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FISSAC

FOSTERING INDUSTRIAL SYMBIOSIS FOR A SUSTAINABLE RESOURCE INTENSIVE INDUSTRY ACROSS THE EXTENDED CONSTRUCTION VALUE CHAIN

Identification of best practices and lessons learnt in Industrial Symbiosis

February 2016

D1.2: Identification of best practices and lessons learnt in Industrial Symbiosis
WP 1, T 1.1

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[1] PU = Public
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0. Summary

This report falls within the scope of Work Package 1, which is to identify current models of industrial symbiosis, analyse them and gradually define the requirements of a new model to facilitate information exchange that can support ongoing and future industrial symbiosis networks.

It summarises the key findings from overall sixty best practices collected from FISSAC project partners. It reviews the state of the art of ongoing industrial symbiosis projects (public and/or private partnerships) and government initiatives in Europe and abroad, as well as the regulatory framework on waste management including technical specifications on the use of recycled materials as raw material for construction applications. Technical and non-technical barriers, risks and uncertainties which might hinder these developments but also drivers of new industrial symbiosis projects have been identified and analysed.

The role of different stakeholders in setting up industrial symbiosis networks, particularly in public private partnerships, and the long-term vision for scaling up is discussed in the end of the analysis.

In addition to this, the report summarises previous experiences and best practices on the reuse and recycling of C&DW stream in order to be integrated in the FISSAC software platform. FISSAC project representatives are closely collaborating with other EU-funded research projects since the project kick off and thanks to active networking, they have identified areas of future project collaboration.

Finally, a review and analysis of various existing ICT tools and methodologies for industrial symbiosis has been undertaken as part of this task. The data collected will serve as input for the definition of requirements of the upcoming FISSAC software platform.

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Abbreviations and acronyms

C2C: Cradle to Cradle
C&DW: Construction and Demolition waste
EEA: European Environment Agency
EIP: European Innovation Partnership
IS: Industrial Symbiosis
JRC: Joint Research Centre
NISP: UK National Industrial Symbiosis Programme
R&D: Research and Development
RCD waste: Recycled Construction and Demolition waste

1. Introduction

1.1 The project

The European- funded project FISSAC 'Fostering Industrial Symbiosis for a Sustainable resource intensive industry Across the value Chain' aims at developing and demonstrating a new paradigm built on an innovative industrial symbiosis model towards a zero waste approach in the resource intensive industries of the construction value chain. The project will tackle harmonized technological and non-technological requirements, leading to material closed- loop processes and moving to a circular economy.

FISSAC project gathers a diverse consortium of twenty-six partners from nine countries (eight EU Member States and Turkey). They range from general contractor and engineering construction companies, non-profit research organisations, SMEs in different sustainable business fields, a public authority, intensive industries, an association for standardisation and certification and an international association of local and regional authorities promoting recycling and sustainable resource management.

The project kicked off in September 2015 and will last until February 2020.

1.2 Objective

In order to have a holistic overview of various networks of stakeholders involved in industrial symbiosis, FISSAC project partners completed a first stakeholder analysis, which set up a network that will be used throughout the project lifetime. The second task of FISSAC project is to conduct an analysis of examples, models and methodologies considering their best practices and lessons learnt. The status of previous and current IS initiatives at European and international level are studied. Technical and non-technical barriers affecting IS exchanges as well as new drivers for the development of IS networks are identified.

The report includes an overview of the European and international framework focusing on waste management, recycling and disposal, as well as an evaluation of existing regulations and technical specifications on the use of recycled materials as raw materials for constructive applications.

Previous experiences from other relevant EU- funded projects were shared in view of establishing collaboration opportunities and future synergies. Finally, a detailed evaluation of existing ICT tools and platforms for industrial symbiosis is presented. This information will serve as input to the definition of requirements of the integrated software platform in WP6.

2. Industrial Symbiosis- the context

2.1 Definition of Industrial Symbiosis

The word 'symbiosis' builds on the notion of biological symbiotic relationships in nature where two, or more, species exchange materials, energy, or information in a mutually beneficial manner. By working together in industrial symbiosis, the benefit is greater than the sum of all individual benefits. (Chertow, 2000). Literally, the word symbiosis means 'living together' (Lambert, et al., 2002).

Resource exchange has existed for a long time (e.g. scrap dealers and charities organizing clothing drives, as well as companies buying and selling residual materials). To distinguish industrial symbiosis from other types of exchanges Marian Chertow and her colleagues has adopted a '3-2 heuristic' as a minimum criterion. Thus*, at least three different entities must be involved in exchanging at least two different resources to be counted as a basic type of industrial symbiosis.* (Chertow, 2007)

IS involves interconnections among industrial processes performed by traditionally separate industries, such as the physical exchange of materials, energy, water and by-products to create mutual benefits (Boons et al. 2011, Chertow 2000). Using IS, companies may create competitive advantages and improve their overall environmental and economic performance. IS usually (but not necessarily) occurs between geographically proximate firms, e.g. firms co-located in clusters or industrial parks, as well as at the regional level (Paquin, 2009). However, this is not a rule anymore: Industrial Symbiosis can occur even among long distance firms if environmental and financial benefits determine this.

Local or wider co-operation in industrial symbiosis can reduce the need for virgin raw material and waste disposal, thereby closing the material loop - a fundamental feature of the circular economy and a driver for green growth and eco-innovative solutions. It can also reduce emissions and energy use and create new revenue streams. It is important to highlight the circular nature of cooperation in the value chain i.e. the exchange of all parties in all stages of the development, production, use and end-of-life of a product.

2.2 Historical development of IS projects and initiatives

Industrial symbiosis is currently being implemented in many countries around the world, driven by public or private players. Europe has some EU support networks for industrial symbiosis and European Innovation Partnerships such as National Programmes (e.g. NISP (UK), Finnish Industrial SymbioSis System- FISS), regional initiatives (e.g. Sotenäs municipality (Sweden)) and local initiatives (e.g. Kalundborg (DK)). However, for making industrial symbiosis a wide-spread, mainstream, commercial reality more needs to be done to manage the flow of waste material from different sectors and industries, and there is still much to understand about :

- environmental and societal impacts;
- harmonization of technologies and processes;
- adaptation and harmonisation of policies;
- civil society engagement to a circular economy at local, regional and EU- level;
- waste resources information;
- waste treatment technologies;
- business models and coordination within value chain actors

It is the aim of FISSAC project to work with a multi-stakeholder approach and address these aspects.

The table below summarises the status of international Industrial Symbiosis networks and the latest developments in each country:

Table 1- Status of international IS networks and latest developments

Country	Programme
Belgium	Development of the association FISCH (http://www.fi-sch.be/en/) for sustainable chemistry and integration of industrial symbiosis Development of the Belgian SusChem platform as a partner of Suschem Europe Development of low carbon industrial parks by the government
European Union	Research and Implementation programs: H2020, SPIRE6, COST, LIFE+ are supporting industrial symbiosis

	EU project EPOS (http://www.spire2030.eu/epos/) aims to assess IS potential and development of business cases
Germany	German Industrial Ecology Network: grouping together 15 to 20 institutions around industrial ecology Implementation: development of a GIS for waste heat monitoring in Bavaria
Italy	Law on Environmentally equipped industrial areas (APEAs) since 1998. Ongoing pilots across the country Industrial clusters are integrating IS in the agricultural, furniture, tanning and oil/wine sectors Implementation: Emilia- Romagna project and IS platform in Sicily (eco-innovazione sicilia)
Spain	National trend on the development of district heating and cooling networks Implementation: District 22 at Barcelona continuous improvement and development
Sweden	Development of public- private partnerships for operationalising industrial symbiosis Development of a national IS resource centre and network coordinated by Linkoping University Existing collaborative platforms: 'spill till gold' (waste to gold), ' valuefromwaste.sw', Re!Source, Processum Implementation: Use of residual low-grade heat in industry and urban food production Implementation: Forest industry is developing activities for tall oil (by-product of wood pulp manufacturing) upgraded to be used by oil company PREEM Implementation: Port-city integration for combined bio-economy and sustainable urba development work
United Kingdom	The National Industrial Symbiosis Program in the UK began in 2005 as a government backed program as a series of regional facilitators helping businesses link up to reuse waste products. Since 2013 it has been operated as by International Synergies a consultancy who aim to find symbiosis opportunities for businesses globally. Latest development of NISP[2] focuses on the publication of case studies in relation with NGOs and business associations including the Mac Arthur Foundation Ongoing benchmarking studies between the UK and China on IS development Implementation: British Sugar Ltd developed IS for the last 20 years

Country	Programme
China	Circular economy promotion law: the reference model for implementing IS in industrial parks. More than one hundred o-going EIP initiated by the Chinese EPA. Main focus on solid waste exchange, waste heat exchange and information exchange. Implementation: Tianjin is the oldest IS network in China Guitang Group is an IS network in an agro-food sugar based industrial complex
Japan	Development of IS using waste heat from power plants to supply nearby factories or residential areas

2 http://ec.europa.eu/environment/waste/prevention/pdf/NISP_Factsheet.pdf
http://www.international-synergies.com/what-we-do/for-business/

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	Implementation: IS for waste heat reuse networks in Fukushima recovery region The Eco-town project implemented a waste plastic and PPT bottles recycling system to turn them into substitution fuels for the iron and steel industry
South Africa	IS is includied in industrial policy (action plan 2016/17) of the Department of Trade and Industry. IS is perceived as an enabler for sustainable economic development and regional development. The national strategy focuses on embedding IS in the industry, including stakeholders such as the government, businesses and local programmes. Implementation: WISP (Western Cape Industrial Symbiosis Programme) funded by the government to facilitate IS Valorisation of agricultural waste in the Western Cape province Two regional pilot projects under development in Ganteng (GISP) and Kwazulu Natal (KISP) funded by the NCPC/DTI Development of an EIP project in Atlantis industrial park

Source: 12th Industrial Symbiosis Research Symposium (ISRS), July 2015

2.3 European and international framework

Construction and Demolition Waste (C&DW) is one of the heaviest and biggest waste streams generated in Europe. It accounts for approximately 25%-30% of all waste generated and consists of numerous materials including concrete, bricks, gypsum, wood, glass, metal, plastic, solvents, asbestos and excavated soil, many of which can be recycled.

C&DW has been identified as a priority waste stream by the European Union. There is a high potential for recycling and re-use of C&DW, since some of its components have a high resource value. In particular, there is a re-use market for aggregates derived from C&DW waste in roads, drainage and other construction projects. Technology for the separation and recovery of C&DW is well established, accessible and relatively inexpensive.

The Waste Framework Directive (2008/98/EC) aims at providing a framework towards a European recycling society with high resource efficiency. According to Article 11.2, '*Member States shall take the necessary measures designed to achieve that by 2020 a minimum of 70% by weight of non-hazardous C&DW excluding naturally occuring material defined in category 17 05 04 in the List of wastes shall be prepared for re-use, recycled or undergo other material recovery*' (including backfilling operations using waste to substitute other materials).

Based on a recent assessment of C&DW, the potential for increasing the level of recycling and re-use is significant with performance of Member States varying from under 10% to over 90%. The average recycling rate was calculated at around 46% across the EU (see Figure 1 below). If not separated at source, C&DW could contain small amounts of hazardous waste, which could pose threat to the environment but also hamper the recycling process.

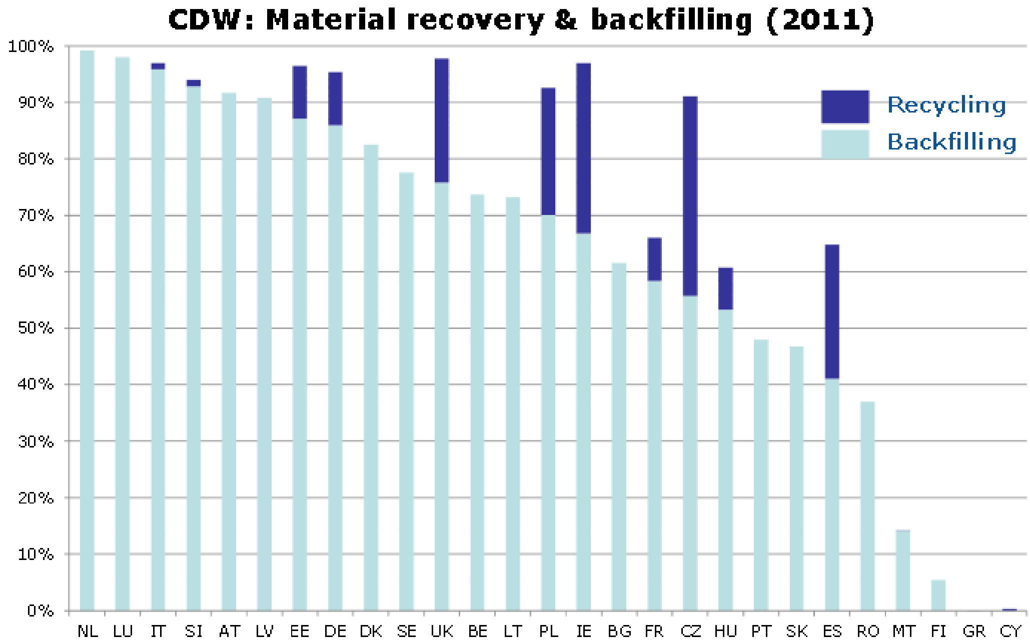

Figure 1- Material recovery and backfilling- Construction and Demolition waste in EU-27 (last update 2011) [3]

Ongoing and completed studies on C&DW:

Management of C&DW in the EU - requirements resulting from the Waste Framework Directive and assessment of the situation in the medium term (2011)[4]

The objectives of the study were:

1. to specify the requirements resulting from the EU waste legislation regarding C&DW by establishing operational definitions of concepts and
2. to perform a quantitative and qualitative analysis of the status quo of C&DW and establish a scenario for 2014.

The study focussed on five Member States (Finland, Belgium- Flanders, Germany, Hungary and Spain). It was found that C&DW practices vary greatly from one MS to another.

The report underlines that data quality and lack of harmonised reporting guidelines makes it challenging to draw conclusions on C&D waste generated. If we consider some reasonable corrections, a safe estimation of total C&DW I EU-27 is at 0.94 tonnes per capita of C&DW (excluding excavation material) i.e. 461 million tonnes in 2005.

Resource Efficient Use of Mixed Wastes (2014-16)

The study aims to investigate the current C&DW management situation in EU Member States, identifying obstacles to recycling and potential deficiencies that could lead to non-compliance with EU waste legislation. Good practices in terms of creating conditions for increasing C&DW recycling and for improving the quality of recycling and recovery will be identified and a set of recommendations addressing potential barriers will be formulated. In parallel, success stories of efficient C&DW management will be showcased,

3 ec.europa.eu/environment/waste/studies/pdf/CDW%20Statistics%202011.pdf
4 http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf

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illustrating key elements, as well as the necessary preconditions. Finally, the credibility of official C&DW statistics will be reviewed by identifying the sources of inaccuracy and proposing measures for improvement.

The first task concluded with publishing a series of draft factsheets on C&DW management in EU-28 Member States. [5] The factsheets include a detailed overview of the national legal framework, non-legislative instruments, C&DW management performance, C&DW management in practice and C&DW sector characterisation.

The outcome of the study will be presented at a seminar in March 2016 in front of relevant stakeholders, EU officials and Member States representatives.

Identifying macro-objectives for the lifecycle environmental performance and resource efficiency of EU buildings (JRC, 2015)[6]

This study contains information about the 'macro-objectives' for the environmental performance of buildings. It provides an analysis:

- EU MS policies and initiatives on resource efficiency;
- Evidence for the most significant environmental impacts along the lifecycle of buildings;
- The priorities of existing schemes and tools that are used in the EU property market.

Waste prevention in Europe- the status in 2014 (2015)[7]

The European Environment Agency (EEA) publishes an annual review of waste prevention programmes set by EU Members following the mandate of the Waste Framework Directive (2008). The report gives an overview of cross-programme comparison, including scope, objectives, indicators, monitoring systems and measures and policy instruments. An analysis of examples of good practice of the 27 programmes is finally included.

Some key findings from the study, pertaining to C&DW management:

- all programmes except for the Bulgarian and Latvian cover the construction/ infrastructure sector
- C&DW is covered in all but the Bulgarian, Latvian, Polish and Portuguese programmes

The report illustrates some good practice examples:

Austria: 'Building material passes'

The Austrian waste prevention programme contains a series of measures related to 'building material passes' as a planning instrument to support repair, reuse and high-quality recycling in the construction sector. The plan is to develop standards for these building passes and to incorporate core information into the central building register run by Statistics Austria. In the future, the details of the material composition and the contents of potentially hazardous substances will be registered.

[5] http://ec.europa.eu/environment/waste/studies/mixed_waste.htm

[6] http://susproc.jrc.ec.europa.eu/Efficient_Buildings/docs/151222%20Resource%20Efficient%20Buildings_Macro%20objectives%20WP_Final%20version.pdf

[7] http://www.eea.europa.eu/publications/waste-prevention-in-europe-2015

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Hungary: Coordinating body for prevention of construction and demolition waste

After a significant increase of construction and demolition waste over the last 10 years in combination with a rather low recycling rate, the Hungarian waste prevention programme will create a coordinating body for the prevention of construction and demolition waste. The aim of this new institution will be to support research and development activities in the field and to exploit synergies between the different ongoing research projects more efficiently.

Finland: Environmental classification system for buildings

In Finland, the waste prevention programme promotes aspects of waste prevention and material efficiency in the construction phase of new buildings by applying an environmental classification system. The aim is to put an accent on building convertibility, durability of structures, prevention of water and module damage, and the updatability of building automation when designing, constructing and supervising buildings.

Malta: Limit unnecessary construction waste

In Malta, waste prevention focuses in part on the prevention of construction and demolition waste, the largest waste stream in terms of volumes. Guidance on the excavation of limestone with a view to reduce construction and demolition waste is planned, as are discussions between all relevant stakeholders during the revision of local plans to limit unnecessary waste. There is an emphasis on promoting the value of the limestone resource at the excavation stage and on harnessing the potential of technology to make the process more resource efficient.

Looking at the qualitative waste prevention objectives, the report outlines that:

- In Flanders, C&DW is addressed in a specific plan for material-efficient construction.
- In Wales, industrial waste has been set to reduce by 1.4% annually until 2050, using 2006/07 as baseline.
- In Bulgaria, the volume of industrial waste per unit of GDP in 2020 is set to be less than 2010.

Industrial symbiosis in the context of circular economy

The European Union has recognized that IS has direct relevance not only to resource efficiency, but also to a broader policy agenda covering innovation, green growth and economic development. Considering that sustainable growth, resource efficiency and enhancing European industry are all priorities on the EU's agenda, promoting industrial symbiosis and circular economy at the EU level has progressively gained importance and is considered as a way to decouple economic growth from resource consumption. However, the potential benefits of IS have been recognised only recently in the EU's policy documents, and explicit references to industrial ecology as a way to promote sustainable consumption and production have appeared only recently (Lehtoranta et al. 2011).

Current European Union policies

In 2012, the European Resource Efficiency Platform (EREP), a high-level stakeholder group with a mandate to deliver concrete policy recommendations for implementation across Europe, selected industrial symbiosis as one of seven top priority areas. By June 2013, EREP had credited IS networks already active in Europe for reducing carbon emissions, preserving resources and improving the competitiveness of European companies, especially SMEs (European Commission 2013). In December 2012, the EC together with EREP published a document entitled "Manifesto for a Resource Efficient Europe". The document highlighted the importance of "a systemic change in the use and recovery of resources in the economy" for ensuring future jobs and competitiveness, and outlined potential pathways to CE through innovation and investment, regulation, tackling harmful subsidies, increasing opportunities for new business models and setting clear targets (European Commission, 2012).

Following this, recent European policy documents have increasingly supported IS as an integral part of economic and environmental policy (e.g. Europe 2020 strategy and its flagship initiative "A resource-efficient Europe").[8]

In 2014 the role of CE and IS in European policy was further strengthened by setting a dedicated policy on the subject entitled ''Towards a circular economy: A zero waste programme for Europe''.[9]

Finally, the new Circular Economy package (2015)[10] contains measures to address the whole materials cycle from production to consumption through to waste management and the use of secondary raw materials, with the aim of contributing to closing the loop of product lifecycles through greater recycling and re-use. The action plan seeks to make links to other EU priorities and the ultimate goal is to transform Europe into a more competitive, resource efficient economy, in line with the EC's priorities of boosting economic growth and providing new job opportunities.

The CE package makes reference to the construction and demolition waste, which is identified as a priority area. The significant volume of waste, the wide variety in re-use and recycling rates across the EU and the role of the construction sector are highlighted. The need to establish common standards and protocols for sorting waste is acknowledged, with special focus on hazardous waste.

2.4 Description of the FISSAC template for collecting best practices

ACR+ drafted a template to collect ''Factsheets on industrial symbiosis best practices''. All project partners contributed to this task and submitted their relevant cases highlighting best practices including key facts and figures.

The various inputs were coordinated at national level and one partner per country acted as a single collection point. ACR+ was the task coordinator for drafting the template, collecting the information, analysing and compiling it into a consolidated file. The cases were overall grouped into four main categories and every single case was then characterised accordingly.

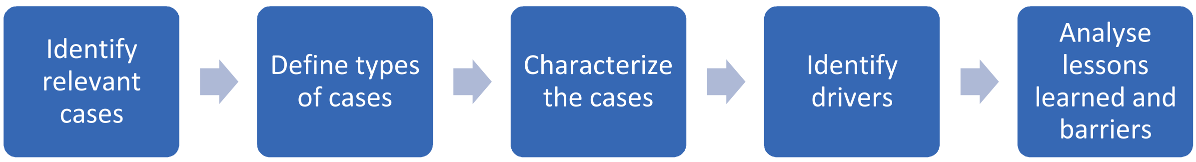

Figure 2 – Planning of best practices analysis

Following the analysis, the various cases were inserted into a mind mapping in order to have an overview of the collected cases. In total, four categories were introduced:

[8] http://norden.diva-portal.org/smash/get/diva2:875756/FULLTEXT01.pdf
[9] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0398R%2801%29
[10] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

Figure 3- The four categories

The first category encompasses projects with symbiosis based on (de)construction materials:

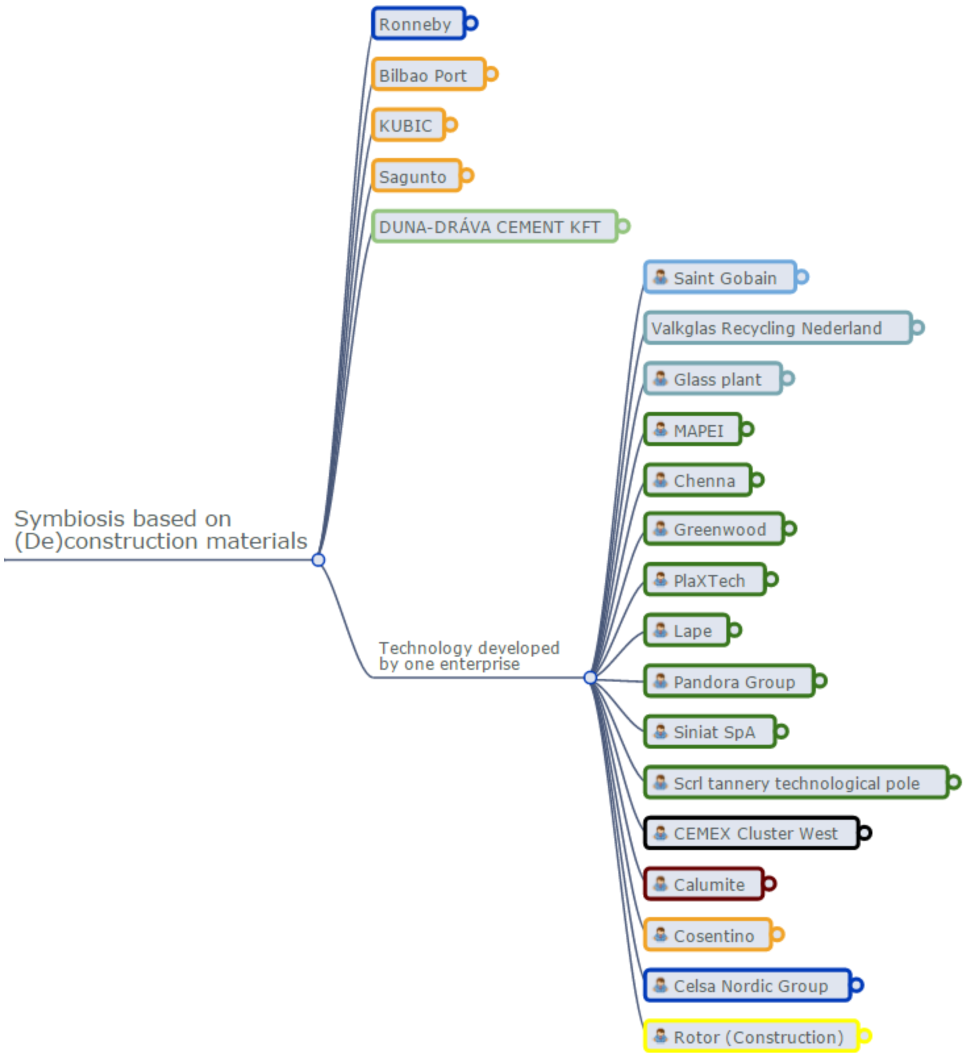

Figure 4- Symbiosis based on (de) construction materials

The second category encompasses projects with symbiosis created with various materials:

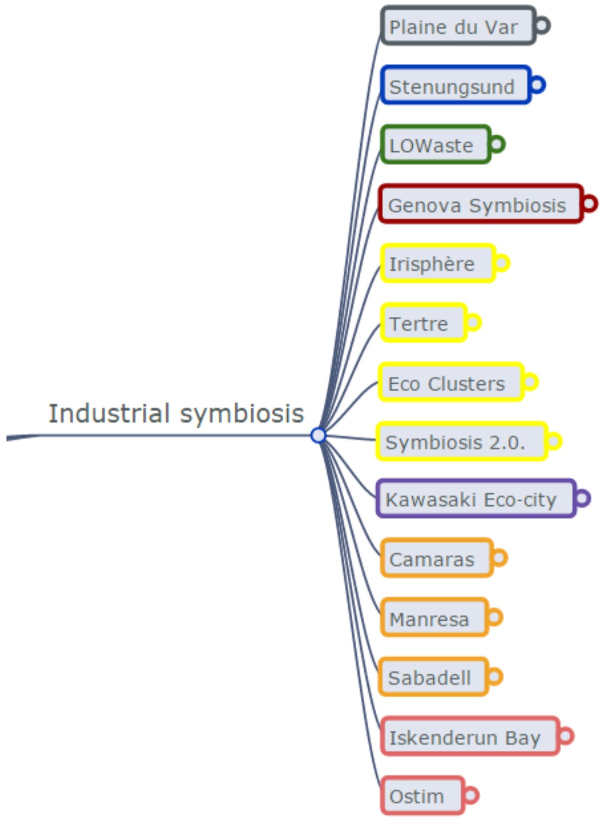

Figure 5- Industrial symbiosis

The third category encompasses projects with the symbiosis including heat and power projects:

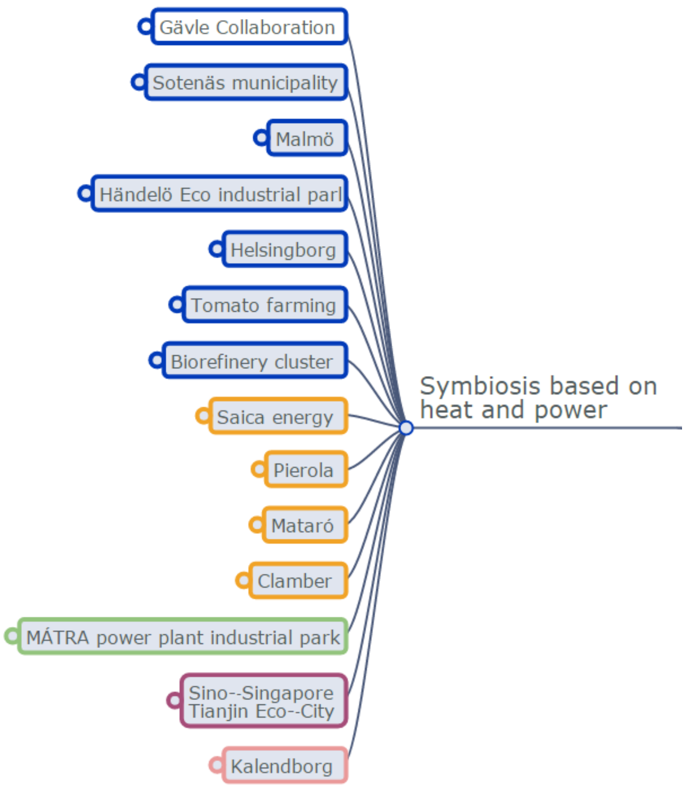

Figure 6- Symbiosis based on heat and power

The fourth category encompasses plans, regulations and research programmes linked to symbiosis:

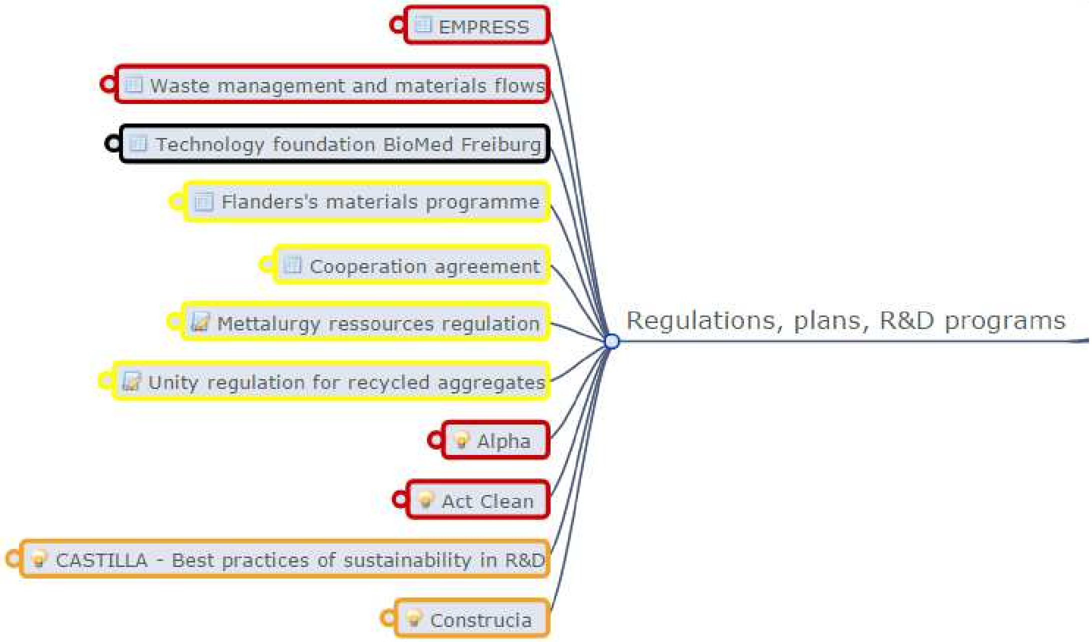

Figure 7- Regulations, plans and R&D programmes

The colours represent the country of the project location:

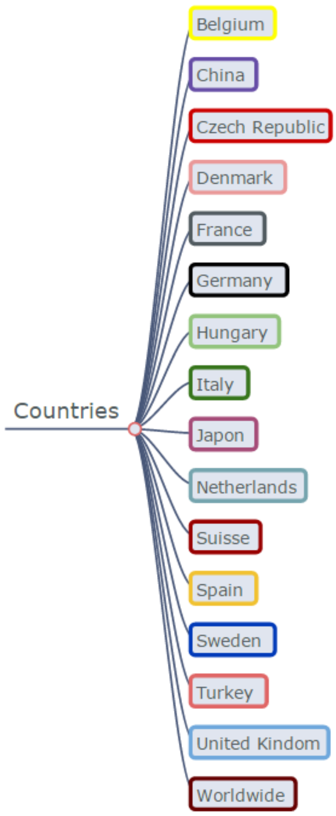

Figure 8- Countries represented

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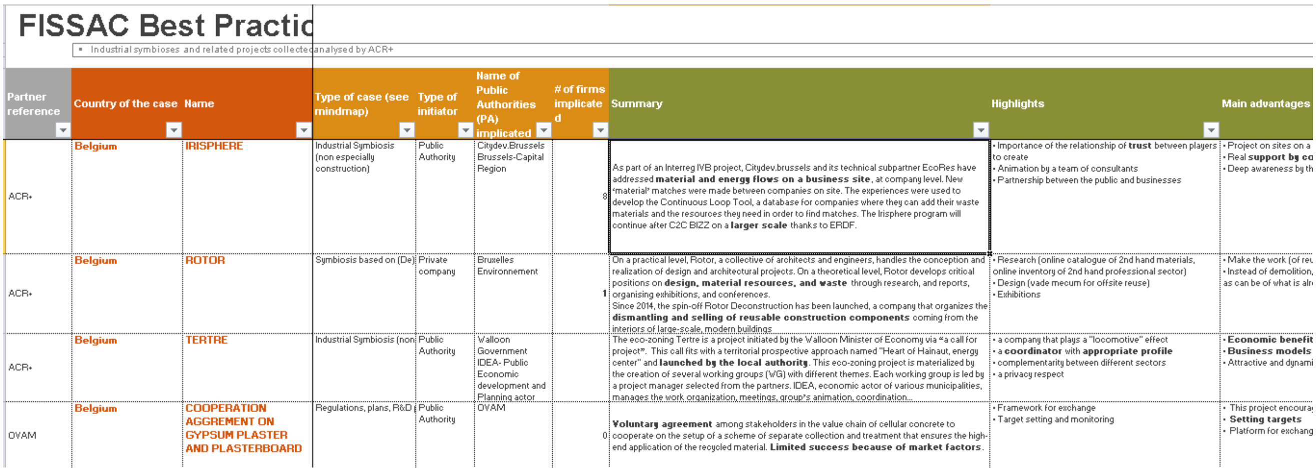
Following this, a table was created summarising all sixty cases including the following information: Partner reference, Country of the project, Name, main web link, Type of project, Type of initiator, Name of Public Authorities implicated, numbers of firms implicated if available, Summary, Highlights, Main advantages, Main difficulties and/or challenges.



FISSAC Best Practic
▪ Industrial symbioses and related projects collecte analysed by ACR+

Partner reference	Country of the case	Name	Type of case (see mindmap)	Type of initiator	Name of Public Authorities (PA) implicated	# of firms implicated	Summary	Highlights	Main advantages
ACR+	Belgium	IRISPHERE	Industrial Symbiosis (non especially construction)	Public Authority	Citydev.Brussels Brussels-Capital Region	8	As part of an Interreg IVB project, Citydev.brussels and its technical subpartner EcoRes have addressed **material and energy flows on a business site**, at company level. New 'material' matches were made between companies on site. The experiences were used to develop the Continuous Loop Tool, a database for companies where they can add their waste materials and the resources they need in order to find matches. The Irisphere program will continue after C2C BIZZ on a **larger scale** thanks to ERDF.	• Importance of the relationship of **trust** between players to create • Animation by a team of consultants • Partnership between the public and businesses	• Project on sites on a • Real **support by co** • Deep awareness by th
ACR+	Belgium	ROTOR	Symbiosis based on (De)	Private company	Bruxelles Environnement	1	On a practical level, Rotor, a collective of architects and engineers, handles the conception and realization of design and architectural projects. On a theoretical level, Rotor develops critical positions on **design, material resources, and waste** through research, and reports, organising exhibitions, and conferences. Since 2014, the spin-off Rotor Deconstruction has been launched, a company that organizes the **dismantling and selling of reusable construction components** coming from the interiors of large-scale, modern buildings	• Research (online catalogue of 2nd hand materials, online inventory of 2nd hand professional sector) • Design (vade mecum for offsite reuse) • Exhibitions	• Make the work (of reu • Instead of demolition, as can be of what is alr
ACR+	Belgium	TERTRE	Industrial Symbiosis (non	Public Authority	Walloon Government IDEA- Public Economic development and Planning actor		The eco-zoning Tertre is a project initiated by the Walloon Minister of Economy via "a call for project". This call fits with a territorial prospective approach named "Heart of Hainaut, energy center" and **launched by the local authority**. This eco-zoning project is materialized by the creation of several working groups (WG) with different themes. Each working group is led by a project manager selected from the partners. IDEA, economic actor of various municipalities, manages the work organization, meetings, group's animation, coordination...	• a company that plays a "locomotive" effect • a **coordinator** with **appropriate profile** • complementarity between different sectors • a privacy respect	• **Economic benefit** • **Business models** • Attractive and dynami
OVAM	Belgium	COOPERATION AGGREMENT ON GYPSUM PLASTER AND PLASTERBOARD	Regulations, plans, R&D	Public Authority	OVAM	0	**Voluntary agreement** among stakeholders in the value chain of cellular concrete to cooperate on the setup of a scheme of separate collection and treatment that ensures the high-end application of the recycled material. **Limited success because of market factors**.	• Framework for exchange • Target setting and monitoring	• This project encoura • **Setting targets** • Platform for exchang

Figure 9- the FISSAC xls table

The table below displays a synopsis of the sixty identified cases to be then analysed (Country/ Name of project/ Main advantages).

Table 2- Synopsis of Identified cases (Country/ Name of project/ Main advantages)

Country of the case	Name	Main advantages
Belgium	**IRISPHERE** www.irisphere.be	• Project on a small scale in urban areas; • Real support by consultants commissioned and supported by the public authority; • Deep awareness by the businesses of opportunities for synergies.
Belgium	**ROTOR** www.rotordb.org www.rotordeconstruction.be	• Make the work (of reuse, recycling and waste material) accessible to a wide audience; • Instead of demolition, it proposes, when it is possible, to preserve the building volumes and make use as much as can be of what is already there.
Belgium	**TERTRE** http://www.info-pme.be/news/video-tertre-hautrage-un-ecozoning-qui-marche-/	• Economic benefits linked to raw materials and energy prices; • Business models changes with environmental constraints/opportunities; • Attractive and dynamic image to all stakeholders
Belgium	**COOPERATION AGGREMENT ON GYPSUM PLASTER AND PLASTERBOARD** http://www.ovam.be/gips-en-gipskartonplaten (In dutch)	• This project encourages selective demolition; • Setting targets; • Platform for exchange and creative reflection; • Trials and studies; • Value chain cooperation of stakeholders
Belgium	**COOPERATION AGGREMENT ON SHEET GLASS** http://www.ovam.be/vlakglas (in dutch)	• This project encourages selective demolition; • Platform for exchange and creative reflection; • Trials and studies; • Value chain cooperation of stakeholders

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Belgium	**COOPERATION AGREEMENT ON CELLULAR CONCRETE** [http://ovam.be/cellenbeton#acties (in dutch)](http://ovam.be/cellenbeton#acties)	• This project encourages selective demolition; • Setting targets; • Platform for exchange and creative reflection; • Trials and studies; • Value chain cooperation of stakeholders
Belgium	**FLANDER'S MATERIALS PROGRAMME (VMP)** http://www.vlaamsmaterialenprogramma.be/flanders%E2%80%99-materials-programme	• Added value and/or economies create opportunities for exchange and cooperation; • Governance of projects, leverage by external partners; • Emphasis on cooperation; • Extensive consultation looking at obstacles in all fields (legislation, practices, business and finances, …); • Applied research; • Aimed at SMEs
Belgium	**METALLURGY RESOURCE REGULATION** [http://ovam.be/grondstoffenregeling-metallurgie (in dutch)](http://ovam.be/grondstoffenregeling-metallurgie)	• This regulation encourages the recycling of materials from metallurgical production processes (included in the The Ministerial Decree), which are considered as raw materials instead of wastes
Belgium	**OVAM MATERIALSCAN** www.materialenscan.be	• SMEs are aware of the costs of materials (average 40% of total costs); • SMEs are aware of the loss of material in their process (average 18%)
Belgium	**UNITY REGULATION FOR RECYCLED AGGREGATES** [http://ovam.be/gerecycleerdegranulaten (in dutch)](http://ovam.be/gerecycleerdegranulaten)	• This regulation encourages selective demolition; • Setting the activities of crushing plants and of sorting lines in similar framework; • Comprehensive management system to monitor the flow and quality of recycled aggregates; • Quality control; • Monitoring collection, transport, acceptance and production of debris to aggregates
China/Singapore	**CHINA/SINGO-SINGAPORE** **TIANJIN ECO-CITY** http://www.tianjineco- -city.com/en/index.aspx	• A sustainable city to work, live, play and learn in; • With clear and measurable outcomes; • Accessible from key cities and industrial districts in the region; • Harmonies among people, environment and economy
Czech Republic	**CZECH REPUBLIC/ACT CLEAN PROJECT** http://act-clean.eu/	• Create high-quality and current database of innovative technologies; • Eco-efficient production processes; • Cleaner production and use of environmentally friendly technologies; • Re-use of waste; • Access to current information; • Establishment of a help-line in innovative technologies
Czech Republic	**CZECH REPUBLIC/ALFA PROGRAMME** https://www.tacr.cz/index.php/en/programmes/alfa-programme.html	• Support; • Projects implementation; • New opportunities for research projects; • New knowledge applied in the form of innovation

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Czech Republic	**CZECH REPUBLIC/EESS (VIZE 2024)/PLATFORM FOR RESOURCE EFFICIENCY AND SUSTAINABLE CONSUMPTION AND PRODUCTION** http://www.empress.cz/	• Information sharing; • Promotion; • Education; • Projects implementation
Czech Republic	**CZECH REPUBLIC/THE 2014-2020 OPERATIONAL PROGRAMME ENVIRONMENT (OPE)/ PRIORITY AXIS 3: WASTE MANAGEMENT AND MATERIAL FLOWS, ENVIRONMENTAL BURDEN AND RISKS** http://www.opzp.cz/about/	• Protect and ensure the quality of environment; • Promote efficient use of resources; • Elimination of the negative impacts of human activities on the environment and climate change mitigation
Denmark	**KALUNDBORG** www.symbiosis.dk/en	• An atmosphere of trust and mutual beneficial partnership existed in Kalundborg even in the absence of specific experience between firms; • The presence of two or more firms that produce and consume a continuous stream containing useful by-products; • Profitable material exchanges have been identified quite quickly; • Flexible and self-sustaining system, no central management centre, room for new players to join and new by-products to be ised as raw materials.
Germany	**BIOTECH PARK FREIBURG-GERMANY** http://www.biotechpark.de/index.php?lan=en&env=start	• Subsidies for the tenants; • Contribution to the urban and regional business development; • Support for the young and established biotechnology companies
Germany	**CEMEX CLUSTER WEST – GERMANY** http://www.cemex.com/AboutUs/Germany.aspx	• Established synergistic production system; • Clinker substitution contributes significantly to the decrease of CO_2 emission
Hungary	**DUNA-DRÁVA CEMENT KFT (HEIDELBERG CEMENT GROUP) HUNGARY** http://www.duna-drava.hu/hu	• Lower production costs; • Automated technology, with less human labour required; • More stable product quality can be reached compared to the technology with natural plaster-stone; • Waste is diverted from landfill – environmental benefits + cost reduction for the power plant
Hungary	**MÁTRA POWER PLANT INDUSTRIAL PARK (MÁTRAI ERŐMŰ ZRT.)** http://www.mert.hu/hu/ipari-park	• Materials are diverted from landfill and sold for profit; • The groundwater from the mining could be used; • The power plant can share the services it has already paid for (protection, factory doctor etc.)
Italy	**Chenna Srl** http://www.chenna.it/	• Effective reduction of waste produced locally and resources saving; • Increase of recovered materials; • Decrease in the use of raw materials and other

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		resources in industrial processes
Italy	**Greenwood Srl** http://www.greenwood-venice.com/en/index.html	• Effective reduction of wood use and wood saving; • Increase of recovered materials; • it does not release harmful pollutants into the environment; • When the material comes to the end of its natural life, it can be 100% recycled in the same production process or can be used as fuel in waste-to-energy plants
Italy	**Lape Srl** http://www.lape.it/	• Use of production waste of LAPE or other companies' processes; • Performances of the recycled insulation material comparable to those of the original product (thermal conductivity, 0.032 W/mK)
Italy	**LOWaste Project** http://www.lowaste.it/index.html	• Effective reduction of waste produced locally and resources saving; • Increase of recovered materials; • Reduction of CO2 emissions due to the lower amount of waste disposed of in landfills; • Decrease in the use of raw materials and other resources in industrial processes; • Can be promoted through public authorities in public construction thanks to the experience made in tender rules by Ferrara municipality
Italy	**MAPEI RE-CON ZERO Project** http://www.mapei.com/AE-EN/focus-on.asp?IDNews=2383	• Complete recovery of return concrete, avoiding the use of landfills; • It does not produce waste neither solid nor liquid; • It reduces the consumption of natural aggregates; • It reduces road transport; • It is easy to use and not based on hazardous substances; • It determines lower cost of disposal; • It reduces the cost of supply of natural aggregates
Italy	**Pandora Group** http://www.pandoraidea.com/#/11/1/1/	• Recycle material from both post-consumer and pre-consumer waste
Italy	**Plaxtech Srl** **http://www.plaxtech.eu/en_US/index.html**	• No use of virgin raw materials; • No waste production; • Reduce energy consumption; • Eco-sustainable process; • Eco-friendly products
Italy	**Santa Croce Tannery District** http://www.assoconciatori.com/index.php?option=com_content&view=article&id=54:fanghi-ecoespanso&catid=47:partners&Itemid=69	• Recycling of sludge, avoiding the use of landfills ; • It does not produce solid waste

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Italy	**Siniat SpA** http://www.siniat.it/	• Recovery and recycling of gypsum waste ; • No use of virgin raw materials; • No waste production
Japan	**JAPAN KAWASAKI ECO-TOWN** http://nett21.gec.jp/Ecotowns/data/et_b--kawasaki.html	• It became one of the leading area where recycling facilities are clustered; • By-product exchange among business entities
Netherlands	**NETHERLANDS/GLASS PLANT USES WATER BY-PRODUCT** http://www.ardaghgroup.com/news-centre/win-for-ardagh-at-the-first-international-resource-recovery-awards	• Clear financial benefits to all actors. The water treatment plant avoids the cost of disposing their waste product, and the glass manufacturer can use this secondary raw material as an alternative; • Financial viability: There is a significant cost benefit to using the secondary raw materials instead of primary raw materials. Because of the large potential benefits, the company were willing to spend the significant research effort necessary to overcome technical and other problems; • Leadership: A passionate, determined and competent person drove the process and managed to solve a number of problems; • Collaboration: The glass manufacturer worked with the water companies towards a common goal; • Technical knowledge was available to solve a key problem - how to dry the pellets cost effectively. This was solved with the development of a purpose built truck which dries the pellets in transit using heat from the engine.
Netherlands	**NETHERLANDS/VALKGLAS/ FLAT GLASS COLLECTION** http://www.vlakglasrecycling.nl/index.php?page=home-en	• Benefits to stakeholders: Glass makers benefit from access to more recycled glass. Glass industry benefits from the greater flexibility of creating a voluntary scheme; • Collaboration: In 2000, Dutch sheet glass manufacturers launched an initiative to set up a voluntary recycling scheme in order to meet their producer responsibility (EPR); • Supportive legislation: In the Netherlands, it was made compulsory for all producers and importers of double glazing to pay a waste disposal fee of €0.50 for every m2 of insulated glass. This funds the recycling scheme; • Design: In the Netherlands, frames are put into the buildings first and glass units are added afterwards. It means that the glass and frames can be separated very easily and cheaply. This is a big factor in the financial viability of the scheme; • Culture: Dutch people are environmentally conscious and are willing to recycle; • Geography: The relatively small size of the country affects the cost of logistics; • Communication: good communication is vital to maintaining quality of the collected material. This is done through newsletters, website, brochures, mailings etc; • Training: Collection point managers are provided

		training about what can and cannot be put into the glass containers. Preventing contamination is vital to maintaining quality and hence, the viability of the scheme; • Incentives: Containers are given to collection points for free. Any sheet glass that is too dirty to be recycled is removed as residual waste and the costs of this are reclaimed from the party responsible. When the quality is good a small collection fee is given to the collection point as a reward; • Financial viability: Affordable rent is charged for renovation/demolition projects that wish to hire a glass recycling container.
Spain	**CASTILLA LA MANCHA (SPAIN)/ CLAMBER: "CASTILLA-LA MANCHA BIO-ECONOMY REGION"** clamber.castillalamancha.es	• Public administration participation; • Rental of facilities; • R & D projects; • Participate as partners in projects with competitive funding; • Training of personnel in biotechnology
Spain	**CATALONIA (SPAIN)/MATARÓ WATER COMPANY: "GREEN TUBE" district heating with waste and sewage treatment plants heat recovery** http://www.messa.cat/es http://www.aiguesmataro.cat/ca/el-tub-verd	• The Green Tube uses excess energy from environmental infrastructures of Mataró thanks to the synergy between all the by-heat waste managers producers; • The Green Tube provides services to customers for instant water heating and air conditioning at competitive prices; • The Municipality uses the facilities for environmental training, public exhibitions, school programmes, raises environmental awareness
Spain	**SAICA ENERGY RECOVERY PLANT** http://www.saica.com/en/Pages/Home.aspx	• Adequate technical performance; • No complementary transformation/manipulation of PSA to be applied; • Cost-effective and sustainable; • Good industry cooperation
Spain	**SPAIN / SAGUNTO INDUSTRIAL AREA** http://discovery.ucl.ac.uk/762629/2/762629_Vol.II_Appendices.pdf	• Potential IS networks development through kernel analysis • Knowledge of how and why things does not work properly
Spain	**SPAIN/INDUSTRIAL BY-PRODUCTS EXCHANGE SYSTEM: CAMARAS** http://www.camaras.org/bolsasubproductos/	• Recovery and reuse of materials and products for disposal; • Lower costs of acquisition of raw materials and products and waste disposal; • Finding new customers and diversification of suppliers; • Guidance on new business opportunities; • Reducing the volume of waste and by-products.; • Improving the quality of the environment

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Spain	**BEST PRACTICES OF SUSTANABILITY OF R&D (CASTILLA Y LEÓN, SPAIN)** **http://www.medioambiente.jcyl.es/web/jcyl/MedioAmbiente/es/Plantilla100/1284136625009**	• Use of aluminium and RCDs waste as raw material in different application; • Reduce energy consumption and CO2 emissions; • Avoid to dump in the landfill.
Spain	**ALMERÍA (SPAIN)/COSENTINO/ RECYCLED PRODUCTS** **http://www.cosentino.es/**	• Cosentino Group identified a new market niche, and thanks to the Cradle to Cradle Certified recycled surface ECO by Cosentino, Cosentino Group has established itself as the leading provider of recycled surfaces in the world; • An outstanding feature of our environmental strategy is the company's active policies for air control and dust and VOC reduction; water management with the achievement of continuous reuse and "zero discharge"; and the reuse of waste as raw material for recycling into new products; • For Cosentino Group, the launch of the recycled surface ECO by Cosentino has been a success story, not only because of the benefits for society for launching a sustainable and Cradle to Cradle Certified Silver product, but also from a business point of view. Since the launch of ECO by Cosentino in April 2009, total worldwide sales have reached over 24 million Euros or about 32 million US Dollars.
Spain	**CONSTRUCTION SITE METHODOLOGY and innovative associated business model** **www.construcia.com**	• Synergies between providers-clients-actors can be pre-defined. Future development of symbiosis detected in advance; • Inclusion of industrial symbiosis concepts in construction; • Better knowledge and engagement of suppliers; • New perspective through stakeholders dialogue
Spain	**ELS HOSTALETS DE PIEROLA, BARCELONA (SPAIN)/CAN MATA-CERÁMIQUES PIEROLA/ENERGY RECOVERY OF BIOGAS** **http://www.pieraecoceramica.com/es/produccion-ecologica-con-biogas/**	• The establishment of a cooperation framework between two private companies; • Energy, environmental and economic savings; • Use of renewable energy replacing fossil fuels.

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Spain	**MANRESA EN SIMBIOSY (SPAIN)/ industrial symbiosis implementation project in the Municipality of MANRESA** http://www.simbiosy.com	• Municipalities seem to be good promoters of IS in the territory; • Benefits for both, companies and Municipality, are high; • Help companies to visualize how to maximize resource efficiency reducing costs; • Promotion of the innovation and industrial competitiveness; • Creation new companies and jobs; • Social benefits; • Promotion of circular economy and industrial symbiosis concepts; • Strengthening Manresa's industrial network.
Spain	**PLAINE DU VAR (FRANCE)** http://www.inex-circular.com/fre/36/l-experience-de-la-plaine-du-var	• Use of the first results of the national plan Recybéton; • Reduce transport distances and improve logistics; • Improve exemplary of the sector; • Revitalize local construction materials industry; • Generate savings on purchases of resources and disposal costs
Spain	**SABADELL-BARBERÀ (SPAIN)/IS in INDUSTRIAL CORRIDOR: information, training, implementation and promotion** http://www.bdv.cat/es/noticies/simbiosis-industrial-fomento-de-la-economia-colaborativa-en-los-poligonos-de-barbera-del	• Municipalities are good promoters of IS in the territory; • Benefits for both, companies and Municipality, are high; • Third party dinamizator always needed
Spain	**BASQUE COUNTRY/BILBAO PORT** www.bilbaoport.es	• The EAF steel slag concrete exhibited 15% higher density than design concrete due to the higher density of steel slag aggregates; • The necessary volume of steel concrete for precast concrete blocks or docks is lower than the designed concrete due to its higher density; • The EAF steel slag concrete precast blocks showed higher stability for docks reinforcement; • The EAF steel slag concrete was more economic than design concrete; • Reductions in 60% of natural aggregate being replaced by steel slag aggregates; • Reductions in large amounts of energy and emissions needed for extraction, crushing, screening, cleaning and transporting the natural aggregate that is replaced by steel slag aggregates

Spain	**BASQUE COUNTRY/KUBIK** http://www.tecnalia.com	• The incorporation of EAF steel slag aggregates (by weight) in structural concrete does not exhibit deleterious performance. It exhibits enhanced performance when comparing to concrete made with natural limestone aggregate; • The mechanical behaviour of concrete containing EAF steel slag aggregate was higher than OPC, especially, without air entrainment on the dosage; • The EAF steel slag concrete exhibited 10-15% higher density than OPC due to the higher density of steel slag aggregates; • The steel concrete showed similar durability as OPC.
Sweden	**STOCKHOLM** **CBI** **OCTOBER 2015** http://celsa-steelservice.se/	• Eco-friendly and well-plannned smart business parks are needed. • Sweden has no shortage on aggregate and filling materials. • A financially winning concept is hard to find for other material replacements than cement. • Instead, logistics can be an advantage. • A smart business park with crushed glass and high quality crushed concrete waiting to be recycled just around the corner can make the difference • A fine example of this can be found for a reinforcement producer
Sweden	**BIOREFINERY CLUSTER - NORTHERN COAST OF SWEDEN** http://www.processum.se/en/	• Driven people (enthusiasts) in the member companies who believed in the project and initiated it and also a driven CEO of Processum; • A triple helix organisation favour the development of the cluster; • Good basis for applying for funding due to the breadth and number of involved actors; • Pioneers of the biorefinery concept resulted in project attention, less competition, and a high profile. The project created credibility in the concept of biorefinery; • Main part of fund on research and innovation to be competitive on the knowledge intensive sector of biorefineries; • Available test-beds to facilitate scaling up technologies.
Sweden	**CITY OF MALMÖ, HARBOUR AREA** www.malmo.se	• City of Malmö has as a coordinating function. The city has strong commitment to work with sustainable development, which is important in the start-up phase; • The energy company Eon has previous experience of working with industrial symbiosis, in Norrköping. Eon is an important stakeholder in the Malmö symbiosis; • Large energy, water, waste and material flows witch is a good base to build on; • A willingness to cooperate between actors; • The harbour area is expanding and when the city is looking for new actors to settle down, they are trying to find companies who fits into a symbiosis network.
Sweden	**HÄNDELÖ ECO INDUSTRIAL PARK, NORRKÖPING** https://www.liu.se/forskning/reportage/hallbara-	• A strong municipality and its environmentally motivated actions, e.g. the establishment of a district heating system, supporting the use of waste and biomass as fuels in the CHP plant and establishing

	norrkoping?l=sv	markets for biogas and steam; • Possibility to produce steam with low CO2 emissions, enabled the production of low-CO2 ethanol and created a symbiosis between producer and consumer; • The high intensity farming activities in the region, enables synergies; • Innovative and entrepreneurial mindset.
Sweden	**INDUSTRY PARK OF SWEDEN, HELSINGBORG** http://www.industrypark.se/	• Industrial symbiosis has delivered savings; • Trust and openness between the actors; • Industrial symbiosis is integrated in the daily work and the culture, it is not a project.
Sweden	**MUNICIPALITY OF RONNEBY** http://www.ronneby.se/sv/sidowebbplatser/cefur/	• Ability to facilitate networks between companies and academia; • Local industry sees the potential economic benefits of working according to C2C-principles.
Sweden	**SOTENÄS MUNICIPALITY** www.sotenas.se http://www.sotenas.se/nyheter/nyhetsarkivet/sotenaskompetenscentrumflyttartillsymbioscenterhagaberg.5.452a963f1506ac3fcd7bf0a.html	• Public partner take lead; • Long term work; • A strong entrepreneurship in the region; • Large potential to utilize waste and heat locally; • Trust between actors
Sweden	**THE CHEMICAL CLUSTER IN STENUNGSUND (AND OF WESTERN SWEDEN)** http://kemiforetagenistenungsund.se/ http://www.businessregiongoteborg.com/huvudmeny/clusters/strongclusters/chemistryandmaterials.4.af7e50614cdb7ef12aafaea.html	• Already integrated cluster when forming the vision “Sustainable chemistry 2030” in 2010. The companies in the cluster have developed a trust and openness towards each other; • Regional companies prioritise investment in research and development; • The cluster is located in a region with a lot of knowledge and skilled labour; • A triple helix organisation and good cooperation has created many synergy effect and cross-fertilization; • A high level of enthusiasm among the key personnel in the cluster and organised networks involving representatives from the participating companies to find regional solutions and collaboration projects; • A holistic approach on sustainability questions.
Sweden	**THE GÄVLE COLLABORATION** http://www.gavleenergi.se/sv/Fjarrvarme/Om-fjarrvarme http://www.bomhusenergi.se/om-bomhus-energi	• Already an established collaboration between the two main partners to develop further; • Collaboration secured the actors energy demand and supply; • A holistic approach was used for the energy collaborations; • The project was based on openness, respect, commitments and trust between the companies involved.
Sweden	**TOMATO FARMING AT THE ELLEHOLM FARM…** http://elleholmstomater.se/index.html	• Cooperation between different companies gives a higher productivity; • The driving force is economical.

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Switzerland	**GENEVA SYMBIOSIS PROJECT – SWITZERLAND** http://www.cyclifier.org/project/geneva--symbiosis/	• The GIS tool create added value for technical analysis of IS opportunities and risk evaluation; • Provides powerful tool for visualization and communication; • Can be used as a guide to set up priorities and detect quick wins for an efficient and local use of resources
Turkey	**INDUSTRIAL SYMBIOSIS PROJECT IN ISKENDERUN BAY/TURKEY** http://www.endustriyelsimbiyoz.org/amac/, http://www.ttgv.org.tr/tr/endustriyel-simbiyoz, http://www.skdturkiye.org/haber/SKDveUyelerdenHaberler-195	• A great potential for collaboration; • Raw materials saving; • Waste reduction; • Improvement of working conditions and public health; • Increase in stakeholder awareness on IS; • Clear financial benefits to all actors. The water treatment plant avoids the cost of disposing their waste product, and the glass manufacturer can use this secondary raw material as an alternative; • Financial viability: There is a significant cost benefit to using the secondary raw materials instead of primary raw materials. Because of the large potential benefits, the company were willing to spend the significant research effort necessary to overcome technical and other problems; • Leadership: A passionate, determined and competent person drove the process and managed to solve a number of problems; • Collaboration: The glass manufacturer worked with the water companies towards a common goal; • Technical – Technical knowledge was available to solve a key problem - how to dry the pellets cost effectively. This was solved with the development of a purpose built truck which dries the pellets in transit using heat from the engine.
Turkey	**INDUSTRIAL SYMBIOSIS PROJECT IN OSTIM ORGANIZED INDUSTRIAL REGION/TURKEY**	• Due to the diverse type of products, there is a great potential for IS; • Economic advantages for small regional producer companies (New business opportunities for SME's); • Reduction in raw material usage and waste; • Improvement of working conditions and public health
United Kingdom	**UK/SAINT GOBAIN GLASS' UNIQUE RECYCLING SCHEME** http://uk.saint-gobain-glass.com/content/cullet http://uk.saint-gobain-glass.com/node/199	• Clear financial benefits to all actors. The glass processors avoid the cost of disposing their waste product and earn money by selling it (equivalent to raw material price). The glass manufacturer can use more recycled glass and hence, reduce emissions and energy; • Leadership: A passionate, determined and competent person drove the process and managed to solve a number of problems; • Technically proven – the science of using recycled glass to make new glass was already well understood and accepted by the glass making industry. This helped to make uptake faster; • Technical– a suitable container to collect the glass pieces was required. It had to be easy to use, easy to move, fit onto trucks, and safe. The solution found was to use large double skin polypropylene bags which

		have excellent resistance to broken glass can hold 1 tonne of material; • Communication: Training is provided to keep the waste glass pure, and to prevent contamination by other wastes. SGG provides clear explanations of how the system works and what the processors should and should not put in the bags. A brochure and CD are also used; • Logistics – The scheme is financially viable because of back hauling. Trucks which deliver new glass sheets are also used to carry the waste glass back to the factory. This keeps transportation costs low; • Incentives – Participant companies are paid for the glass pieces and hence, this is an incentive for managers to participate. Interest (and hence quality) is maintained by running a monthly competition to reward good performers; • The equipment, training and support is provided for free.
Worldwide	**CALUMITE (STEEL BY-PRODUCT USED AS RAW MATERIAL IN GLASS MANUFACTURING)** **http://calumiteint.com/**	• Large advantages to using this new material (cost savings, better glass quality) instead of just staying with traditional, tried and tested materials. Without the additional benefits, people would not have undertaken the work and risks involved with using a new raw material; • Leadership: A passionate, determined and competent person lead the process and kept it going through its many ups and downs; • Trials: The leader worked in a glass factory and had the power and desire to trial the new material (without trials, it would never have become commercially acceptable); • Quality: A dedicated company was set up to process the by-product, deal with any changes in the primary process, and guarantee product quality. Without quality guarantees, glass companies would not have taken the risk of using this new material.

Below there are figures illustrating the interactions and key players inside the the industrial symbiosis networks of two Swedish projects and Kalundborg project, all mentioned in Table 2.

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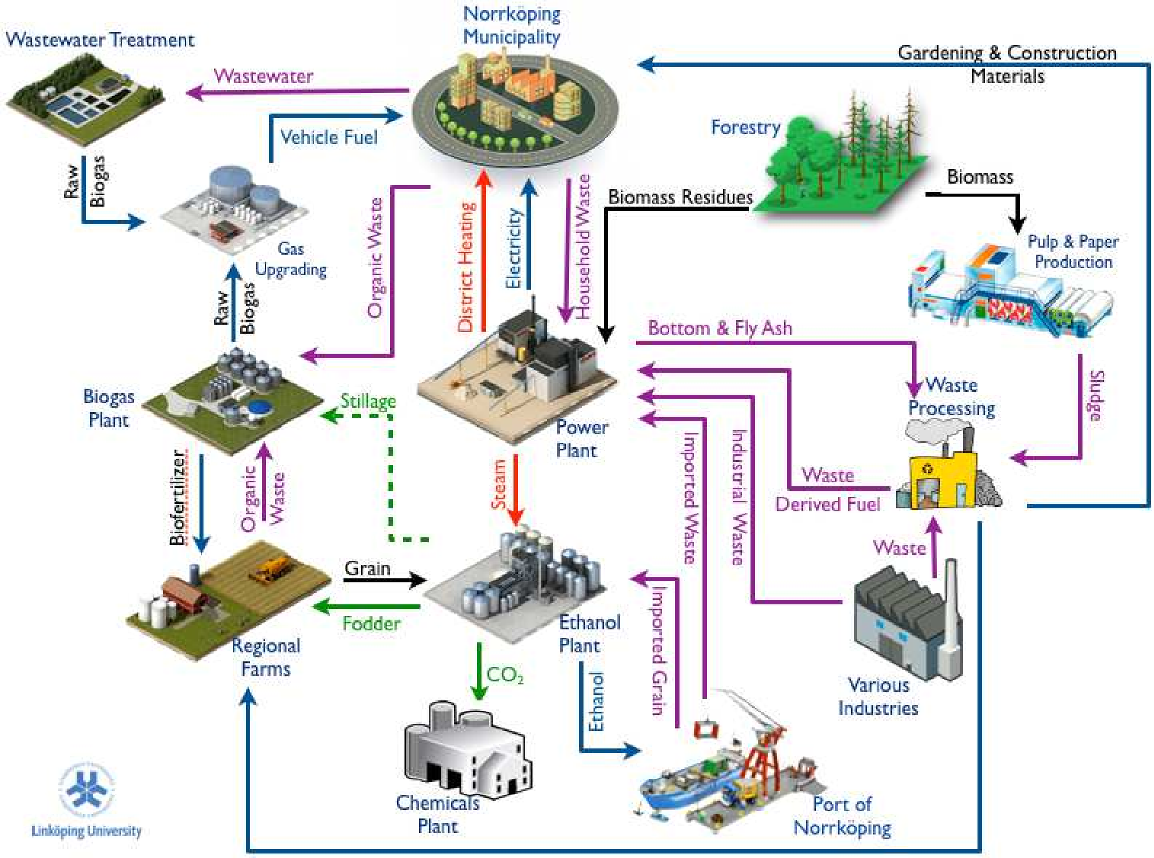

Figure 10 - Example of Händelö eco-industrial park, Norrköping, Sweden (Source: http://www.industriellekologi.se/symbiosis/norrkoping.html)

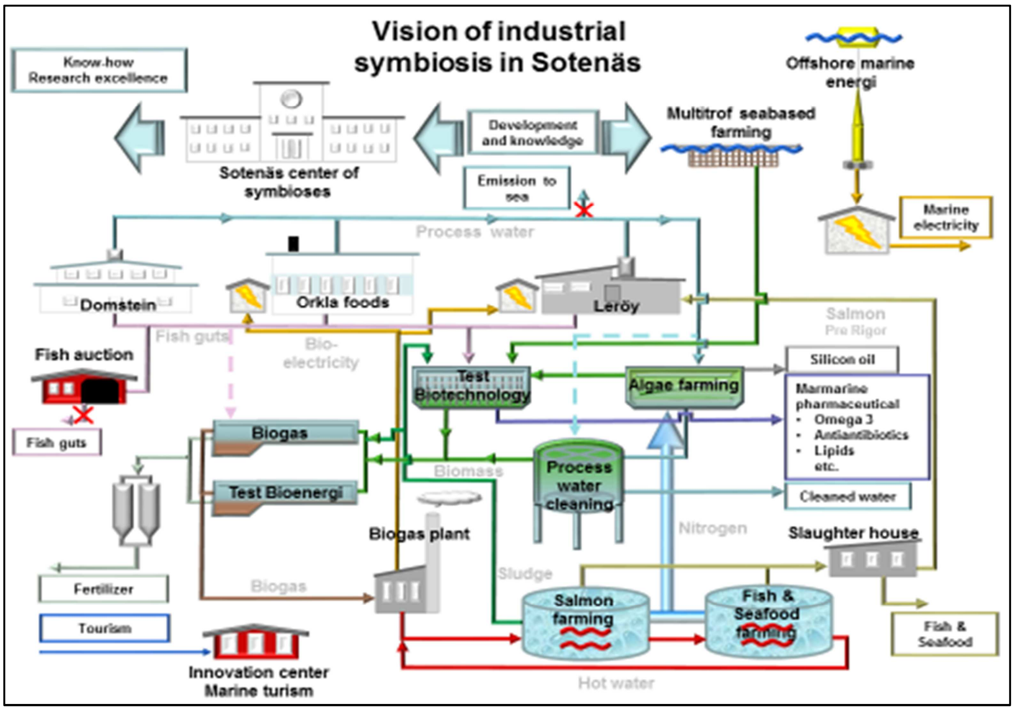

Figure 11- A vision of industrial symbiosis in the industrial area of Sotenäs, Sweden

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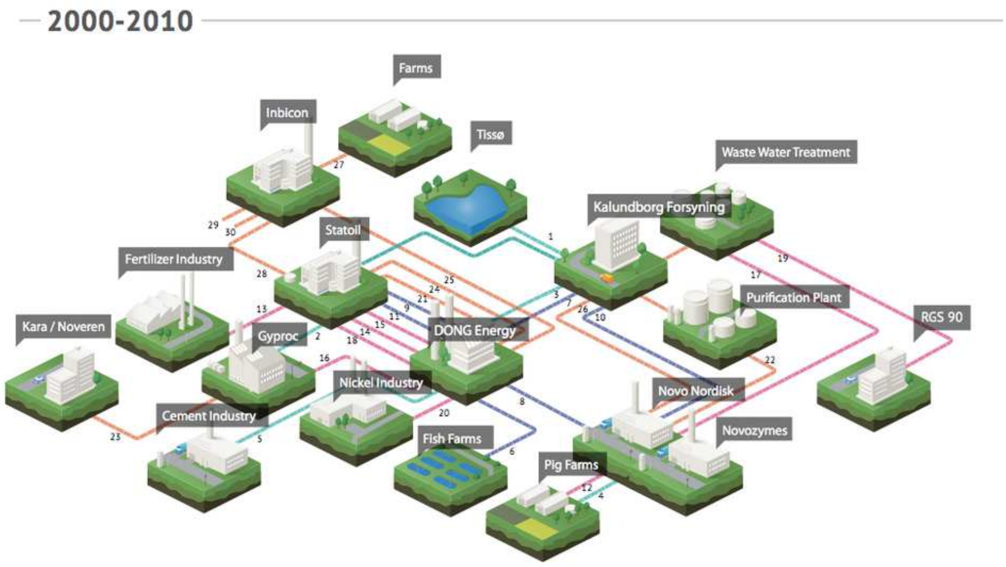

Figure 12- Kalundborg Symbiosis diagram, Denmark

2.5 Issues identified during the data collection process

A template factsheet for collecting data on relevant Industrial Symbiosis projects was circulated amongst all FISSAC project partners in mid October with a deadline for submission four weeks later, which was extended by two more weeks.

The inputs were first coordinated at national level (single point of collection per country) to avoid duplications or include irrelevant information. In several cases, the partner in charge had the opportunity to conduct interviews with IS project representatives for additional clarification and qualitative insight.

Thanks to the expertise in the Consortium and the stakeholder analysis performed in the first place, the project partners were able to identify on time the relevant projects and key stakeholders to include in the data collection.

In spite of the collective efforts for streamlining the data collection and analysis, not every project factsheet had the same level of detail, particularly the lessons learnt and the indicators for economic and environmental performance. It can be attributed to the limited time and availability of interviewed experts.

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3. Analysis

3.1 Characteristics of the collected cases

The cases were sorted according to their function, the location, their types, the project initiators, their types of implementation.

3.1.1 Geographical spread

Fifty-six cases have been collected in Europe and five in international markets

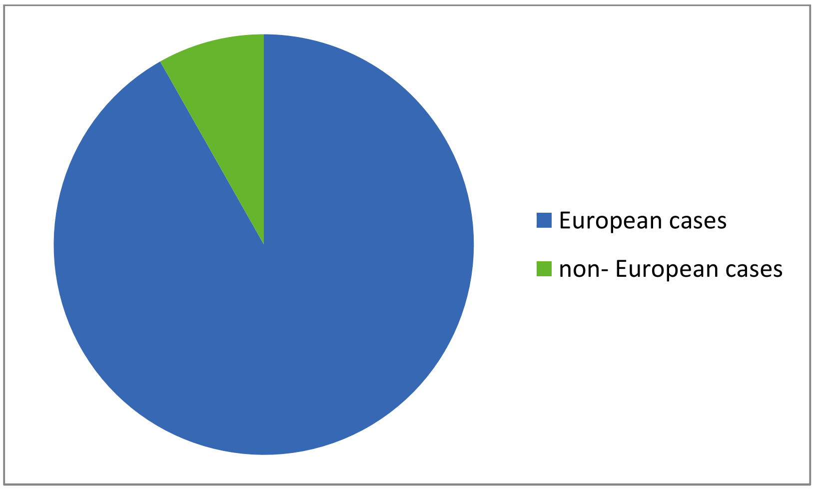

Figure 13 – European and non-European cases split

The majority were identified in Spain (14 cases), followed by Sweden (10), Belgium (10) and Italy (9).

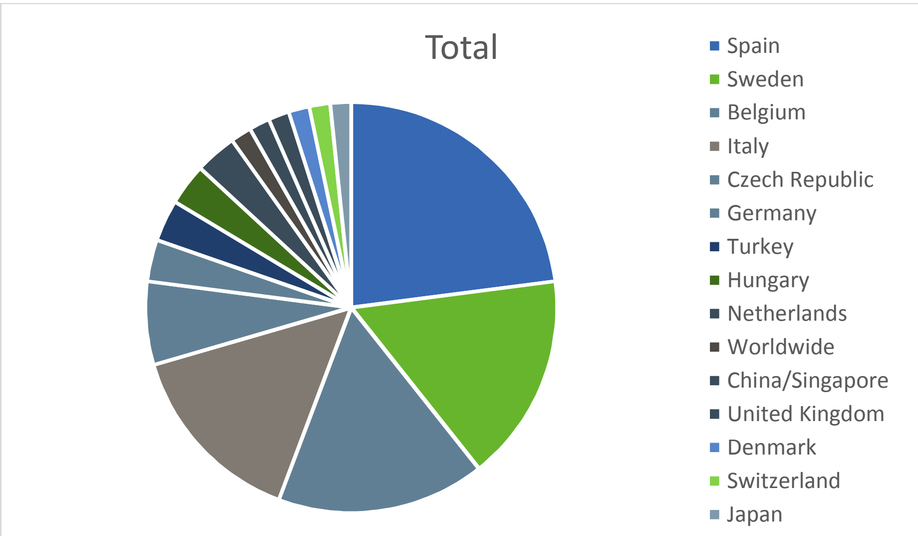

Figure 14 – Split by country

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3.1.2 Types of projects

Four different types of projects have been identified:

- 21 cases of industrial **symbiosis based on (De)construction materials** where the majority of materials exchange is of construction sectors. As we have found few examples of industrial symbiosis focus on the construction sector, we have also collected a sub-category of cases that are technology of reutilisation developed by one company.
- 14 cases of industrial **symbiosis based on heat and power** where the basis of the symbiosis is the energy even if, afterwards, others materials can also be exchanged.
- 13 cases of **industrial symbiosis** where two or more industrial facilities or companies in which the wastes or by-products of one become the raw materials for another. These cases are not especially based on (de)construction materials but can be source of inspiration for FISSAC project.
- 13 cases of **regulations, plans, Research &Development programs** that are not exactly industrial symbiosis cases but that are interesting experiences of regulations, plans or R&D programs related to the sustainability of the construction sector.

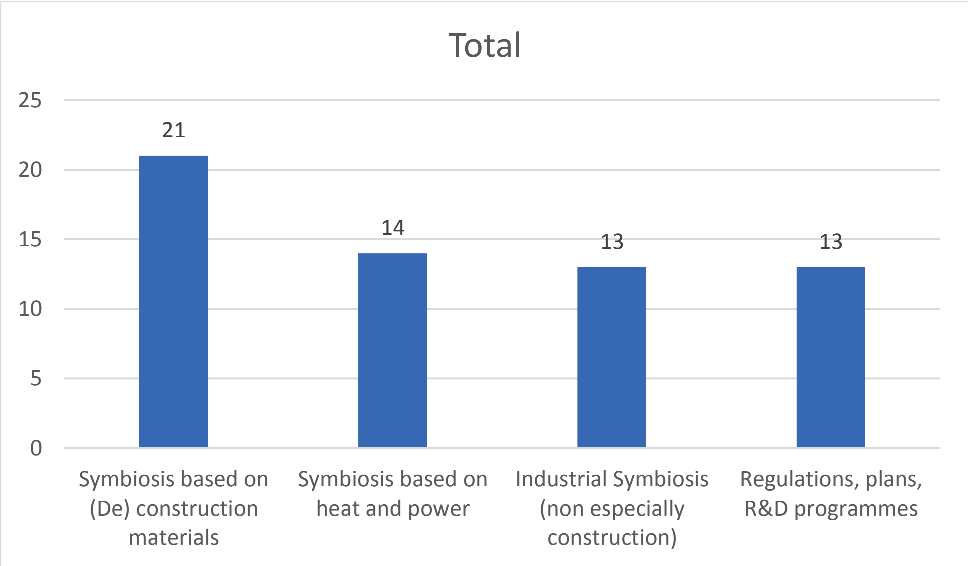

Figure 15 - Type of project

3.1.3 Project initiator

From the total cases identified, we found that 34 projects are initiated by private companies with or without a public authority involved while 27 projects are led by a public authority.

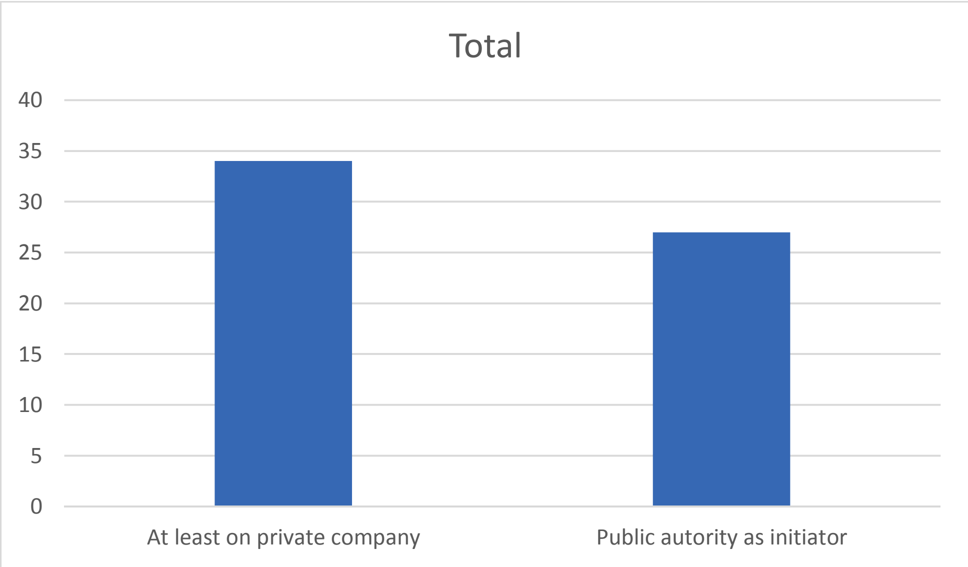

Figure 16 - Type of initiator

From the total cases,

- 29 cases are related to regulations, plans, R&D programs (13 cases) and technology developed by one **individual** company (16 cases)
- 32 cases are industrial symbiosis cases in which
    - 23 cases are initiated by a **public authority** (72% of the 32 cases)
    - 9 cases are initiated by **private companies** (28% of the 32 cases)

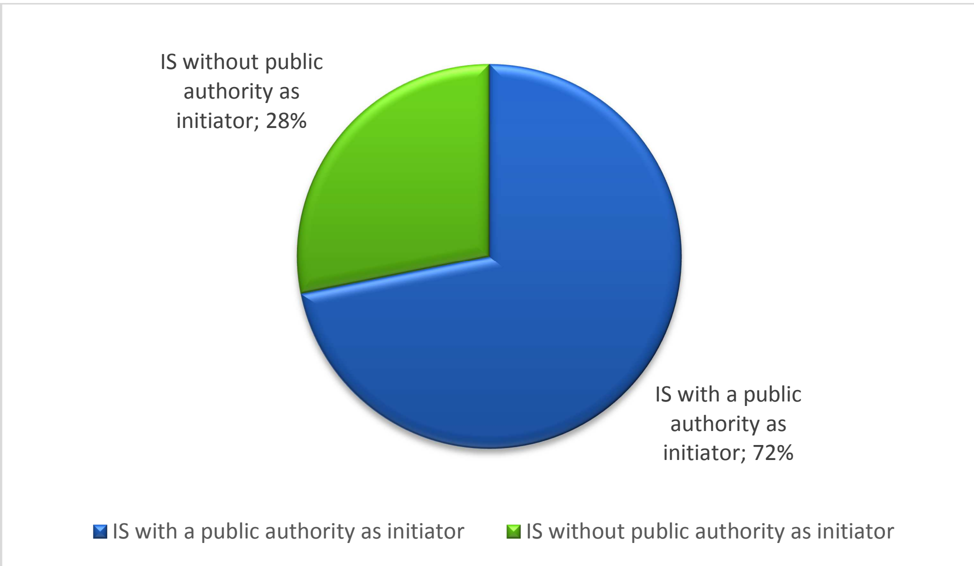

Figure 17- IS with and without public authority as initiator

3.2 Indicators of economic and environmental impact

From the collected cases, only a few included indicators describing the economic and environmental impact of the project. The non-European case Sino-Singapore Tianjin Eco-City illustrates the set of KPIs. Another case with quantitative results is the Kalundborg case in Denmark.

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In the rest of cases, few data indicators were introduced to describe the material flow, economic performance and environmental impacts. Even though indicators are used to evaluate and forecast the development of an industrial symbiosis project, publicly available information is currently limited as companies tend not to disclose any data.

For example, Felicio and Amaral (2013) describe an analysis of the environmental indicators used in Eco-Industrial Park (EIPs) through a systematic literature review[11]. This overview will serve as a good starting for discussion in Task 1.4 ''Identification and development of ecoinnovation, waste and IS indicators''.

Table 3- KPIs

Sino- Singapore Tianjin Eco-City	
22 quantitative and 4 qualitative Key Performance Indicators are described	
Good Natural Environment Ambient Air Quality Quality of water bodies within the Eco-city Quality of Water from Taps Noise Pollution Levels Carbon Emission Per Unit GDP Net Loss of Natural Wetlands	**Healthy Balance in the Man-made Environment** Proportion of Green Buildings Native Vegetation Index Per Capita Public Green Space
Good Lifestyle Habits Per Capita Daily Water Consumption Per Capita Daily Domestic Waste Generation Proportion of Green Trips Overall Recycling Rate Access to Free Recreational and Sports Amenities Waste Treatment Barrier-Free Accessibility Services Network Coverage Proportion of Affordable Public Housing	**Developing a Dynamic and Efficient Economy** Usage of Renewable Energy Usage of Water from Non-Traditional Sources Proportion of R&D Scientists and Engineers in the Eco-city Workforce Employment-Housing Equilibrium Index

3.3 Barriers

The transformation of an industrial estate from a purely waste management facility to an IS focus requires close collaboration between industries in the area and the variety of synergy projects of different types (Golev and Corder 2012). The IS maturity grid has to reflect the barriers and drivers for synergy projects to mature and thrive, as well as stress the importance of evolutionary changes in eco-industrial development of a region.[12]

Seven types of barriers have been overall identified and could be classified as follow: three barriers related to the three pillars of the sustainable development (Environment, Economic, Social), two barriers related to "soft aptitudes" (information and collaboration) and two barriers related to "practical obstacles" (technics and regulations).

a. Commitment to Sustainable Development

The social aspects of industrial symbiosis should be equally considered and not neglected: Organizational strategy, goals, and performance measures have to motivate managers to develop and change their mindset. The personnel should be encouraged to participate in the synergy projects, contributing to the company's goals.

[11] http://www.gcsm.eu/Papers/46/2.6_167.pdf

[12] http://onlinelibrary.wiley.com/doi/10.1111/jiec.12159/pdf

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b. Financial

Synergistic activities are expected to bring a positive economic outcome along with the environmental benefits. However, lack of access to long-term financing and uncertainty about the profitability of the partnership might hinder the project. High initial set up costs to create the infrastructure to enable recycling and symbiosis may prove a big barrier to the creation of schemes.

c. Community engagement

Community awareness (of the environmental and economic impacts and benefits that industries generate) can be a strong driver to initiate but also halt or delay the development of different projects. Well-established communication channels between the industries and local community, as well as the initiation of environmental education programs, and on site consultation help to ensure the legitimate status of new synergies.

d. Lack of information

Lack of detailed qualitative and quantitative data on waste streams and local industries' material/water/energy requirements might fail to provide the basis for developing regional resource synergies. The inexistent habit to share information and the knowledge sharing issue within and amongst companies and institutions is a detriment to progress.

e. Culture for cooperation

The cooperation and trust between key players, spirit of information sharing, and network development are important factors, without which no real synergy projects will be created. A neutral coordinating body (e.g., interindustry council) can play such a role. As a new alternative concept, IS has to be introduced and therefore a moderator is essential to teach, create trust and make things happen. Often in a value chain, cooperation is constrained because of imbalances in the cost/benefit ratio for the different partners. An open exchange about gains and effort of all stakeholders and participants can open a process aimed at levelling out the differences.

f. Technical

Technical feasibility is an essential precondition for a potential synergy. The role of R&D is to early detect technical challenges, provide the technical solutions and work closely with the industry in pilot projects. This can be compensated by involving a consultancy or research organization. The difficulty to access the technology from an economic point of view constitutes a barrier: new business models based on circular economy are introduced and technical innovation is affecting the company as a whole not only the waste management facilities.

g. Regulatory

The inconsistencies in the environmental legislation and difficulties to obtain approvals for waste reuse projects from the regulatory authorities may also be an obstacle to potential synergies. At the same time, imposing compulsory legal requirements to recycle specific materials, introducing higher taxes for waste disposal, and so on, are the drivers for synergy projects. Rules on transportation of waste might hinder symbiosis particularly across borders.

Regulation in circular economy has to reinforce the working of the market by ensuring a level playing field and equitable participation where this cannot be achieved among the partners through self-regulation.

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3.4 Other risks and uncertainties

The collected cases give little information about new business models of industrial symbiosis towards a circular economy. There is little or no information on social innovation (for instance new sustainable lifestyles, consumption behaviour, etc).

Also, it is not possible to compare the dynamics for exchange of energy with the symbiosis on materials and by-products. In the case of waste some treatment or conditioning is needed.

3.5 Drivers of Industrial Symbiosis

Each factsheet contains the main advantages of the project and the main difficulties or challenges associated. The lessons learned derived from those factsheets are summarised by categories of drivers and they are illustrated by one concrete example.

Some lessons learned can be highlighted:

- A key success factor is the leadership skills of the leader of a private company and/or of the local authority in charge of the economic development of the region.
- Most importantly, it is the full engagement and vision of a leader (of a public or private entity) which will introduce this new alternative to their colleagues and partners. Leaders should get participants to be open about gains and efforts linked to their involvement to the value chain.
- A continuous information, training, awareness campaign are needed to improve the knowledge of a large branch of stakeholders at each step of the project.
- Cooperation is vital and requires time, tools, trust and a dedicated facilitator.
- Technical challenges are unavoidable; this is why R&D plans will contribute with focus on (reverse) logistic and data collection.
- Regulations and support schemes must be consistent and stable and give a clear direction to the investors in the long term. Trials should allow for temporary changes in the application of regulations if necessary. These can be adopted later in charges to the regulation. Trials should be scaled out in stages to test the durability of the applied business model.
- Resources synergies need to be economically viable. Energy savings are one of the main drivers so far even if new business models based on materials start to be successfully implemented. Economics are considered as a soft spot in industrial symbiosis projects.

LEADERSHIP	
Case "Iskenderun bay" (Turkey) *Industrial symbiosis with various materials*	- Collaborations between companies in Iskenderun Bay region with both economic and environmental returns. - The aims of the project are to increase the competitiveness, to create new market opportunities and to reduce in naturally occurred raw material usage. - A passionate, determined and competent person drove the process and managed to solve a number of problems. - http://www.ttgv.org.tr/en/industrial-symbiosis-cooperation-networks-for-environmental-and-economic-benefits

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AWARENESS	
Case "Helsingborg" (Sweden) *Symbiosis based on heat and power*	- There are many different companies situated in the park and Industry Park of Sweden (IPOS) has developed synergies between them. Excess heat from different plants in the park is used internally in the park. For electricity, steam and heat production, there is also an external use in the regional district heating system. - Good communication between the facilitator IPOS and the companies is highlighted as a success factor. In the same time, a challenge is to deconstruct the belief that the environmental benefits cost money. - http://www.industrypark.se

PLATFORM FOR GOVERNANCE	
Case "Flanders' Materials Programme (VMP)" (Belgium) *Regulations, plans and R&D programmes*	- Long-term vision development, experimental pilot projects, policy-relevant research and concrete priority actions towards circular economy. - It is a 'network of networks', comprising the frontrunners within government, industry, universities and research centres, and non-governmental organizations. - Extensive experience in sustainable materials management, able to identify drivers and barriers to materials management, opportunities for circular economy via innovation, international logistics, new jobs and skills creation, the redesigning of economic policy instruments, consumer behaviour and circular public procurement; - Educational and management tools to prevent value escaping the material flows http://www.vlaamsmaterialenprogramma.be/fmp

INNOVATION	
Case: "Castilla-La Mancha Region Bio-Economy – Clamber project" (Spain) *Symbiosis based on heat and power*	- It consists of two main actions: (a) building a biorefinery and (b) the procurement of R&D to support the development of applied research for SMEs in the region. - To increase the efficiency of the biomass use

	and get not only a source of energy but also products with high added-value, an effort in research and innovation is required. - http://clamber.castillalamancha.es

REGULATORY FRAMEWORK	
Case "Plaine du Var" (France) *Industrial symbiosis with various materials*	- The implementation of an IS project has created the basis to stimulate synergies and apply viable economical models for buying and selling surplus resources: unusables, losts, not used or sharable, using a new web platform tool for analysing industrial data. - This is a complex project due to public financing constraint, the administrative requests and the several levels of governance. - http://www.inex-circular.com/fre/36/l-experience-de-la-plaine-du-var

PROFITABILITY	
Case "Kalundborg" (Denmark) *Symbiosis based on heat and power*	- Eight industrial companies are working together making by-products commercially interesting as new resources in other production processes after the cradle-to-cradle model. - The members focus on large, continuous waste streams, starting with heat. - Each synergy is negotiated over a period of some 40 years and it is established only if it is expected to be economically beneficial. - www.symbiosis.dk/en

COOPERATION	
Case "Tertre" (Belgium) *Industrial symbiosis with various materials*	- This eco-zoning project is materialized by the creation of several working groups (WG) with different themes. Each working group is led by a project manager selected from the partners. The local economic actor of various municipalities, helped by a private consultant, manages the work organization, meetings, group animation, coordination etc - http://www.info-pme.be/news/video-

	tertre-hautrage-un-ecozoning-qui-marche-/

Table 4- Best practices

a) Commitment to Sustainable Development

Leadership: The perception and dedication of company managers that industrial symbiosis will generate viable business opportunities is crucial. Quite often, a passionate, determined and competent person will drive the process and manage to solve a number of problems.[13] A global innovative and entrepreneurial mindset is an asset.[14]

Public authority's commitment: A public authority may take the lead[15] in the majority of the aforementioned projects. A municipality takes quite often a coordinating function: it is important in the start-up phase to have a municipality with a strong commitment to sustainable development.[16] A 'green' municipality can make possible environmentally motivated actions like the establishment of a district heating system or supporting the use of waste and biomass as fuels in the CHP plant.[17]

b) Economics

Economic viability: no decisions are made without making economic sense.[18] It is a precondition even if it is not a sufficient one.[19] Access to sufficient finance and/ or public grants while offering the possibility of economic gains to companies will drive a successful project.

Market niche development: Economic advantages are available for small regional producer companies with the development of new business opportunities for SMEs[20]. It is important to understand and introduce new business and business models in order to achieve new developments in industry.[21]

Financing: It is not easy to implement synergies that require large financial commitments in the short term.[22] High capital is often needed to start implementing synergies.[23]

c) Energy savings

Capturing the caloric value of a waste stream is one of the main drivers for a large category of collected cases.[24]

Social benefits: Industrial symbiosis, in some cases, could help to improve working conditions and public health[25]. Moreover, the environmental strategy of companies can include for instance air control, dust and

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[13] UK/SAINT GOBAIN GLASS' UNIQUE RECYCLING SCHEME, CALUMITE, TURKEY/ISKENDERUN, SWEDEN/STENUNGSUND, SWEDEN/MALMÖ, ITALY/LOWaste, BELGIUM/TERTRE, DENMARK/KALUNDBORG, BELGIUM/VMP

[14] SWEDEN/HÄNDELÖ

[15] BELGIUM/COOPERATION AGGREMENT, BELGIUM/IRISPHERE, BELGIUM/OVAM, MATERIALSCAN, BELGIUM/TERTRE, CZECH REPUBLIC/ACT CLEAN, CZECH REPUBLIC/ALFA, GERMANY/BIOTECH PARK FREIBURG, ITALY/LOWaste, JAPAN/KAWASAKI, SPAIN/BILBAO PORT, SPAIN/KUBIC, SPAIN/CASTILLA, SPAIN/CLAMBER, SPAIN/ MATARÓ, SWEDEN/MALMÖ, SWEDEN/RONNEBY, SWEDEN/STENUNGSUND, SWITZERLAND/GENOVA, TURKEY/ISKENDERUN, TURKEY/OSTIM + CHINA/SINGO-SINGAPORE TIANJIN ECO-CITY, SPAIN/PIEROLA, SPAIN/MANRESA, FRANCE/PLAINE DU VAR, SPAIN/CAMARAS, SWEDEN/HÄNDELÖ, SWEDEN/SOTENÄS MUICIPALITY

[16] SWEDEN/MALMÖ

[17] SWEDEN/HÄNDELÖ, SPAIN/SAGUNTO

[18] DENMARK/KALUNDBORG, SWEDEN/TOMATO FARMING, FRANCE/PLAINE DU VAR, SPAIN/COSENTINO, SPAIN/SAICA ENERGY, SPAIN/CLAMBER, SPAIN/CAMARAS, SPAIN/BILBAO PORT, BELGIUM/TERTRE, BELGIUM/VMP

[19] SWEDEN/HELSINGBORG

[20] TURKEY/OSTIM, SPAIN/COSENTINO, SPAIN/CAMARAS, BELGIUM/VMP

[21] SWEDEN/STENUNGSUND

[22] SWEDEN/HELSINGBORG, SPAIN/COSENTINO

[23] HUNGARY/DUNA-DRÁVA CEMENT KFT

[24] CHINA/SINGO-SINGAPORE TIANJIN ECO-CITY, DENMARK/KALUNDBORG, HUNGARY/MÁTRA, SPAIN/CLAMBER, SPAIN/PIEROLA, SPAIN/ MATARÓ, SPAIN/SAICA ENERGY, SWEDEN/BIOREFINERY CLUSTER, SWEDEN/MALMÖ, SWEDEN/HÄNDELÖ, SWEDEN/HELSINGBORG, SWEDEN/SOTENÄS MUICIPALITY, SWEDEN/GÄVLE, SWEDEN/TOMATO FARMING

VOC reduction, water management with the achievement of continuous reuse and "zero discharge" and the reuse of waste as raw material for recycling into new products.[26]

Indirectly some of the materials exchange can help to limit the emission of carbon dioxide as is the casewith the production of green concrete that uses recycled aggregates.

Demand side: demand on products could be increased thanks to favorable legal conditions[27] and to awareness campaigns.[28]

d) Information

Continued information: information is essential to ensure the necessary quality of the collected material, to understand the environmental benefits, and the operational performance in the middle term. Information can be disseminated via newsletters, a project website, brochures, mailings etc.[29]

New perspectives can be highlighted through stakeholders' dialogue.[30]

Training: In some cases, providing training and regular updates to the personnel involved is necessary. For instance, collection point managers need training on what can or cannot be put into the sorting containers. Preventing contamination is vital to maintaining quality and hence, the viability of the scheme. For example, an account manager could regularly visit the collection points to provide feedback and education. High quality standards have to be set and collection points have to be made responsible for the quality of the collected materials.[31]

Raising awareness: Clear benefits are needed to motivate people to undertake the work and take risks associated with using secondary raw materials.[32] Local industry needs to see the potential economic benefits of working according to industrial symbiosis[33] and to understand the concept and multiple advantages of industrial symbiosis[34].

e) Cooperation

Time: A lot of time is required to solve all the problems and establish new practices[35]. This is often challenging because people are busy with the daily tasks and deadlines.[36] When it is well understood, industrial symbiosis is integrated in the daily work and the culture, it is not a separate project.[37]

Tools: A GIS tool creates added value for technical analysis of IS opportunities and risk evaluation. It provides powerful means for visualization and communication. It can also be used as a guide to set up priorities and detect quick wins for an efficient and local use of resources.[38] Tools to scan the materials of a product could also give advice on material-efficient product design, proposal of suitable action and further trajectories on support and financing.[39]

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[25] TURKEY/OSTIM, SPAIN/MANRESA, CZECH REPUBLIC/ACT CLEAN
[26] SPAIN/COSENTINO, SPAIN/CAMARAS, SPAIN/BILBAO PORT, ITALY/PLAXTECH, ITALY/GREENWOOD, ITALY/CHENNA, ITALY/LOWaste, ITALY/MAPEI, HUNGARY/DUNA-DRÁVA CEMENT KFT, GERMANY/CEMEX, CZECH REPUBLIC/WASTE MANAGEMENT AND MATERIALS FLOWS
[27] SWEDEN/BIOREFINERY CLUSTER, ITALY/LOWaste, BELGIUM/ROTOR
[28] CZECH REPUBLIC/EMPRESS
[29] NETHERLANDS/VALKGLAS/FLAT GLASS COLLECTION, UK/SAINT GOBAIN GLASS' UNIQUE RECYCLING SCHEME, SWEDEN/HELSINGBORG, BELGIUM/ROTOR, BELGIUM/TERTRE, BELGIUM/IRISPHERE
[30] SPAIN/CONSTRUCIA
[31] NETHERLANDS/VALKGLAS/FLAT GLASS COLLECTION, SPAIN/CLAMBER
[32] CALUMITE
[33] SWEDEN/RONNEBY, SWEDEN/MALMÖ, JAPAN/KAWASAKI
[34] SPAIN/SABADELL-BARBERÀ, SPAIN/MANRESA, SPAIN/CONSTRUCIA, BELGIUM/OVAM MATERIALSCAN
[35] FRANCE/PLAINE DU VAR, SPAIN/MANRESA, BELGIUM/VMP
[36] UK/SAINT GOBAIN GLASS' UNIQUE RECYCLING SCHEME, TURKEY/ISKENDERUN, SWEDEN/SOTENÄS MUNICIPALITY, BELGIUM/IRISPHERE
[37] SWEDEN/HELSINGBORG
[38] SWITZERLAND/GENEVA, FRANCE/PLAINE DU VAR
[39] BELGIUM/OVAM MATERIALSCAN, BELGIUM/VMP

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Trust: Trust and openness towards each other is necessary between companies[40]. A triple helix organization and good cooperation could create many synergies and cross-fertilization.[41] It is necessary to accept the fact of becoming more dependent on other companies[42]and understand the benefits of all concerned parties in the value chain, by putting emphasis on the joint development of products.

Facilitator: The implementation is easier when one person is responsible to implement the synergies[43]. Moreover, opportunities to facilitate networks between companies and academia is necessary to accelerate the process of industrial symbiosis.[44]

f) Technical innovation

R&D: Involvement of technology providers and R&D is an essential element in the successful matchmaking between supply and demand.[45] Because of the large potential benefits to using the secondary raw materials instead of primary raw materials, the company will spend significant research effort to overcome technical and other problems.[46] This is why it is important to have an open platformbetween the research/innovation community and the industry[47]. License of patents is necessary to allow replicability of new process[48].

Trial: Without trials, it would be difficult to reach a commercially acceptable process or product[49] In general, many technical problems have to be solved before reaching a mainstream product or process.[50]

Logistics cost is important for that reason a good logistic set up should be put in place.[51] The two main ideas are to reduce the distance of materials transportation[52] and to implement reverse logistics. The geographical location of enterprises is one important driver.[53]

Data and indicators: data collection is a real challenge (waste, materials, production, etc.)[54]. Likewise, the collection of indicators to know the real effectiveness of the stock exchange of byproducts[55] Certification is also needed for rolling up the new technology.[56]

g) Regulation

Stability: any retroactive change in the regulatory framework could affect the driving forces of the development, since projects planning depend on subsidies or support mechanisms.[57] Long-term plans and clear vision are needed to give the signal to encourage firms to put in place industrial symbiosis actions.[58]

Taxes: high cost of landfilling would help to create more environmentally friendly alternatives.[59]

[40] SWEDEN/GÄVLE, SPAIN/SAICA ENERGY, SPAIN/SAGUNTO, BELGIUM/TERTRE, BELGIUM/VMP
[41] SWEDEN/STENUNGSUND, SWEDEN/SOTENÄS MUICIPALITY, SWEDEN/HELSINGBORG, SWEDEN/MALMÖ, SPAIN/PIEROLA
[42] SWEDEN/HELSINGBORG, SWEDEN/TOMATO FARMING
[43] SPAIN/PIEROLO
[44] SWEDEN/RONNEBY, GERMANY/BIOTECH PARK FREIBURG, BELGIUM/TERTRE, BELGIUM/IRISPHERE
[45] UK/SAINT GOBAIN GLASS' UNIQUE RECYCLING SCHEME, SPAIN/SAICA ENERGY, HUNGARY/MÁTRA, SPAIN/CASTILLA, CZECH REPUBLIC/ALFA, CZECH REPUBLIC/ACT CLEAN
[46] CALUMITE
[47] SPAIN/MANRESA, SPAIN/SAGUNTO, SPAIN/CLAMBER, SPAIN/KUBIC, BELGIUM/VMP
[48] ITALY/ PANDORA GROUP
[49] CALUMITE, BELGIUM/VMP
[50] TURKEY/ISKENDERUN, SPAIN/ MATARÓ, CZECH REPUBLIC/ALFA
[51] NETHERLANDS/VALKGLAS/FLAT GLASS COLLECTION, UK/SAINT GOBAIN GLASS' UNIQUE RECYCLING SCHEME, ITALY/PLAXTECH, ITALY/CHENNA
[52] FRANCE/PLAINE DU VAR
[53] JAPAN/KAWASAKI
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[55] CHINA/SINGO-SINGAPORE TIANJIN ECO-CITY, SPAIN/CLAMBER, SPAIN/CAMARAS, ITALY/GREENWOOD
[56] ITALY/LAPE
[57] SWEDEN/HÄNDELÖ, FRANCE/PLAINE DU VAR, ITALY/PLAXTECH, ITALY/CHENNA, GERMANY/BIOTECH PARK FREIBURG
[58] BELGIUM/IRISPHERE
[59] ITALY/SANTA CROCE, HUNGARY/DUNA-DRÁVA CEMENT KFT

Project funded by the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 642154.

Regulation: Regulation is needed to encourage selective demolition.[60]

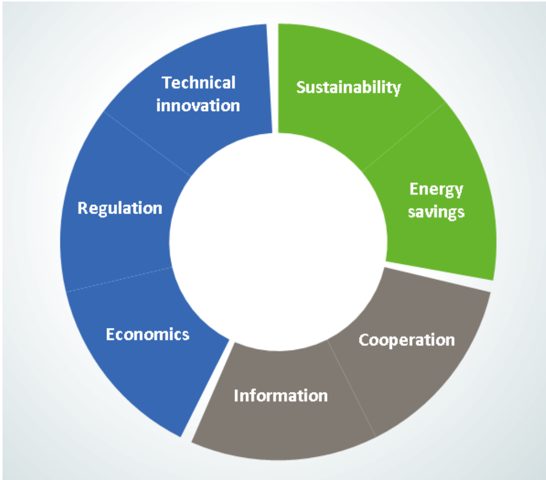

Figure 18- the Seven drivers for industrial symbiosis

4. Recommendations

4.1 Governance and the role of different stakeholders

Motivated people are necessary to implement industrial symbiosis. Tools and technology measures exist but are not enough to improve resource management to desired levels. In the case of industrial symbiosis, a homogeneous group of actors is also not enough. In the majority of the studied cases, a multi-stakeholder approach has proven to work better.

Multiple stakeholders benefit from the network in different ways: for businesses, it directly improves profitability environmental performance, and at an economy wide level, economic prosperity, reduced consumption of resources and carbon intensity, less material lost to landfills. The local and regional authorities benefit from an improved industrial waste management system, local job creation and local economic opportunities. The success of a IS programme is primarily due to the large and diverse network of participating companies as well as high-level stakeholder buy-in which provide public support and assistance recruiting new members and implementing useful common infrastructure if needed.

Industrial symbiosis involves different layers of unlinked participants on a nearly day-to-day basis. That is why, a dedicated group/facilitator is needed to provide brokerage services, linking companies with potential synergistic matches, as well as working with local and regional authorities.

Moreover, openness among participating companies and continued coordination by a stakeholder group such as an advisory council is important both to establish and to maintain the momentum of a symbiosis.

It is important that the partners in the symbiosis or value chain can be open about what they stand to gain from it, or what level of effort they are required to make in order for this process to work. There should exist a willingness for the winners to share the spoils with the partners, mainly at the start of the process, who have to invest time and money into the flow. In a value chain the partners need to adopt co-design as an option. This has to be aimed at reducing the environmental impact and to enable the transformation to

[60] BELGIUM/ROTOR, BELGIUM/COOPERATION AGGREMENT

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a circular flow in the chain. Obstacles to this can be resolved by cooperation and by taking into account the cost/benefit structure of all activities of all partners in the chain.

4.2 How to foster successful Industrial Symbiosis initiatives?

a) Develop soft Skills

Willingness of both companies and local and regional authorities is needed during the process:

- An important change is to understand the importance of **collaboration** instead of competition. The relationship between companies is thus completely different than the general mindset of managers. It is only through collaboration that companies create more effective solutions to face complex challenges as the implementation of synergies. Creativity invariably comes from communities with a common cause. The enterprises have to develop forms of social exchange: mutual trust, knowledge transfer, joint problem solving.

- It is important not to confuse the ‘promoter’ with the ‘facilitator’: the promoter of industrial symbiosis can be a public authority i.e. municipality or a private company or private association whilst the facilitator is a third party which has the skills to develop the IS projects and drive progress (usually a consultancy group).

- Local and regional authorities have to endorse a new role of “**bridging actor**” to coordinate between actors on the territory and establish contacts between entrepreneurs and support actors as innovators, using for example workshop events and seminars. The aim of a bridging actor between the diversity of stakeholders of the territory is to stimulate the co-construction and the implementation of synergies based on a logic of shared value creation both for the economic players and for society as a whole.

b) Map concrete needs

If a bridging actor is identified and the trust sentiment exists, then IS practitioners need to overcome a series of practical barriers. These can vary from not having the right tools to identify the potential synergies, facilitating structures that allow to increase information sharing and collaboration, operational and contractual arrangements for helping companies to share the risks and benefits, adequate regulatory framework, time availability to participate at the working groups and define concrete actions.

c) Impact assessment

Evaluation tools and precise indicators, that allow tracking and quantifying the financial and sustainability benefits of industrial symbiosis, are needed to involve the various stakeholders on the long-term. For example, an important question for local and regional authorities relates to the potential for new businesses and jobs to arise from industrial symbiosis activities. However, in the case studies, exact numbers are not available.

4.3 Towards a long-term vision: how to scale up?

Firstly, to establish a long-term public support framework for industrial symbiosis, including comprehensive and coherent strategies and binding objectives for the IS practitioners.
Concretely, local and regional authorities can and should support and facilitate the development of industrial symbiosis, for instance by promoting the development of networks/clusters based on local and regional strengths and helping players to identify industrial symbiosis exchanges which make a good business case.

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Available financial assets and awareness campaigns are also needed if SME's are targeted.

For the moment, it is mostly municipalities acting as promoters concentrating the efforts on local and regional level.

On the other hand, IS is site-specific, which strongly depends on the local context, business networks and competences. The way to scale up is by finding a way to stimulate the actors to shift their focus from the development of single activities or synergies to the development of a regional network of such synergies. This can happen by facilitating information exchange, communicating the benefits and by interconnecting the different local projects in order to share information, lessons learnt and best practices from each other. The national Industrial Symbiosis programs (e.g. NISP, CRISP, WISP, FISS) are a good example.

5. Collaboration opportunities and previous experiences

5.1 Previous experiences and best practices on the reuse and recycling of the C&DW stream

IRCOW Project (2011-2014)**. Innovative Strategies for High-Grade Material Recovery from Construction and Demolition Waste.**

The "Innovative Strategies for High Grade Material Recovery from Construction and Demolition Waste" (IRCOW) FP7 project has come out with some interesting results of technical and non-technical nature related to managing Construction and Demolition Waste (C&DW) as a resource of valuable materials which can be recovered for high grade applications back in the construction sector. C&DW represents one of the European Union's largest waste streams, by weight and volume. Although many EU Member States demonstrate a strong increase in C&DW managing awareness and infrastructure, in line with the claims of the European Directive on Waste, the overall material recovery performance from C&DW in the European Union reveals that further improvement in the reuse and recycling is needed to move towards a high level of resource efficiency.

In this scenario, ACCIONA, TECNALIA and D'APPOLONIA gained experience with this project which main goal was to develop and validate upgraded solutions by considering a life cycle perspective, ranging from innovative approaches to cutting-edge technologies and products.

IRCOW also suggests introducing some changes in the European policy to make C&DW reuse and recycling happen more often and more effectively. By the end of the project, the most promising IRCOW solutions are on a short track towards market uptake. Deep involvement of industrial stakeholders and national and regional authorities in the project ensured the relevance and applicability of the project results.

One of the work lines of IRCOW consisted in a comprehensive study of the reuse of C&D materials, with the aim to formulate improved strategies. The study revealed that the current reuse markets are limited to components of cultural or aesthetic value and small scale businesses aimed at private consumers and smaller companies. Important barriers hampering the reuse of C&D materials are related to costs (material is cheap compared with labour), quality (quality assurance of reused material is complicated but an absolute requirement in many applications) and weak market structure (the supply of reused C&D material is limited and varying). Initiatives and incentive to stimulate the reuse market are needed, e.g. to include a reuse perspective in public green procurement together with increased knowledge and information on possible applications for reused materials in order to overcome current lack of confidence.

Furthermore, a demo e-platform for the reuse of elements and materials recovered from C&DW, serving as an example of how such an e-platform embracing several functions could operate, was developed under IRCOW.
The overall objective for the C&DW reuse platform is to facilitate and promote the reuse in practice. A dedicated demo stock-exchange tool is its central element. This is complemented by a wiki-area in which e.g. good practices that already exist in some countries are described.

Moreover, as the e-platform has an ambition to help share knowledge and build networks of stakeholders involved in these processes, a database of agents involved in C&DW reuse is also available.
Innovative recycling technologies for C&DW recycling systems, not only for a stony fraction but also for other fractions where there is currently a strong knowledge gap, were examined in IRCOW. Advanced

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automated sorting techniques by color (artificial vision) or chemical composition (spectrometers, lasers, X-Ray, Near Infrared, etc.) were successfully researched and developed for high quality sorting of plastics, gypsum and red-grey stony fraction. Also the treatment of C&DW containing fibrous materials like asbestos, mineral and glass wool and other fibrous materials, based on Microwave Thermal Treatment (MTT) technology was developed and validated. Moreover, a multilayer composite extrusion technology (WPC) has been applied for recycling C&D mineral wool, gypsum plasterboard and mixed wooded materials with recycled plastics.

Additionally, a series of high-grade construction materials and components from recycled C&DW was developed within IRCOW. Cellular concrete C&DW was recycled into raw material for subfloors. A number of cement/chalk based mixtures (such as concrete, ternary mixture and insulating mortars) were produced using recycled (concrete, mixed, EPS) aggregates. Moreover, C&D gypsum waste was recycled into gypsum plasterboards. Multilayer composite decking boards and multilayer panels for façade were also developed. An expert recycling tool assessing environmental and human health risks associated with recycling alternatives is openly available on the IRCOW webpage.

One of the most precious values of the project is a series of observations coming out from five case studies at real construction or demolition sites which were carried out in different parts of Europe. Each of them was focused on different practical aspects of C&DW management towards material reuse, recovery and application for high-grade construction materials and components production. The case studies provided a unique opportunity to validate which of the solutions proposed by IRCOW are technically feasible, economically viable, environmentally more appropriate (based on Life Cycle Assessment studies) and realistically applicable in market conditions.

Finally, IRCOW delivered a set of policy modifications which are deemed necessary. They refer to:

- standardization of recycled concretes based on the definition of a series of recycled aggregate categories linked to their composition and purity;
- promotion of selective demolition processes i.e. separation at source, for which compulsory demolition inventory towards reuse and recycling prior to demolition is implemented;
- regulation of demolition as waste management activity by considering the building-to-be-demolished in the “waste” list of the corresponding Directive;
- initiating regional pilot projects demonstrating feasibility of reuse activities related to C&DW recovered materials;
- application of green public procurement favouring end-of-life design to improve reusability in the future;
- developing and adapting a new system of differentiated gate fees at C&DW recycling plants based on the purity of the incoming material. Low, if any fees for clean stony waste could effectively result in an increase of such material flow while compensating the additional effort required in the production of recycled aggregates from dirty mixed waste.

DEMONSTRATION OF TECHNIQUES AND PRODUCTS DEVELOPED IN IRCOW: EXTENSION OF A PENITENTIARY CENTER (CS4, TERUEL, SPAIN).

Large construction company ACCIONA, pioneer in developing and applying new technologies, was the leader of this case study. Other project partners CONENOR and TITECH (presently TOMRA) were also involved in its implementation.
The Penitentiary Center construction site included the demolition of an old building and construction of a new building. This construction site allowed for the validation of advanced recycling technologies (for stony and organic fraction) together with the demonstration of recycled products developed in the IRCOW and the validation of the new business model proposed for ACCIONA (with regard to the integrated service for recycling C&DW into high- grade applications).

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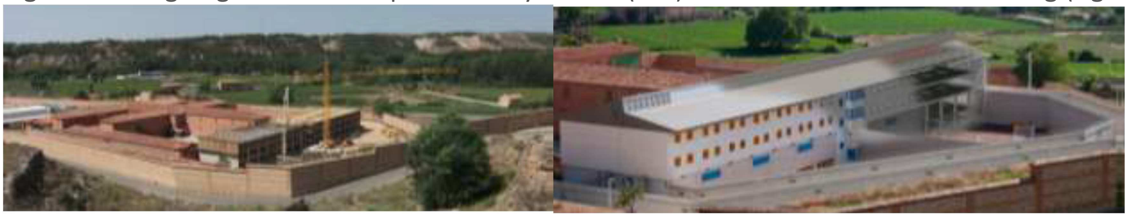
Figure 19- Ongoing works in the penitentiary centre (left) and simulation of new building (right)



Regarding the demolition phase, firstly an inventory of reusable elements was done in order to support the supply chain model developed in IRCOW. Part of the building was intensively demolished in order to obtain mixed C&DW material (concrete, ceramic, gypsum, plastic, wood, etc.). Approximately 25 tons of the resulting C&DW were separated off-site using the new algorithms for the advanced sorting systems developed within IRCOW, in order to validate the new technology and to assess the costs of the process. This task was performed in close collaboration with sorting technology developer TOMRA, at a Spanish C&DW recycling plant where the Near Infrared (NIR) technology has been implemented (BTB, Bilbao). In addition, the demolition of the wall provided aggregates of the concrete nature.

During the construction phase, the aforementioned recovered clean aggregates were used for the manufacture of a concrete slab foundation following the project advanced and optimal dosages defined in IRCOW. Furthermore, also other recycled IRCOW products were installed in the new penitentiary center, namely multilayer composite decking boards (WPC) and a multilayer façade panel.

Figure 20- Recycled concrete, extruded composites and monitoring of façade solution (left to right)

The IRCOW Wood Plastic Composites were manufactured by CONENOR using recovered non-mineral fractions like plastic, wood & mixed wooden materials, gypsum plasterboard and wool insulation waste. The resulting decking profiles were tested by TECNALIA (mechanical and aging test) before being installed in the new building constructed by ACCIONA.

The multilayer façade/partition panel consisted of an acoustic insulation board elaborated with recycled gypsum in the inner layer and a two-layer cement based precast panel elaborated with recycled aggregates and recycled plastic, as the structural element plus outside thermal insulation layer. These elements were installed in a service building. In order to validate them, ACCIONA monitored acoustic and thermal behaviour under real conditions by performing in-situ acoustic tests and temperature measurements related to thermal properties.

D'APPOLONIA developed the techno-economical assessment of this case study. A detailed analysis of current processes, practices and requirements involved in construction as well as demolition management was carried out. Current practices for waste management, with the outlook to develop new practices and the associated business models for the valorization of C&D waste were analysed.

ACCIONA intends to foster its image of innovative enterprise delivering cutting-edge and environmentally friendly solutions through introduction of novel practices aimed at recycling of C&DW for high-grade applications. Building on the strong foundations of the services that ACCIONA already provides in the construction market and after the experience gained from the case study, a new integrated service was developed that consists in delivering dedicated civil engineering and construction services to the green buildings market by working in partnership with all actors involved in the C&DW valorization value chain, namely demolition companies, concrete ready mix manufacturers and processing centers.

Thanks to having pioneered the definition of new concrete mixes in close collaboration with a concrete manufacturer and with TECNALIA, ACCIONA Infrastructure is able to provide concrete parts for both structural and non- structural applications including either up to 50% by weight of coarse recycled aggregates from processed concrete waste or 100% by weight of coarse mix recycled aggregates, thus partially replacing naturally occurring primary coarse aggregates towards increased environmental sustainability and preservation of natural resources. Thereby, ACCIONA Infrastructure is able to coordinate the whole supply chain that is necessary for that purpose, which encompasses demolition, concrete ready mix manufacture and C&DW sorting as well as treatment aimed at recycling.

High-grade recycled concrete applications and thus the related ACCIONA integrated service could be first exploited in those markets in which there is the highest attention especially toward those building certification programs that grant a benefit to the use of sustainable materials or the recycle of C&DW through a return in terms of credits for the certification. Since such credits are particularly involved in the LEED (Leadership in Energy and Environmental Design) certification, countries in which the LEED certification program is mostly applied were regarded as potential target markets. At the same time high-grade recycled concrete applications and thus the related ACCIONA integrated service could be deployed in those markets which offer appropriate C&DW recycling infrastructure in place that is capable to supply enough recycled aggregates to satisfy the potential demand of the market. As a result of the market analysis carried out, among the potential target markets identified by the above described approach, countries with highest opportunities are represented by Spain, which is ACCIONA's domestic market in which thus a high market penetration can be envisaged, as well as Poland, where the company already has an established market position. Interesting opportunities may be also found in Germany, the United Kingdom and France, where ACCIONA has not been present at the construction market yet.

Being at the downstream end of the supply chain and as a construction company delivering engineering and construction services, ACCIONA Infrastructure is the customer interface and the only player in the value network that has the capability to promote the new practice in the construction market and thus pull all other actors of the network towards the potential new market opportunity. Accordingly, ACCIONA Infrastructure will have to promote the use of recycled aggregates into its new building and construction projects. This can only be done by exploiting the conventional channels that are characteristic of the construction sector, meaning public procurement tenders in the case of public entities as well as bid procedures launched by private actors, and proposing the use of recycled aggregates within the applications for tenders or bids prepared by the company. Nonetheless, massive use of recycled aggregates in concrete requires that the supply of such secondary raw materials is secured in adequate qualities and at reasonable price on one side, and on the other side that the concrete is produced according to well defined specifications. This requires that the recycled aggregates are processed by processing centers at the required specifications in terms of particle size as purity. Additionally, massive use of recycled aggregates in high-grade concrete applications will also require that such applications of secondary aggregates prove to meet adequate quality standards. Accordingly, quality protocols would need to be established, conforming to standards and specifications in the same way as it is the case for concrete applications utilizing natural aggregates.

SELECTIVE DEMOLITION OF AN INDUSTRIAL BUILDING: ONSITE RECYCLING AND USE OF RECYCLED AGGREGATES IN CONCRETE MANUFACTURING (CASE STUDY CS1-A, BILBAO, SPAIN)

The objective of this case study was to demonstrate the on-site recycling routes for the stony fraction composed of concrete and masonry oriented towards the use of the derived recycled aggregates in on-site and off-site concrete manufacturing. The works performed by Derribos Petralanda included selective demolition of an industrial building dating from the 1970s, located in an urban environment in the city of

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Bilbao (Spain). After checking that no elements can be recovered for reuse, non-stony waste streams (plastics, paper, etc.) were separately collected and removed from the work-site. Then the mechanical (light followed by heavy) demolition was performed, generating stony material of customized composition for the latter concrete manufacture, based on concrete aggregates or mixed recycled aggregates with fixed ceramics content, according to formulations.

Those stony wastes (concrete, ceramics) were recycled on-site by means of a mobile crusher and sieves, producing coarse and fine recycled aggregates which were characterized and validated by TECNALIA. More specifically, coarse aggregates of three compositions (100% concrete, 80% concrete and 20% ceramics, and 100% ceramics) were produced, as well as ceramic (0/6 mm) sand.

These recycled aggregates were used for the on-site and off-site manufacture of a range of concretes, on the basis of formulations validated within IRCOW, based on the use of 100% coarse mixed recycled aggregates (with up to 35%of ceramics) and also including a concrete with 10% inclusion of ceramic sand. A continuous footing and a slab were constructed using these concretes. Workability and compressive strength of the produced concrete were validated. Monitoring of the concrete slab did not reveal any evidence of damage after almost two years from its construction.

LCA studies showed that the combination of a selective demolition and off-site sorting gave the highest environmental benefit.

5.2 Cluster meeting and synergies with EU- funded projects

Acciona Infrastructures, the FISSAC project coordinator, was invited to participate in the Clustering and Networking event 'Boosting synergies on EU WASTE' organised by the Executive Agency for Small and Medium Enterprises (EASME) on December 8th 2015. The meeting was organized for projects from the H2020 Waste 2014 call "A resource to Recycle, Reuse and Recover Raw Materials" to promote the transition towards a near-zero waste society by boosting innovative, systemic, environmentally friendly and cross-sectorial waste prevention and management solutions, in order to reduce environmental depletion, impacts on health and Europe's dependency on the import of raw materials, and to reinforce its position as a world market leader.

The EASME invited to the event representatives from several related on-going and completed FP7, CIP Eco-innovation and LIFE projects, beneficiaries from SME Instrument, representatives of the SPIRE PPP, EIP Raw Materials, EIT KICs on Climate and on Raw Materials, Enterprise Europe Network and European Commission services from DG GROW, DG RTD and DG ENV. With a view to making synergies happen and to accelerate knowledge exchange.

13 Grant Agreements have been signed under the H2020-2014 Waste-1, Waste-3, Waste-4 and Waste-5 topics and actions have / are about to start in 2015. Importantly, H2020 waste and raw materials actions are fully in line and contribute directly to the Europe 2020 Strategy for smart, sustainable and inclusive growth in particular the flagships Resource Efficient Europe, Industrial Policy for the Globalisation Era and Innovation Union as well as other key policy initiatives such as the Resource Efficiency Roadmap, the 7th Environment Action Plan, the European Industrial Renaissance, the Raw Materials Initiative and the European Innovation Partnership on Raw Materials, the European Innovation Partnership on Water and the Circular Economy Package.

The proposed joint kick-off and networking meeting is considered an effective approach for ensuring the streamlining implementation of these actions funded by H2020 programme and the new knowledge generated by them thus maximizing their impact.

It was expected that this meeting would facilitate the collaboration and knowledge sharing among project beneficiaries and contribute to the exploitation of synergies for more effective project implementation. In addition and considering the agenda planned, further interaction at sectorial level and in the field of stakeholders' engagement, communication, business models and exploitation of results, is foreseen.

The main objectives of this joint kick-off and networking meeting were:

- Share knowledge and experiences that will enhance the creation and exploitation of new knowledge, ensure wider applicability of the project results in a synergetic way and reduce unnecessary duplication of efforts with on-going and past projects;
- Provide participants with good understanding of the content of the other projects of different Waste topics from the same call, thus facilitating identification of commonalities and the potential co-ordination/collaboration on certain activities;
- Foster better understanding between H2020 projects and other EU instruments or networks of potential interest;
- Improve the efficiency and effectiveness of the actions' lifecycle.

This intends to bring the impact maximization of the projects which include:

- Significant increase in European and global market up-take and replicability of eco-innovation solutions contributing to an important reinforcement of the eco-industry landscape in Europe in support to the implementation of SPIRE PPP Roadmap.
- Conversion of wastes or raw materials not currently exploited into valuable resources, in line with the objectives of the EIP on Raw Materials.
- New market opportunities for European businesses and facilitation of exchange of information and increased knowledge.
- A more integrated community of innovators and entrepreneurs in line with EIT KICs dealing with Circular Economy and Raw Materials.
- Leverage of additional R&I investment and identification of new markets in the area of waste and resource efficiency.

The one-day meeting was divided into five sessions looking for maximizing the exchange of information: i) Setting the scene from H2020 Work Programme ii) contributions and benefits to build up synergies from H2020 Waste projects iii) Networking and pitch session, iv) two parallel round table-sessions to identify potential synergies and collaboration grounds among projects and initiatives and v) eco-innovation towards Circular Economy.

The synergies identified among the projects participants are mainly in the areas of knowledge sharing, communication and dissemination, stakeholder engagement, business models and exploitation of results. Related actions were agreed upon.

Furthermore, the Waste projects took lessons learned from the on-going and past projects represented and identified ways to transfer knowledge. Several actions on creating synergies and networking among all projects, and linking actions to the EU instruments were also defined.

The event succeeded at facilitating the collaboration and knowledge sharing among project beneficiaries and EU instruments boosting synergies for effective project implementation and coordinated results looking for maximizing their impact and better support EU waste policies in the transition to a Circular Economy. In this context, it was presented the Circular Economy package adopted on 2nd December 2015 and the H2020 2016-2017 Work Programme which includes a new Focus Area on 'Industry 2020 in the Circular Economy' .

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The meeting was overall very positively perceived and gathered 61 participants who made constructive recommendations and requested that meetings of this type recur in the future.

The H2020 projects on Waste were presented in four different thematic panels based on potential contribution to build up synergies: stakeholders' engagement; communication; business models; exploitation.

The event produced different outcome during the several sessions organized, namely the Networking Session and the Round Tables on potential synergies and knowledge exchange.

The projects and initiatives were grouped in four sectors to facilitate discussions: Construction & building sectors; industrial sectors; WEEE & raw materials sectors; urban mining.

The session started with the pitch presentations of the Climate-KIC start-up PENDULA and the SME Instrument beneficiary ECOSHEET-PRO. This helped to create the networking environment around the previously mentioned groups:

For the Construction & building sectors in which FISSAC was represented, several potential actions were identified during the discussions between the participants on this networking group (CB to reference the actions):

CB1. H2020 Waste-1 projects BAMB and HISER: collaboration on the list of materials and on the BIM for selective demolition
CB2. H2020 Waste-1 projects BAMB and FISSAC: collaboration on the development of "Living Labs"
CB3. H2020 Waste-1 project FISSAC and EIT Climate-KIC start-up PENDULA: common identification of technical solution to access materials; collaboration on complementary software.

The aim of PENDULA is to develop an Online Waste Management Eco-System as there is a lack of sustainable, efficient and competitive waste management solutions. They leverage technology to create an online disruptive total waste management solution for commercial and industrial sector waste generators and recyclers.
This online eco-system allows waste generators to tender their contracts for the most competitive waste management services, monitor waste metrics, and monetize valuable materials more efficiently.
It also enables recyclers to access larger quantities of valuable waste materials, secure new business and efficiently manage transactions.

CB4. H2020 Waste-1 project BAMB and EIT Climate-KIC: collaboration on urban transition, building technology acceleration and exploitation & dissemination of results.

CB5. H2020 Waste-1 project BAMB and EIT Climate-KIC start-up PENDULA: common collaboration on materials quality (materials passports), market identification for reuse and identification of buyers.

CB6. H2020 Waste-3 project CLOSEWEE and EIT Climate-KIC: collaboration on partnerships for their waste platforms.

CB7. H2020 Waste-1 projects and EIT Climate-KIC: common collaboration with start-up PENDULA to increase commercialization of waste recycling in the EU; to evaluate potential interests and/or synergies with Climate-KIC SPS Theme and BTA Flagship.

Outcome from Round tables and Synergies identified:
The potential synergies and knowledge exchange discussed among the participants of these round tables addressed the following questions:

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- Which of your activities and tasks could benefit from collaboration with other projects/initiatives?
- What are your strengths and available resources that can be useful to share with other project beneficiaries and what are your needs that other projects might be able to meet?
- How can you establish collaboration among yourselves in the next two years and beyond and what form should this collaboration have?

Round Table II – Discussion on identifying synergies and collaboration among Waste projects and EU Instruments:
The potential synergies and knowledge exchange among the following projects and initiatives was discussed in this roundtable:

- H2020 Projects: CABRISS, RESYNTEX, FISSAC, BAMB, RESLAG, IMPACT PAPER-REC, MSP-REFRAM
- FP7 projects: ILLUMINATE, REECOVER
- CIP Eco-Innovation (EASME)
- SME Instrument (EASME) and beneficiaries ECOSHEET-PRO
- SPIRE PPP
- EIT Climate-KIC, pathfinder project PECREST and start-up PENDULA

Actions identified (S to reference the synergy):

S3. Education: EIT Climate-KIC, SPIRE PPP and H2020 projects on waste to explore common interest on education activities for their communities (i.e. masterclass on business model development for waste recycling industry).
S4. Innovation: EIT Climate-KIC and EASME to identify a concrete example of complementary projects from WASTE portfolios, looking for maximizing impact of their actions thanks to the synergies in place.
S5. SMEs: networking session to be organized following the SPIRE PPP workshops organized with SMEs to increase awareness about the synergies of the SMEs in the waste industry with different instruments such as the SME instrument, Climate-KIC and SPIRE.

Commitments:
Co3. Climate-KIC/EASME to discuss on possible masterclass on exploitation and business models for H2020 projects on Waste to be co-organized in 2016 Q3.
Co4. Climate-KIC/PPP SPIRE/interested H2020 projects on WASTE meeting, to further discuss potential opportunities for collaboration on single topics, education and start-ups.
Co5. SPIRE/Climate-KIC/H2020 SME Instrument meeting, to further discuss the opportunity to organize a networking session with SMEs and start-ups from waste industry.

Conclusions and Network Actions
The meeting gathered 61 participants representing different projects, initiatives and instruments. The meeting was considered to be very successful in achieving its objectives.

The potential actions from which projects could contribute or take benefits from/to other projects have been identified in the areas of stakeholders' engagement, communication, business models and exploitation.

The specific identified synergies in this first meeting among FISSAC and the other research projects and initiatives (BAMB, start-up PENDULA) will be further analysed. The aim is to see if it is possible to establish collaboration among these projects and benefit and reduce unnecessary duplication of efforts.

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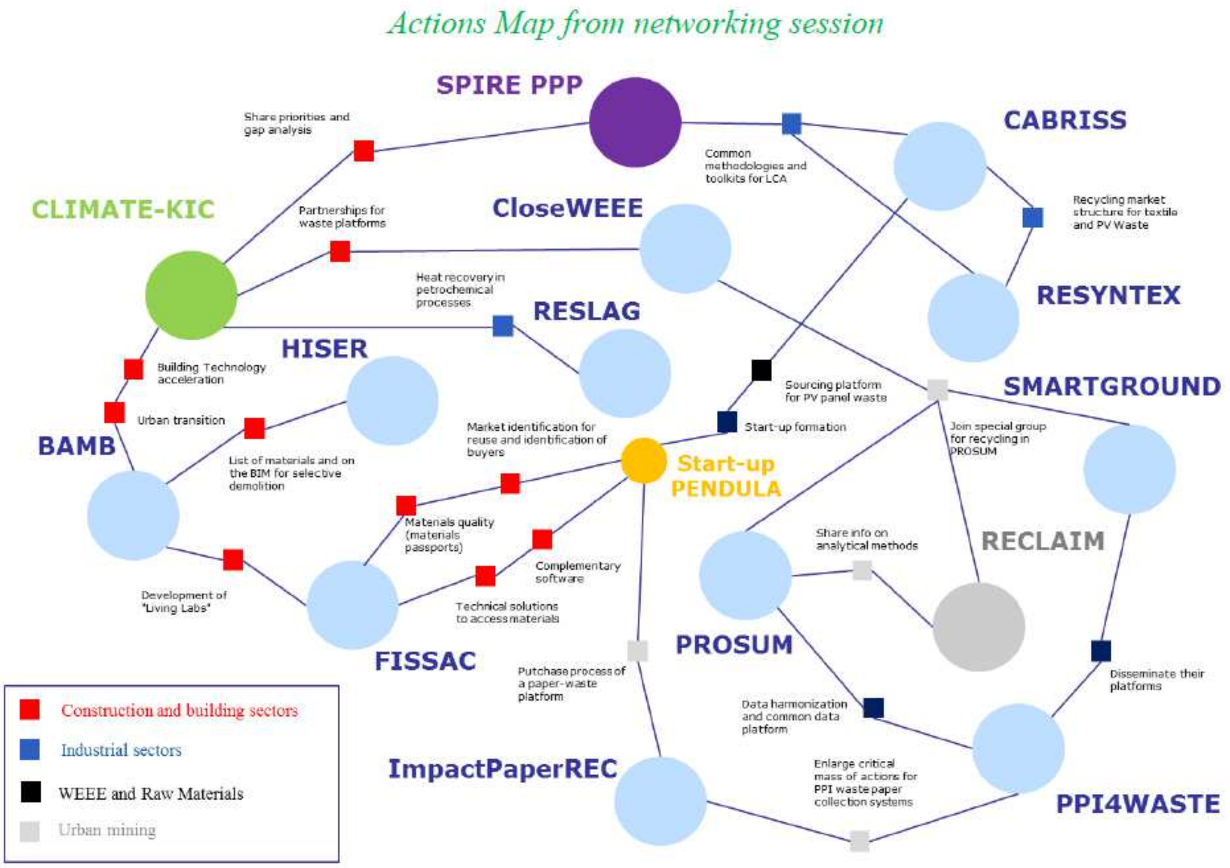
Figure 21- Network actions identified among H2020 projects on waste within the four thematic sectors



6. Review of ICT tools

6.1 Introduction

The scope of an IS network is creating synergies between industries to valorize waste flows leading to environmental, social and financial benefits. Most important outcomes are the avoided burdens in terms of final disposal (landfilling), better use of resources, energy efficiency and moving forward towards a circular economy. IS networks should establish resource exchanges to facilitate recycling and reuse of industrial waste and establish sustainable value chains. They may bring many cross-sectorial members together, from segments of industry, generating a high number and variety of industrial waste streams with potential to be valorized. This necessitates high amount of information to be assessed during planning, design, implementation and monitoring of IS networks. Furthermore, communication of meaningful information to stakeholders, other IS networks and authorities also relies on handling of this high amount of information. In FISSAC project, an entire process has to be implemented, based on an adaptive methodology, in order to put in place innovative industrial symbiosis model between industries (steel, aluminium, natural stone, chemical and demolition and construction sectors) and stakeholders in the extended construction value chain. To this end, ICT tools can support IS efforts immensely. The following detailed discussion aims to analyze previous IS ICT tools based on fundamental functionalities. This discussion provides a basis for the vision and system requirements of the FISSAC IS platform to be developed under WP6.

6.2 Previous ICT tools and brief definitions

Brief definitions of existing IS tools is presented in ANNEX and summarized form is listed in the Table 3, followed by a discussion of these tools for industrial symbiosis in Section 7.

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Table 5- Description of IS tools

ICT Systems for Industrial Symbiosis				
Systems Studied	**Status**	**Availability**	**Year**	**Description**
Knowledge-Based Decision Support System (KBDSS)	Completed	None	1996	KBDSS was developed to identify opportunities for reuse, co-treatment, recycling, and disposal of wastes from industrial facilities. The system was tested on four industrial plants in Trinidad which processed gas and steel and produced fertilizer and methanol.
Designing Industrial Ecosystems Toolkit (DIET)	Cancelled	Public, reportedly unusable,requires MS Office 95	1996-1999	DIET system developed to overcome the tacit knowledge challenge through an extensive rulebased expert system. Attempting to codify more tacit knowledge with this approach is less than elegant and can quickly balloon into a seemingly inexhaustible and arbitrary alchemy of rule-based methods.
Industrial Materials Exchange Tool (IME)	Cancelled	None	1997	The IME was intended to aid in the identification and analysis of so-called "byproduct synergies" unlike the most of other tools.
Dynamic Industrial Materials Exchange Tool (DIME)	Completed	None		DIME integrated IME and dynamic model to evaluate economic,environmental, and social implications of ethenol,natural gas fuel,and transportation systems,along with their effects on primary and secondary industries.
MatchMaker!	Completed	None		Match Maker adapted the IME model to a relational database with a standardized material taxonomy coupled with the SIC codes.
Industrial Ecology Planning Tool (IEPT)	Completed	Source code available, requires ArcView GIS	1998	IEPT provides material reuse model that identifies cost-optimal water reuse scenarios by integrating linear programming optimization with a visual GIS map based framework.
WasteX	Cancelled	None	2001-2005	WasteX was clearly differentiable from other waste exchanges and performed a deliberate attempt to catalyse industrial symbiosis through a waste exchange advertising marketplace.
Industrial Ecosystem Development Project (IEDP)	Cancelled	None	1997-1999	IEDP gathered data from 182 facilities and the database was compiled by using company-specific data, which was stored in the GIS module.The project quickly resulted in at least 3 implemented partnership exchanges.
Residual Utilization Expert System (RUES)	Completed	Available to the original project funding organizations,		RUES was created to evaluate industrial residuals as sources for road construction material. RUES is narrow in scope compared with other systems surveyed.
Institute of Eco-Industrial Analysis Waste Manager (IUWAWM)	Operational	Reporting software—purchase and demo available over the web; under development	1996	IUWAWM included an environmental management network tool (Waste Manager) to standardize waste data using European waste codes, and GIS and logistics optimization tools (Waste Analyzer) to assess waste disposal and recycling.
Industrie et Synergies Inter-Sectorielles (ISIS) and Presteo	Operational	In use by the developer	2001	Presteo tool was developed to make ISIS database accessible to non-expert users. This tool is a web interface of ISIS based on input-output matching system and use GIS to find geographically proximate companies with similar codes in system.
SymbioGIS	Operational/ continuous development	In use by the developer	2006	SymbioGIS stores and utilizes data from input-output analysis, and literature review to document and detect potential exchanges and service sharing in a given region. A GIS interface allows the visualization of potential exchanges and facilitates technical and geographical feasibility assessment.
Core Resource for Industrial Symbiosis Practitioners	Operational	In use by the developer and select partners	2005-2006	CRISP platform aims to share best practices and provide advices for companies. Communication between regional offices proved to be challenging, consequently and create to enable relationship management, synergy management, data collection and

(CRISP)				reporting, communication and collaboration through a single internet portal.
SYMBIOSIS	Completed	Not available on web	2010	SYMBIOSIS platform was created to develop a tool enabling companies share resources (materials, energy products, water, services and expertise). It offers some operational tools (regulation and BAT databases, quick LCA and Ecodesign tools, etc.) to companies and stakeholders .
e-Symbiosis	Not completd	Not available on web	2014	e-SYMBIOSIS presents an IS ontology design. The matching is enabled by calculating the similarity of two resources. The similarities are determined upon tacit and explicit knowledge and also carries out environmental assessment considering embodied carbon, environmental impacts of energy consumption, transportation impact, landfill diversion and virgin material saved and aggregating these different impacts by means of a weighing function.
C2CBIZZ tools	Completed	Available on the web	2009-	Cradle to Cradle is an innovation platform which has six modules in total that can be selected independently according to specific needs of users for generating positive impacts by improving the quality of products, systems and services.
USBCSD	Completed	Available on the web	2013-2015	The software allows users to post available or desired material, help identify reuse opportunities, negotiate and exchange underutilized materials and also provides detailed reports on savings or environmental benefits, producing bug reports, and monitoring transaction progress closely by project team.
ZeroWIN	Completed	Available on the web		ZeroWIN waste prevention tool gives the possibility to compare the effects of different waste prevention measures in three different industry sectors. User can define specific systemsettings and choose between several waste prevention options.
Looplocal	Completed	Not available on web	2012	Looplocal tool is a strategic matching tool for supporting regional resource transfers and works with data sources and compares industrial symbiosis data and estimated material and energy flows (on a facility level) to identify potential IS transfer information along key stakeholder and network .
Material Input per Service Unit (MIPS)	Completed	Available on the web		MIPS is an elementary measure to estimate the environmental impacts caused by a product or service. The whole life-cycle from cradle to cradle (extraction, production, use, waste/recycling) is considered and it can be applied in all cases, where the environmental implications of products, processes and services need to be assessed and compared.
COMETHE	Completed	Not available on web	2007	In COMETHE project, five pilot studies were carried out to design a methodology and tools for the implementation of industrial ecology approaches on a business park scale involved.
EPESUS	Under developme nt	Being developed	2012	EPESUS software is capable of providing material and energy flow analysis which is linked to life cycle assessment based on ISO standards. Data inquiries are possible on plant or industrial park level and on waste stream basis. Furthermore, EPESUS allows for scenario analysis where results for individual cases can be compared against benchmark values.

[61]

[61] Two more IS ICT tools were identified but no further evaluated due to time constraints: Green Book Live (http://www.greenbooklive.com/) is a free to use online database designed to help specifiers and end users identify products and services that can help to reduce their impact on the environment. DRIDS (Demolition and Refurbishment Information Database) http://nfdc-drids.com/ provides information on removal processes, waste management, segregation&storage, H&S legislation etc.

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6.3 Definitions of assessment criteria and functionalities

The ICT tools introduced in the previous section were evaluated according to their functionalities. These functionalities or assessment criteria were identified according to a 3-level structure (Figure 22). In the process based scheme of these tools, five general areas of interest were identified by Grant et al (2010).

1. Opportunity identification,
2. Opportunity assessment,
3. Removal of barrier for realization,
4. Commercialization,
5. Documentation and publication.

These five areas were set as the top level criteria according to which past IS tools were evaluated. Later, top level categories were elaborated in terms of more specific functionalities and lower levels of criteria were introduced based on the literature survey carried out.

Definitions for each functionality are provided in the following discussion:

6.3.1 Opportunity Identification

The initial step to realize IS relations is to identify the possibilities that would lead to establishment of waste exchange and utilization practices. Matching is the core activity required under all approaches for opportunity identification. Main idea is to bring company that can benefit from waste exchange together. To identify opportunities, one may make use of the following:

New Process Discovery

A process can be defined as any activity or operation, which transforms a waste/by-product into a usable resource. New process discovery functionality entails identification of a novel approach that leads to this kind of activity.

Material and energy input – output (I/O) data can be defined based on a unit process occurring within a manufacturing chain or the whole chain as a system (**Process based input/output (I/O) definition – 1.1.1**). This approach allows integration of I/O data into material flow analysis (MFA) or life cycle assessment (LCA) methodologies.

In order to determine a reusable product, the system can screen all available unit processes to match a by-product flow with all input flows entering unit processes. Definition of waste or by-product flow as an input to a process indicates its potential to be valorized within a value chain (**Path finding between flows – 1.1.2**).
Reference Documents on BATs (BREF) list many possible techniques for cleaner production and can be used to identify IS opportunities (**Best available techniques (BAT) – 1.1.3**).

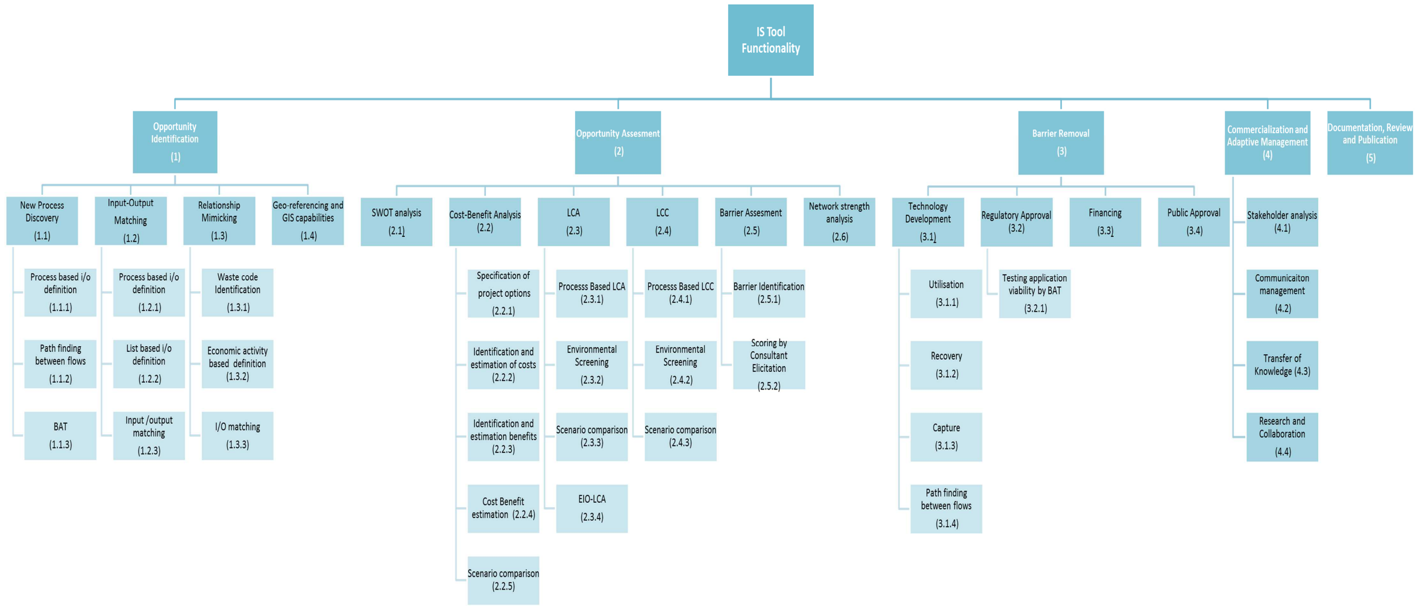

Figure 22- The functionality tree used for the assessment of IS ICT tools

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I/O Matching

I/O matching is very similar to path finding between the flows explained under new process discovery in that it aims to reveal the possible interacting processes through waste exchange. As a software tool functionality, the difference between these two is how this possible interaction is detected. Path finding requires directional flows to be defined between unit processes, whereas, I/O matching relies on list based comparisons. For this purpose, the initial step is **the process based I/O definition (1.2.1)** to be put together in the form of lists (**list based I/O definitions – 1.2.2**). Next, the I/O lists for various unit processes are checked against each other to find matching flows (**I/O matching – 1.2.3**).

Relationship Mimicking

Relationship mimicking use success stories to identify and replicate IS opportunities. This functionality again requires modelling of the past IS relations on a unit process basis. However, in this case, it may not be possible to determine every I/O flow of existing companies and IS networks. Here economic activity codes and 6-digit waste codes can provide a common basis for the matching process. Every company involved in a success story can be assigned to the proper economic activity code (NACE or ISIC etc.) (**economic activity based facility definition – 1.3.1**) and waste streams involved in symbiotic flows can be identified in terms of waste codes (**Waste code matching – 1.3.2**). Waste code matching can be combined with NACE codes to obtain the list of wastes originating from each sector as well as the wastes that can be utilized in every sector (**I/O matching – 1.3.3**).

6.3.2 Opportunity Assessment

Following identification of opportunities, next step in establishment of operational IS network is to assess the possibilities. The practices should not only result in good waste management but also pave the way to good business opportunities for strong IS networks to develop. Therefore, techno-economic feasibility criterion is as important as environmental sustainability under opportunity assessment.

SWOT analysis

SWOT analysis is an analytical tool to identify internal strengths and weaknesses as well external threats and opportunities of a company, a venture or a project (SWOT Analysis, 2015). SWOT analysis can be used in the course of opportunity identification so as to see whether strengths and opportunities related to that activity outweighs the weaknesses and threats. Furthermore, SWOT can be utilized to increase the chance of success of an IS project by utilizing weaknesses and threats to identify the barriers to the project and eliminate them.

Cost-benefit analysis (CBA)

CBA is the exercise of evaluating a planned action by determining what net value it will have for the beneficiaries [62]. CBA entails elaboration of all the beneficial outcomes of a project or investment and all costs associated with the project. For a project or an investment to be approved its benefits should outweigh the costs. Therefore, positive monetary balance at the end of a project is in the core of CBA. However, CBA may be misleading when environmental benefits or a decrease in human mortality is achieved as an outcome since it is often hard to determine the monetary equivalence of ecosystem health or human life. Still, CBA is an important tool for establishing financially mutualistic relations between IS members.

[62] http://www.inc.com/encyclopedia/cost-benefit-analysis.html

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CBA can be carried out for a single activity or maybe utilized to compare different alternatives. If comparison is involved, CBA starts with specification of the project options, which can be obtained at the end of opportunity identification stage (**Specification of project options – 2.2.1**). Next the costs and benefits of the IS opportunity is identified and estimated (**Identification and estimation of costs and benefits – 2.2.2 & 2.2.3**). Following step is to check whether there are more benefits than the costs for a given activity (**Cost-benefit estimations – 2.2.4**). When multiple activities are assessed, cost-benefit scores can be compared to each other to determine the most profitable option (**Scenario comparison – 2.2.5**).

Life cycle assessment (LCA)

LCA is determination of environmental impacts of a process, product or a service over their life cycle. Here, life cycle implies all the processes from raw material acquisition (cradle phase) all the way to end-of-life (grave phase). It also covers manufacturing and use phase in between. LCA brings a holistic approach with the way it handles entirety of the functional system and ability to evaluate a broad range of impact categories. Furthermore, owing to its inclusive scope definition, LCA can identify cross-media effects of cleaner production activities and benefits at a cross-sectorial level, which are two important aspects to be consider in case of IS relationships.

LCA can be carried out at different levels of detail depending on the requirements of the project at hand. A full LCA ideally covers all the processes from cradle-to-grave and all relevant impact categories (**Process based LCA – 2.3.1**). Sometimes due to limited data availability or LCA being executed as a preliminary assessment, LCA can be streamlined or a screening assessment can be made (**Environmental screening – 2.3.2**).

LCA quantifies environmental impacts based on relevant indicators and results in impact values, which may seem arbitrary to general audience. It becomes a more powerful tool when used for comparisons (**Scenario comparison – 2.3.3**). These comparisons can be based on emission limits, benchmark values, environmental targets or IS options obtained during opportunity identification.

One specific type of LCA uses economic flows between sectors instead of material and energy flows and termed as **economic I/O LCA** (**2.3.4**)

Life cycle costing (LCC)

LCC incorporates certain aspects of CBA and LCA. It can be defined as the determination of all costs of a product, process or a service over its life cycle. The main difference between CBA and LCC is that LCC reflects the life cycle approach like LCA and includes costs originating from every process. By this way LCC is capable of identifying hidden costs better than CBA. Furthermore, environmentally favorable options can be prioritized in LCC by utilizing environmental hurdle approach or similar techniques.

LCC can be carried out using the process based I/O data (**Process based LCC – 2.4.1**) or at a **screening** level (**2.4.2**). LCC can also be utilized for comparison purposes (**Scenario comparison – 2.4.3**).

It is important to note the costing for each step and attribute costs and benefits to all partners in the value chain. This can serve as a basis for a system of (voluntary) repartition within the value chain.

Barrier assessment

Barrier assessment is one of the most crucial elements of the opportunity assessment. Proper identification of technical and non-technical barriers of IS systems on a case-basis supports establishment of stronger IS networks. Barrier assessment identifies challenges to realization by assessing market, political, social, environmental, financial, and technical feasibility. Results of SWOT analysis, CBA, LCA, and LCC can provide

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valuable input to the barrier assessment step. This assessment should include **barrier identification** (**2.5.1**) as well as **consultant elicitation** (**2.5.2**) due to interdisciplinary nature of the barriers.

Network strength analysis

This step aims to evaluate the performance of an IS network in as early as design phase. Network strength analysis can be extensive as it takes the number of IS connections made, potential benefits in terms of material flows, the extent of mutual benefits etc. into account. It translates these aspects into index scores and indicators including reciprocity (mutual benefits for all cooperating members in an IS network) and centrality (indication of a company's position in a network – direct centrality- and its measure of influence and ability to pass on information – betweenness centrality).

6.3.3 Barrier removal

Barrier removal is a continuous process, which starts at the design phase and goes on during operation of the IS network, in order to maximize long-term benefits. Various barrier removal methods targets different aspects to overcome the bottlenecks.

Technology development

Technology development aims to set up new processes to overcome technological barriers and provide better utilization of wastes. These may include pilot implementation or small-scale production to provide proof of concept prior to full scale implementation. **Utilization** (**3.1.1**), **recovery** (**3.1.2**) and **capturing** (**3.1.3**) technologies can be considered during this step. In order to maximize material and energy efficiency, technology development efforts can benefit from path funding functionality to identify suitable I/O flows (**Path finding between flows – 3.1.4**).

Regulatory approval

Whenever applicable, all necessary permits should be obtained before IS networks become operational. This may include waste transportation or IPPC permits. Although ICT tools can provide limited support for obtaining permits, they can provide guidance based on assessment of BATs (**Testing application viability by BAT – 3.2.1**).

Financing

Even if environmental benefits of IS connections are apparent, financial issues may prevent companies to move forward with waste exchange. Especially CBA and LCC can aid companies to analyze their economic benefits or devise alternative financial strategies to initiate IS networks.

Public approval

Lack of public acceptance may delay companies to get involved in reutilization of waste for different purposes. Results from all the robust methodologies that analyze costs and benefits of IS relations at opportunity assessment step can be conveyed to public to increase the level of public acceptance.

6.3.4 Commercialization and adaptive management

Commercialization process starts from opportunity assessment then go to basic and applied research with creativity which results innovation. Technology analysis, researching process and informing stakeholders (support community) can be key aspects of a commercialization process.

Stakeholder analysis

Stakeholder analysis includes identification of all the parties that may be effected by the IS network operation and also all parties that have the capability to influence the design, approval and operation. Stakeholder analysis should list all the related individuals, groups or organizations including vulnerable groups and media. Then stakeholders should be categorized by the level of impact they receive from the IS project and level of influence they may exert on the project. Stakeholders can be grouped into four categories as (i) high influence/high impact, (ii) high influence/low impact, (iii) low influence/high impact, and (iv) low influence/low impact.

Communication management

Communication strategies can be set for different stakeholder categories according to their level of involvement during design and operation of the project. High influence- or key stakeholders such as authorities may be involved more or informed more frequently compared to low influence/low impact stakeholders. In addition to stakeholder communication, internal communication within IS members is another issue to be addressed. An IS ICT tool can support participant communication through analysis and dissemination of KPIs, which can be obtained through various analysis carried out for opportunity assessment. Network strength indicators, in particular, should be monitored on a regular basis and communicated to key stakeholders and IS network members.

Transfer of knowledge

Another important aspect of establishing a well operating IS network is to analyze previous and current IS experiences both in terms of their success and failures. For this purpose, these case studies should be translated into the KPIs and network strength indicators. Such a database can be used as a benchmark to analyze current situation of the IS network. This approach can also be valuable in terms of sharing knowledge among existing IS networks.

Research and collaboration

This aspect of the ICT tool is closely related to the transfer of knowledge. The analysis results of the IS networks not only should support good management practices for the IS networks but also should pave way to innovation and research. The KPI and indicator database should support this task.

6.3.5 Documentation, review and publication

All the analyses results should be well documented and reviewed periodically by IS management. In industrial symbiosis community, documentation and publication step is important for develop innovations and diffuse in community.

Many industrial companies established quality assurance systems (QAS). To handle all exchanges between participants' technology, waste and knowledge as well as all these synergies' becomes a part of already existing QAS. Therefore, system documentation and publications become more of an issue since a sound documentation management system and monitoring of KPIs are required by QAS. It also provide to support and promote to stakeholders' quality management system for working integrated zero waste philosophy in ecocycle.

6.4 Analysis of the previous ICT tools and their limitations

Current lack of availability of is one of the common major shortcomings of the ICT tools. Unfortunately, due to limited excess to the software, ICT tools were assessed according to first and second level criteria only. Due to this fact, assessment is mostly based on literature review or short descriptions of ICT tools. Therefore, for the ICT functionalities reviewed given in **¡Error! No se encuentra el origen de la referencia.**, a differentiation

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was made between the properties explicitly described in references and the ones implied within descriptions.

A quick overview of the results shows that a lot of ICT tools were concentrated on opportunity identification and opportunity assessment. IEPT and IEDP only targeted utilization of a single type of waste, industrial wastewater and waste slag respectively. Most common functionality is I/O matching based on I/O lists. One of the main shortcomings of simple list matching such as in the case of WasteX is to harmonize or standardize waste exchange classes (Lombardi and Laybourn, 2007). For this purpose a common scheme such as 6-digit waste codes of European List of wastes is necessary. IUWAWM followed this approach.

Among the ICT tools, the most advanced matching capabilities are provided by eSymbiosis. Here, matching process is carried out on the basis of the properties (type of resource, quantity of resource, pattern of supply, availability, location) compared against descriptions created by the users. Under this tool, semantic matching allows for suggestive coupling; when an exact solution is not identifiable, solutions proven for similar types of resources are identified. These choices are presented to the user as suggestions with reports of their semantic similarity. The approach also allows for partial matching in cases where the registered industries satisfy the request only partially. Apart from direct matching, eSymbiosis points out to cases where direct I/O relationship is impossible without prior prepossessing of output from the source through enabling technologies (chain matching). This functionality expands direct matching between two industries by introducing additional participants. eSymbiosis also performs “resource decomposition” when certain types of resource can be separated into smaller streams that can be processed in parallel (Trokanas et al, 2012).

DIET, MatchMaker!, IEDP, Presteo, SymbioGIS included relation mimicking. Only two tools (KBDSS and IUAWM) included new process discovery or matching through modelling of unit processes through identification of directional flows. Matching through pathway finding can be an invaluable functionality as it is fundamental to important analyses including MFA, LCA and LCC. For this purpose, EPESUS software utilizes a combination of pathway finding and I/O lists. EPESUS users are able to see the I/O tables at different level of complexities (unit process, facility, and eco-industrial park). I/O flows are also used to create process models where origin and destination of each flow is known in terms of the unit processes within a manufacturing process. Through this ability, the flows within the technosphere and exchanges between technosphere and ecosphere can be differentiated, which is important for LCA calculations.

Another functionality worth mentioning is geo-referencing through GIS. GIS capabilities can provide powerful assistance for opportunity identification. Value of GIS capabilities was realized by a number of tools including IEPT, IUWAWM, Pesteo, SymbioGIS, SYMBIOSIS and EPESUS.

In terms of opportunity assessment, DIET has the extensive capabilities through LCA including EI/O LCA and barrier assessment. EPESUS can also carry out LCA according to ISO standards. Beside DIET and EPESUS, KBDSS and DIME is able to conduct LCA. An LCC module is recently introduced to EPESUS, which being utilized for cost estimation in buildings as well as manufacturing processes. Although eSymbiosis is capable of assessing environmental impacts, the impact categories are limited and weighing step causes the assessment to be subjective. Chain matching and resource decomposition properties of eSymbiosis also help user to identify the barriers. These two are the only tools that included barrier assessment in their structure. RUES and SymbioGIS carry out opportunity assessment through CBA. SWOT analysis and network strength analysis have not been covered by any ICT tools before.

Another important shortcoming of previous tools is facilitating barrier removal. According to the survey results, eSymbiosis and C2CBIZZ tools offer technological barrier removal by suggesting preprocessing requirements and decomposition of output stream. The latter also offers financial assessment and barrier removal.

Previous tools had very limited coverage on communication and adaptive management issue as well. Only SYMBIOSIS tool by ENEA differentiates from the rest of the group with its capabilities in transfer of knowledge, technological advice, and research and collaboration. CRISP also provides services under this category; however, it does not have any functionality apart from commercialization and adaptive management category. All activities of CRISP are structured around communication functionality. USBCSD Marketplace also suggested to have capabilities under this category.

No information could be reached regarding how documentation, review and publication issues were handled by the previous ICT tools.

Some tools are documented through publications and project deliverables in detail including CRISP (UK), SYMBIOSIS (Italy) and C2CBIZZ. Some tools are elaborated in web pages like MIPS, but most of them especially the older ones (KBDSS, WasteX, IEPT etc.) are explained in papers and reviews. Thus, documentation function is evaluated and given in two parts in Table 2.

Most important basic property of the functionalities on which ICT tool analysis was based is major reliance on tacit knowledge. Tacit knowledge or know-how can be roughly defined as the knowledge obtained as a result of experiences and interactions. Tacit knowledge provides underlying framework for explicit knowledge. Reliance on tacit knowledge creates challenges for collection, analysis and dissemination of data related to IS networks. These methodological challenges include:

i) Modelling range of information in relation to the supplying and receiving industries. Waste exchange requires a minimum set of data to support the exchange and the formation of a synergy.

ii) Modelling range of data that contain industrial activity within a region, different patterns, and background industrial activities.

iii) Modelling of best practice and IS experience (tacit knowledge) that reflects on technological, economic and environmental benefits from cases (Schiller et al, 2014).

The only two system known to address the challenge of tacit knowledge are DIET and eSymbiosis system. Although the operational efficiencies are not known, the limitations in the use of production rules are well elaborated. Limitations are notified in the use of higher level tacit knowledge and reuse of knowledge (Gruber, 1995).

When challenges brought by reliance of tacit knowledge are considered, communication functionalities become a crucial part of future IS tools. Currently, in absence of a complete decision support scheme, IS practice relies on manual interpretation of data in the course of face-to-face communication and case-by-case analysis by IS practitioners. For instance, CRISP contains explicit knowledge and enables symbiotic matching but proprietary and custom-based datasets are backward oriented and this creates a limitation for NISP about innovation.

New approaches toward IS and circular economy emphasize the importance of holistic approach. Absence of an inclusive and holistic approach can be considered as an important critic to all ICT tools overviewed. As can clearly be seen in **¡Error! No se encuentra el origen de la referencia.**, so far, no ICT tool was able to address all major components of IS network design, implementation and operation.

Table 6 - Summary of the functionalities of existing IS ICT tools

		KBDSS	DIET	IME	DIME	MatchMaker	IEPT	WasteX	IEDP	RUES	IUWAWM	Presteo	SymbioGIS	CRISP*	SYMBIOSIS	eSymbiosis	C2C	USBCSD Market place	ZeroWIN	LoopLocal	MIPS	COMETHE	EPESUS
Opportunity Identification	New Process Discovery	✓								❍	✓				❍			❍		❍			✓
	Input-Output Matching	✓	✓	✓	✓	✓	✓	✓	✓	❍	✓	✓	✓	❍	❍	✓	✓				❍		✓
	Relationship Mimicking		✓			✓		✓	✓	❍	❍	✓	✓			✓			❍	❍		❍	
	Georeferencing and GIS						✓		✓		✓	✓	✓		✓								✓
Opportunity Assessment	SWOT analysis																						
	Cost Benefit Analysis		✓	✓	✓		✓			❍	✓		✓				✓					❍	
	LCA		✓												❍	✓					❍	❍	✓
	LCC																						✓
	Barrier Assessment													❍								❍	
	Network Strength Analysis																						
Barrier Removal	Technology Development										✓					✓	✓	❍					
	Regulatory Approval																					❍	
	Financing																✓	·					
	Public Approval																						
Commercialization and Adaptive Management	Stakeholder Analysis														❍		✓	❍				❍	
	Communication Management													❍	❍		✓	❍					
	Transfer of Knowledge													❍			✓	❍					
	Research and Collaboration													❍			✓	❍					
Documentation	Web Pages and Reviews	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓			✓	✓	✓	❍	✓
	Publications													✓	✓		✓	✓				✓	

* Compared to the other IS tools surveyed, CRISP resembles a project and contact management suite in contrast to a design tool and separates itself by clearly demonstrating its ability to facilitate coordinated collaboration between multiple

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✓: Defines the ability which is mentioned in reviews, papers or the official web site with the function name and ❍: Defines the ability which is mentioned in publications indirectly

6.5 Vision for FISSAC ICT tool and recommended functionalities

6.5.1 Vision

The fundamental aim of the ICT Platform to be developed under FISSAC project is to demonstrate and maximize environmental, social and financial benefits of IS networks to support circular economy structure. Furthermore, the ICT Platform should facilitate formation and operation of IS networks by following the FISSAC IS Methodology.

FISSAC Software Platform aims to go beyond the existing platforms by integrating capabilities of EPESUS and GEO-CLUSTERING software and adding network analysis functionalities to assess the roles of partners within the industrial symbiosis network and evaluate the success of overall operation using social network analysis (SNA) methodologies. The FISSAC Industrial Software Platform therefore will be able to respond to resource efficiency and environmental performance concerns (by the help of LCA), logistic issues (GIS data) and support decision-making processes.

During design, implementation and monitoring of the symbiosis operations (through SNA/industrial symbiosis indicators), FISSAC will develop and demonstrate innovative processes for separating and sorting to achieve higher recovery rate.

Following the survey of previous ICT tools on IS, FISSAC ICT Platform will address the following needs for the IS:

- follow a holistic approach by employing life cycle methodologies including LCA and LCC;
- handle closed-loop and circular network structures;
- deliver support on every stage of establishment of IS networks in terms of (i) opportunity identification and assessment, (ii) barrier assessment and removal, (iii) adaptive management, (iv) communication and transfer of knowledge, and (v) documentation;
- create reusable content through SMART KPIs, network analysis indicators, eco-efficiency indicators etc.;
- become a source of information for transfer of knowledge to key stakeholders and IS community;
- handle tacit knowledge (know-how) through exploration of semantic ontologies and integrate qualitative information (SWOT, stakeholder analysis etc.) with quantitative data; and
- facilitate barrier elimination and monitoring through network strength analysis for long-term success of IS networks.

None of the previous IS tools were identified to target constructions sector in particular. FISSAC Project aims to develop an ICT platform that will enable cross-sectoral synergies in construction sector. However, the coverage of the ICT platform will not be limited to the construction sector. Rather, it will be applicable to a different value chains and will be more inclusive in terms of sectorial scope.

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6.5.2 Recommended functionalities

Holistic approach:

The survey shows that a great deal of efforts has been concentrated on opportunity identification. However, in order to create long-term IS connections, it is necessary to bring a holistic approach capable of

- analyzing the opportunities,
- assessing barriers and develop a strategy to overcome them
- providing support for network design
- assisting monitoring activities, and
- facilitating internal and external communication.

This way the IS ICT tool can provide guidance on not only initiating IS connections but also for design and monitoring to support successful implementation and operation.

Tacit information or know-how:

Tacit information provides better communication, problem-solving and coordination skills as well as a better understanding of motivations and incentives for cooperation for organizations. On a network level, tacit information offers in depth view on how to cooperate, network identity and expectations for reciprocity. Consequently, an ideal ICT tool should be able to collect, interpret and provide meaningful outputs from tacit knowledge.

Qualitative and quantitative information:

An extension of ability to process tacit information is the ability to integrate qualitative and quantitative information. Whether at opportunity identification stage or during further analyses including SWOT and stakeholder assessments, ICT tool should be able translate qualitative information into SMART (Specific, Measurable, Attainable, Relevant, Time-bound) indicators to obtain meaningful and useful results.

Case-specific and high-volume data:

IS networks are highly case-specific due to variations in waste types, waste generation amounts, logistic issues and presence of necessary sectors to receive and utilize wastes. As a result, no IS network may be the same as another, which means opportunity assessment and barrier removal activities should be carried out on a case-by-case basis. If not developed to provide solutions for a single IS case, an IS ICT tool should be able to incorporate case specific data into generic methodologies through development of proprietary databases.

ICT networks can also demand processing of high volume of data or big data especially at opportunity identification phase where many possible connections are investigated between high numbers of potential network participants. This demand may also persist at network strength analysis and monitoring phase.

I/O analysis:

One of the most fundamental functionalities of an IS ICT tool is I/O analysis. It provides basis for opportunity identification (matching) and multiple analysis under opportunity assessment (LCA, LCC and network strength analysis).

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Barrier assessment and removal:

Another important functionality for wide adoption of the ICT tool is to properly address technological, financial, environmental and social barriers. First, they need to be identified and then ICT tool should provide analytical capabilities to develop strategies to remove these barriers. CBA and LCC, LCA, SWOT and stakeholder analysis, and finally BAT support and path finding matching are powerful methodologies that can be utilized for this purpose on financial, environmental, social and technological barriers respectively.

Communication and transfer of knowledge:

For successful implementation and operation of an IS network, it is important to realize presence of bottlenecks created by lack of proper communication strategies with key stakeholders as well as among IS network members. An IS network can profit from strong stakeholder communication strategy. Accordingly, the IS ICT too should allow users to identify and analyze stakeholders based on their influence or impact. Furthermore, positive impacts of IS network can be maximized throughout the IS community by facilitating transfer of knowledge.

Support for quality management systems:

Quality management systems are already in practice in many industrial companies. Through use of KPIs and well-structured documentation, analyses carried out under the IS ICT tool should support the quality management systems.

7. Conclusions

This report serves as a first step of identifying current models of industrial symbiosis, analysing them and gradually defining the requirements of a new model to facilitate informaton exchange to support development of current and future networks. It summarises the key findings from overall sixty best practices collected from FISSAC project partners. It reviews the state of the art of ongoing industrial symbiosis projects (public and/or private partnerships) and government initiatives in Europe and abroad.

The report also provides information about the regulatory framework on waste management including technical specifications on the use of recycled materials as raw material for construction applications. Technical and non-technical barriers, risks and uncertainties which might hinder these developments but also drivers of new industrial symbiosis projects have been identified and analysed.

The role of different players in setting up industrial symbiosis networks, particularly in public private partnerships, and the long-term vision for scaling up is discussed.

In addition to this, the report provides an analysis of previous experiences and best practices on the reuse and recycling of C&DW stream in order to be integrated in the FISSAC software platform. FISSAC project representatives are working closely with other EU-funded research projects and some areas of future collaboration have been identified.

Finally, various existing ICT tools and methodologies for industrial symbiosis have been identified and extensively analysed as part of this task. The data collected will serve as input for the definition of requirements of the upcoming FISSAC software platform.

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ANNEX

Template for collecting Factsheets on Industrial Symbiosis best practices

NAME OF THE REGION (COUNTRY)/ INDUSTRIAL SITE/ TOOLS

Surface (only for region): … km²
Population (only for region): … inhabitants/firms (year)
Density (only for region): …/km²
Target audience:
Geographical area:

General information

Main web link:

Main documents (with web link):

- …

Initiators /coordinators (please specify type of actors e.g. policy makers/ local authorities etc.):

- …

Main partners (please specify type of actors e.g. policy makers/ local authorities etc.):

With the support of:

- …

With the financial support of:

- …

Future funding opportunities for Industrial Symbiosis (to be used for developing Living Labs concept, identify projects and further collaboration)

- …
-

Summary

Type of instrument:

☐	Calculator
☐	Coaching
☐	Economic measures
☐	Education and communication
☐	Guidelines
☐	Organizational measures
☐	Regulations
☐	Target setting and planning
☐	Voluntary and participative measures
☐	…

Governance/Main steps of the IS project/strategy/tool (max 4 lines):

….

Highlights

….

Description of instruments and actions implemented (max 8 lines)

…….

Regional projects or test beds for industrial symbiosis

…….

Main shared/analyzed resources:

☐	Materials
☐	Energy
☐	Water
☐	By-products
☐	Services
☐	Knowledge
☐	Networks

Results

Type of results	Description	Year
	-	-
	-	-

Lessons learnt

Main advantages:

- …

Main difficulties and/or challenges:

- …

Contacts

Overview of IS ICT tools

Knowledge-Based Decision Support System (KBDSS)

KBDS System was developed by B.W. Baetz and C.A. Boyle in 1996 for industrial parks. The system was able to identify waste treatment, reuse and disposal options. It contained a total of 25 such processes knowledge base for defining the optimal waste flow. It is not currently operational.

Designing Industrial Ecosystems Toolkit (DIET)

DIET was developed by the US EPA and Clark University in 1996. The Materials Flow Through the Community project in Massachusetts evaluated and determined it was not usable as a support tool in its current developmental stage (Grant et al, 2010). The toolkit involved three tools (i) Facility Synergy (FaST), (ii**) the Designing Industrial Ecosystems (DIET), and (iii) Regulatory, Economic and Logistic (REaLiTy).**

- **The Facility Synergy tool helped modeling eco-industrial park by defining potential resource and potential firms.**
- **The Designing Industrial Ecosystems Tool aids optimizing objectives of industrial participants and linkages by Facility Synergy Tool.**
- **Regulatory, Economic and Logistic Tool specifies the barriers through a database.**

It is reported unusable since it runs on MS Office 95 and DIET discontinued in 1999.

Industrial Materials Exchange Tool (IME)

IME was developed in 1997 and it had two modified versions; DIME and MatchMaker!. IME identified byproducts through data collection and computer analysis. The geographic scale of this tool was the city of Brownsville. IME investigated synergies among eight companies in Brownsville and four synergistic connections were implemented. In Tampico, Mexico, IME was used to identify 63 synergies of which nine passed initial assessment and were pursued. This tool is no longer available.

Dynamic Industrial Materials Exchange Tool (DIME)

DIME integrated IME and Idaho National Engineering and Environmental Laboratory's System Dynamics model to evaluate economic, environmental, and social implications of industrial symbiosis activities (Grant et al, 2010). User feedback to DIME included performing validation, unsuitability to real-life applications and lack of geo-referencing/GIS capabilities. A need for expansion in scope to include life-cycle assessment enhancement, flex fuel blends, and socio-economic "net" cost benefits were suggested (Shrosphire, 2000).

MatchMaker!

MatchMaker! was developed by graduate students at Yale as a course assignment. The aim of this tool was to standardize material taxonomy according to Standard Industrial Classification of Economic Activities (SIC), which allows uniform input from multiple users thus creating a scalable system. MatchMaker! utilized a relationship mimicking function, which relied on specific or generic data. The prototype development ended upon graduation of the student designers and no full version was released for commercial purposes; however, their work is the first to document strategies for material taxonomy and system ownership/deployment in the context of ICT for IS (Grant et al, 2010).

Project funded by the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 642154.

Industrial Ecology Planning Tool (IEPT)

IEPT was created within the context of graduate study in 1998 (Noble, 1998). It aims to support industrial water reuse at industrial park level and integrates linear programming optimization with a visual Geographical Information System (GIS) map based framework (requires ArcView GIS). In this way, IEPT provides material reuse model, identifies cost-optimal water reuse scenarios. (using linear programming). A case study, consisting of a 20 facility sample group was performed with IEPT. Although Grant et al. mentioned the tool's availability on his paper, IEPT could not be accessed.

WasteX

Main aim of WasteX, developed by a group of companies in Jamaica with the support of The Environmental Action Program of the Canadian International Development Agency, is to catalyze industrial symbiosis through creation of an online waste exchange advertising marketplace (Lombardi and Laybourn, 2007). Initial data was provided by National Solid Waste Management Program and 15 companies' waste and disposal cost data integrated. The tool, focused on outputs only, was operationally online from 2001 to 2005 (Lombardi and Laybourn, 2007).

Triangle J – Industrial Ecosystem Development Project (IEDP)

IEDP, developed by the US EPA between the years of 1997 – 1999, gathered data from 182 facilities and identified 49 unique potential byproducts exchanges involving 48% of the participants. The database was compiled by using company-specific data, which was stored in the GIS module. The project concluded that short-term action could result in partnerships for cost-effective reuse of 12 byproducts whereas 24 byproducts showed partnership opportunities and 13 byproducts did not find potential matches within the limited system of participants (Grant et al, 2010). The project was canceled before completion and the tool is not available.

Residual Utilization Expert System (RUES)

RUES was developed by the University of Alabama. The data for waste slag was organized for the purpose of environmental screening, general application analysis, and specific application analysis. This project is available to the funding organizations and requires Level5 software shell*

Institute of Eco-Industrial Analysis Waste Manager (IUWAWM)

IUWAWM was created by Institute of Eco-Industrial Analysis in 1996 in Germany. The local opportunities realized mostly involved sharing information about waste disposal methods, although a few input-output material linkages were established (Sterr and Ott, 2004). IUWAWM included an environmental management network tool (Waste Manager) to standardize waste data using European waste codes, and GIS and logistics optimization tools (Waste Analyzer) to assess waste disposal and recycling. This software can provide results (recycling methods, symbiosis opportunities, etc.) at a regional level. Although any company can purchase the Waste Manager software, analysis and optimization tools are under development. Users need a network of geographically proximate participants to most effectively utilize the Waste Analyzer (Grant et al, 2010).

Presteo

Presteo tool has developed by Durables Ltd. to make (ISIS (Industrie et Synergies Inter-Sectorielles) database* accessible to non-expert users. This tool is a web interface of ISIS based on input-output matching system and use GIS to find geographically proximate companies with similar codes in system It uses a facilitator interaction model which resembles a developing knowledge network. The State and Republic of Geneva in Switzerland has been using it since 2006 with an expanding network of currently 31 companies and identified 17 potential synergies so far. Presteo is also used in four industrial areas in France (LGCD, 2012).

*ISIS: ISIS database was created by French Research Ministry in 2001 in order to store industry flow information obtained from bibliographic sources.

SymbioGIS

SymbioGIS tool was developed in 2006, in Switzerland for urban planners to facilitate industrial symbiosis. SymbioGIS matches the data by input output analysis and GIS interface provides the geographical feasibility information. It is in use by the developer.

Core Resource for Industrial Symbiosis Practitioners (CRISP)

The National Industrial Symbiosis Programme (NISP) is the first industrial symbiosis program on a national scale (Grant et al, 2010). It was launched in 2005, in the UK. The NISP helps companies to implement resource optimization and efficiency practices. It provides a platform to share best practices and advices for companies. At the beginning, communication between regional offices proved to be challenging, consequently, CRISP was created to enable relationship management, synergy management, data collection and reporting, communication and collaboration through a single internet portal. It is operational in national scale and in use by developer and selected partners.

The Industrial Symbiosis Platform (SYMBIOSIS)

SYMBIOSIS platform was created by Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA). Environmental Technologies Technical Unit started a project for the development of a platform for IS in 2010 to create a tool enabling companies share resources (materials, energy products, water, services and expertise). SYMBIOSIS offers some operational tools (regulation and BAT databases, quick LCA and Ecodesign tools, etc.) to companies and stakeholders (SYMBIOSIS, 2015).

SYMBIOSIS provides means of stakeholder involvement, promotion, and dissemination through a website. On-line or on-site collaboration of companies is desired. It allows assessment and data collection from companies via a geological database with GIS support.

The relation between associated companies, their own input-output and possible synergies among companies goes through links. ENEA input-output table foresees a taxonomy for the inventories taking “materials, energy, services, skills” into account as resources and official waste code system of Italy (according EU regulation) (SYMBIOSIS, 2015).

e-SYMBIOSIS

e-SYMBIOSIS is an output of Development of knowledge-based web services to promote and advance Industrial Symbiosis in Europe with the contribution of the financial instrument LIFE of the European Union Project (LIFE09 ENV/GR/000300)[63]. It was completed in June 2014. The project was implemented in Greece and the UK.

[63] http://www.esymbiosis.gr/islive/

The project presents an IS ontology design. The matching is enabled by calculating the similarity of two resources. The similarities are determined upon tacit and explicit knowledge. Although weighting coefficients are described by the authors as "experimental", this ontology[64] for IS addresses the knowledge gap that was mentioned in Grant et al (2010). The opportunity identification function is incorporated into the tool for pre assessment of the potential linkages, which support matching process (Trokanas et al, 2012).

eSymbiosis also carries out environmental assessment considering embodied carbon, environmental impacts of energy consumption, transportation impact, landfill diversion and virgin material saved and aggregating these different impacts by means of a weighing function (Trokanas et al, 2015).

C2CBIZZ tools

Cradle to Cradle is an innovation platform for generating positive impacts by improving the quality of products, systems and services (C2C Online Guideline, 2015). C2C-BIZZ partners developed different whitepapers and tools that support users to apply C2C-principals to their business. Some tools are helpful for general business development, while others refer to a specific module. This project was initiated in September 2009. The tools developed under the project are still operation.. There are six modules in total that can be selected independently according to specific needs of users. These modules are supported by management, economic and technical tools. Inventory, communication and strategy, charter, development framework, operational framework and C2C centre tools are defined as the management tools. The technical tools are comprised of continuous loops (online database), guideline for energy assessment and guideline for diversity tools. Finally, valuation and guided choices towards a circular business model tools are defined as economic tools.

USBCSD (United States Business Council for Sustainable Development) Materials Marketplace

The United States Materials Marketplace was launched as a pilot project in 2015 to test the feasibility of a national exchange where traditional and non-traditional industrial waste streams could be matched with new product and revenue opportunities. The Marketplace leverages the expertise and networks of three founding partners: The US Business Council for Sustainable Development (US BCSD), the Corporate Eco Forum (CEF), and the World Business Council for Sustainable Development (WBCSD) [65].

The US BCSD's cloud-based Materials Marketplace software originally developed in May 2013 by the US BCSD to support the Hebei By-Product Synergy Project. The software allows users to post available or desired material, help identify reuse opportunities**,** negotiate and exchange underutilized materials. Through a built-in interface, all marketplace users can generate real-time reports on key metrics. The software also provides detailed reports on savings or environmental benefits, producing bug reports, and monitoring transaction progress closely by project team.

ZeroWIN

ZeroWIN (Towards Zero Waste in Industrial Networks) is funded by the EC under the 7th Framework Programme. The project aims at regional collaboration of companies from traditionally separated sectors to facilitate by-products – energy, water and materials. ZeroWIN waste prevention tool gives the possibility to

[64] Ontology is a formal definition of the types, properties and relationships of the entities that exist for a paritcular domain of discourse in computer and information science. An ontology compartmentalizes the variables needed for some set of computations and establishes the relationships between them (Trokanas et al, 2012)

[65] http://materialsmarketplace.org/executive-summary/

compare the effects of different waste prevention measures in three different industry sectors. User can define specific system settings and choose between several waste prevention options. ZeroWIN waste prevention tool is still available as user-defined[66].

Looplocal

Looplocal tool has been developed by Department of Industrial Ecology at KTH, in Stockholm and applied to Swedish production industries in 2012 **¡Error! No se encuentra el origen de la referencia.**. The tool is a strategic matching tool for supporting regional resource transfers and works with data sources such as: the thousands of proven 'industrial symbiosis' transfers created around the world through utilization life cycle and material flow inventories, national and European statistics, and industrial geography databases. This tool compares industrial symbiosis data and estimated material and energy flows (on a facility level) to identify potential IS transfer information along key stakeholder and network (Aid et al., 2015).

Material Input Per Service Unit Tool (MIPS)

MIPS tool is provided by greeneconet[67] which is a platform for connecting small and medium enterprises for a green economy. MIPS is an elementary measure to estimate the environmental impacts caused by a product or service. The whole life-cycle from cradle to cradle (extraction, production, use, waste/recycling) is considered. MIPS can be applied in all cases, where the environmental implications of products, processes and services need to be assessed and compared (Green Econet, 2015)

In order to apply the MIPS tool, data on materials, fuels, transport, services and food need to be introduced according to five input categories of abiotic and biotic materials, water, air, and earth movement in agriculture and silviculture (available at http://wupperinst.org/uploads/).

COMETHE

COMETHE (Conception of Methodological and evaluation Tools for Industrial Ecology) project was funded under 2007 Call for projects of the Eco-technology and Sustainable Development Research Programme (PRECODD)[68]. During this project, five pilot studies were carried out to design a methodology and tools for the implementation of industrial ecology approaches on a business park scale involved (COMETHE, 2015).

There are four modules of the project related to analysis of the business potential and the territory, investigation of the feasibility of "eco-industrial" synergies, definition of implementation scenarios and integration of the process into a sustainable territorial development strategy.

EPESUS

Eco-Industrial Park Environmental Support System - EPESUS is an Eco-Innovation project developed by Ekodenge under the Entrepreneurship and Innovation Programme (EIP) component of Competitiveness and Innovation Framework Programme (CIP).

The general aim of the system is to serve Small and Medium Size Enterprises (SMEs) within an industrial park or in any communication network, in improving their environmental requirements and

66 http://wastepreventiontool.boku.ac.at/ZeroWIN_WastePreventionTool.htm
67 http://www.greeneconet.eu/
68 http://looplocal.org/?page_id=56

competitiveness in international platform. The project aims at supporting the SMEs regarding their resource and energy efficiency by the aid of a software tool (EPESUS, 2015)[69].

EPESUS software is capable of providing material and energy flow analysis which is linked to life cycle assessment based on ISO standards. Data inquiries are possible on plant or industrial park level and on waste stream basis. Furthermore, EPESUS allows for scenario analysis where results for individual cases can be compared against benchmark values. The tool is suited to individual facilities as well as clusters of industrial sectors, and eco industrial parks as a whole. The tool allows the users to monitor the whole material flow data, at unit process detail and evaluate the results in the LCA methodology at the web platform.

DIET, IME, WasteX and IEDP are IS systems which are canceled. KBDSS, DIME and Matchmaker! are completed studies but not available.
Firstly, DIET toolkit that contains FaST, DIET and REaLiTy tools is evaluated by The Material Flow Through The Community project in Massachusetts and determined it was not useful as a support tool and pointed out their concerns about high cost of expertise to overcome the weaknesses. The IME was intended to aid in the identification and analysis of so-called "byproduct synergies" unlike most other tools but it was not available to users outside of Bechtel (now Nexant) which was the corporation provide this project. WasteX was canceled because of failing to create an effective participant- based network. IEDP could not find enough potential matches within the limited system of participants. But it was expected to find successful matches when the number of participants increased.

Grant et al. refers the oldest systems; Matchmaker KBDSS, DIET and IME as initiation or immature work. KBDS system's final results were not able to provide economic data and system required further development to make it marketable and also external validation. DIME was provided by modifying IME and it was canceled due to validation and application on real data inability and absence of GIS functionality. And also it was supposed to include LCA and net cost benefits functionality. Matchmaker was a master students' project and existed on its own.

[69] http://www.epesus.net/

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CORRIGENDUM

May 2016

With reference to the FISSAC deliverable D1.2 ''Identification of best practices and lessons learnt in industrial symbiosis'' (February 2016), and the suggestions made by the EASME (April 2016), the following Corrigendum should be attached:

1. page 37- 43: Section 3.5 ''Drivers of Industrial Symbiosis'', Source: FISSAC collected case studies (FISSAC, 2016)

2. page 43-45: Section ''Recommendations'' , Source: FISSAC collected case studies (FISSAC, 2016)

3. page 46- 50: Section 5.1 ''Previous experiences and best practices on the reuse and recycling of the C&DW stream'', Source: Acciona Infrastructures Business Intelligence

4. page 50- 54: Section 5.2 ''Cluster meeting and synergies with EU-funded projects'' , Source: (EASME, 2016) https://ec.europa.eu/easme/sites/easme-site/files/8-dec-2015-kick-off_network_meeting_eu_waste_ri_projects_final_report.pdf

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