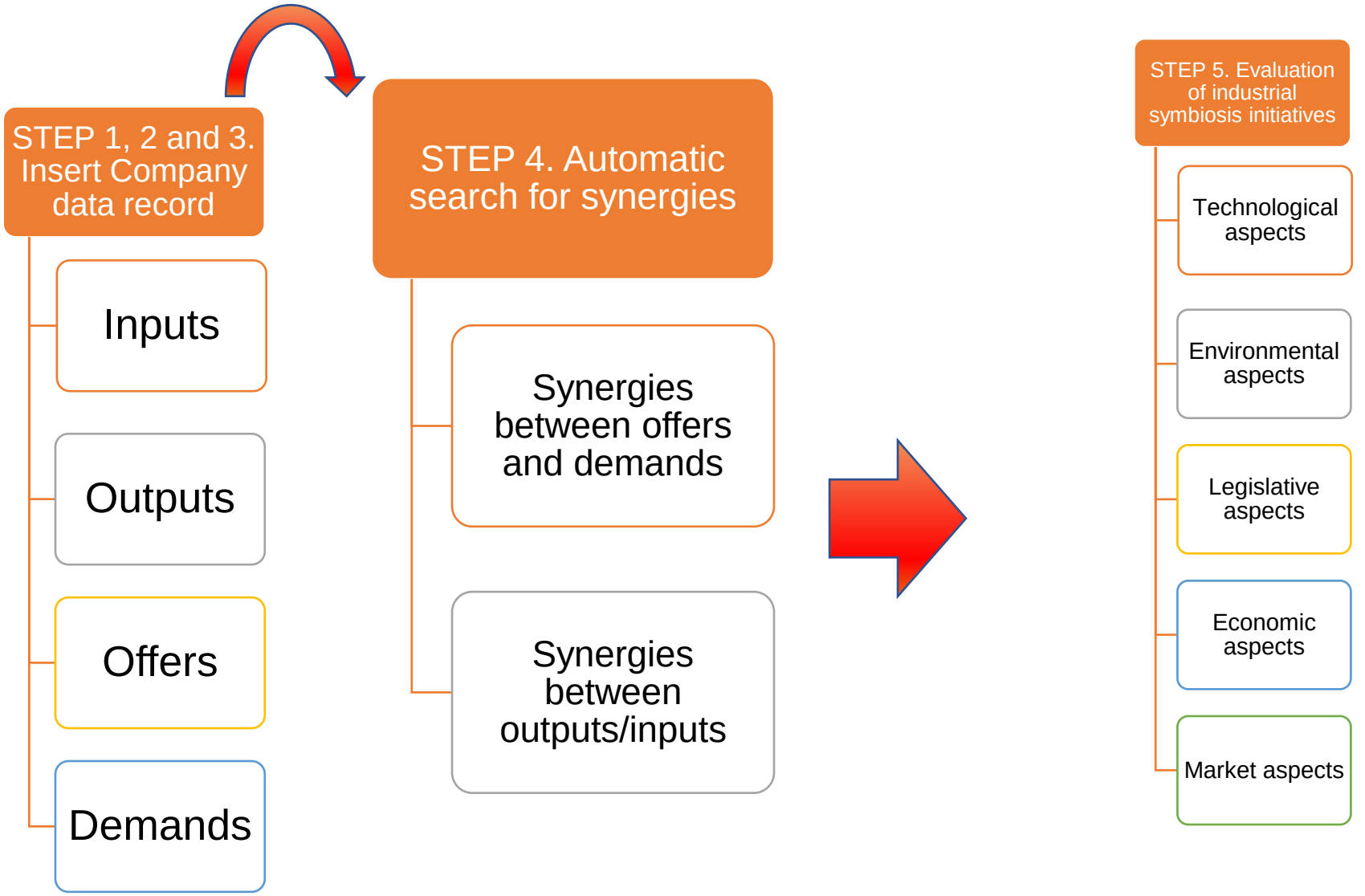

TOOL: SYMBINET

The "SYMBINET" portal will make innovative functionalities available to users, such as the development of predictive algorithms based on artificial intelligence for the establishment of synergies (matchings) between companies. This project is now in development. It will finish in November 2021.

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Project led by AIDIMME in collaboration with AINIA, ITC and ITI.

SIMBYNET will collect advanced multisectoral functionalities that will promote the development of Industrial Symbiosis initiatives among industrial companies in the Valencian Community.

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5. Barriers to the implementation of industrial symbiosis models.

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There are several challenges related to the implementation of industrial symbiosis models in companies.

The barriers can be classified in 3 blocks:

1. - Information, Awareness and Training

- There are problems related to the evidence of benefits for companies related to industrial symbiosis.
- It is important to increase the dissemination actions in order to increase the level of knowledge of IS possibilities.
- Most companies work “isolated”, and they don’t know each other activities.
- Facilitators are necessary in order to put into contact different interests. It is not a spontaneous process

2. - Waste/by-products regulations

- Nowadays, waste/by-products regulations are a huge barrier to industrial symbiosis actions. To overcome this problem, it is necessary to increase the actions to speak with regulators, with the goal to change the paradigm. In order to move to a circular economy model, it will be necessary to use waste materials from a company as a raw material.
- Initiatives related to the management of waste or by-products are now illegal with current laws.

3. – Economic aspects

- If the distance between companies is great, it could become economically unfeasible to carry out industrial symbiosis actions, unless the material resource has great added value
- There are contractual aspects that must be agreed upon before carrying out actions related to industrial symbiosis
- If the price of the raw material is low, it makes it difficult to implement industrial symbiosis actions.

4. – Technological implementation

- The “raw material” (by-product, waste) has to have certain quality, and its flow must be continuous (matching product, quality, cost and production).
- Re-processing of waste/by-products is often needed in order to be useful as raw material.
- Infrastructure costs have to be taken into account: pipes, storage room, logistical aspects...

6. Success factors.

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- The ideal application of the concept of Industrial Symbiosis would consist of designing industrial zones, eco-industrial parks where, in global terms, the inflows and outflows to the biosphere in global terms of matter and energy are drastically reduced (including the products that are manufactured, that at the end of their useful life they will have to return to the polygon to be reprocessed).

- However, in reality we find industrial zones created long ago. Geographical proximity is frequently associated with industrial symbiosis, although it is neither essential nor sufficient, since it is not based solely on a physical exchange of resources.

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- For an industrial symbiosis action to be successful, proximity is not necessary, however there are other factors that contribute favorably such as: diversity of contributing industries, good communication between the companies involved, establishment of firm collaboration, and capacity for innovation.

- One of the key success factors is to connect professionals from different sectors of activity who must have an open mind to change the way things are done.

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- The driving effect that large companies (or sectors) can have on smaller companies when carrying out actions related to industrial symbiosis should be noted.

- It is highly recommended to contact existing recyclers in the region.

- It should be considered that a possible symbiotic collaboration may require the development of a research project to be possible

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- Before carrying out any type of action related to industrial symbiosis, it is highly recommended to carry out a previous feasibility analysis, at various levels (technological, legal, environmental and economic), in order to carry out a prior assessment, and thus increase the possibility of success.

- It is important to know which waste streams are currently neither recycled nor valued and to know the causes, whether due to problems of collection, transport, classification, recycling, recovery, etc.

7. Conclusions

Industrial Symbiosis Guideline

- Industrial Symbiosis is still in an incipient and little extended phase, but gradually it is necessary to lay the foundations for its development.

- Companies are the driving force behind the changes implied by industrial symbiosis, and this means that companies must collaborate with each other, establishing relationships between interest groups for the benefit of the entire industrial fabric.

- To obtain success stories and an agile Industrial Symbiosis, companies must be prepared, through awareness-raising and training actions on the subject.

PRODUCE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement no. 870037.