FISSAC

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

Project Validation, SWOT and Concept replicability

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0. SUMMARY

The main objective of WP7 ”Industrial Symbiosis replicability and social issues”, with specific reference to Task 7.3 “Evaluation of the replicability of the model”, is to demonstrate the replicability of FISSAC model in different products/sectors and different geographical areas.
The FISSAC model consists of:

- FISSAC Industrial Symbiosis scenario (construction value chain)
- Methodology: procedure to implement FISSAC model
- Software Platform: to support the methodology implementation
- FISSAC Material and process LCI library

Within D7.2, “Report on Industrial Segmentation, Criteria and correlation to the FISSAC first application”, the replicability concept was investigated in order to set up a methodology for industrial segmentation and for the evaluation of replicability potential, through a list of tailored criteria to guide the assessment of different opportunities. The identified criteria are aimed at investigating aspects of different nature, to cover all the possible opportunities and weaknesses for the scheme under analysis and to enable to identify main barriers and drivers for the implementation of such symbiosis.
Within D7.5, “Project Validation, SWOT and Concept replicability”, the criteria defined in D7.2 were applied in order to assess the replicability potential in different sectors and different countries.

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Abbreviations and acronyms

CDM	Construction and demolition materials
CDW	Construction and demolition wastes
CE	Circular Economy
DESI	Digital Economy and Society Index
EC	European Commission
ECI	European Copper Institute
EIR	Environmental Implementation Review
EU	European Union
ICA	International Copper Association
ICT	Information and Communication Technologies
IS	Industrial Symbiosis
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LL	Living Lab
MSW	Municipal Solid Waste
WFD	Waste Framework Directive
WPC	Wood-rubber-plastic composites

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1 INTRODUCTION

In the framework of WP7, the main aim of Task 7.3 is to assess, once the FISSAC model is defined and validated, the replicability of the model. This kind of assessment includes:

- the replicability of the IS opportunity investigated within the project;
- the replicability of the model to different fields and type of products;
- the replicability of the model in different EU target countries.

Within D7.2, "Report on Industrial Segmentation, Criteria and correlation to the FISSAC first application", the replicability concept was investigated in order to set up a methodology for industrial segmentation and for evaluation or replicability potential, through a list of tailored criteria to guide the assessment of different opportunities. Specific criteria were developed both to assess the replicability potential at country level and to assess the replicability potential in other sectors.
The replicability potential of the FISSAC model has been investigated; the main results are reported within this document, D7.5 "Project validation, SWOT and concept replicability".

With reference to the replicability potential in different countries, the FISSAC partners responsible for the organization of the Living Labs have been involved: they have been asked to compile, for their country, the Evaluation Matrix with the criteria and to assign a score (from 1 to 5) to each criteria to provide some insight. Of course, this assessment can't be exhaustive, but it can provide a first overview at country level.

In Figure 1, the countries and the partners involved in the assessment are shown.

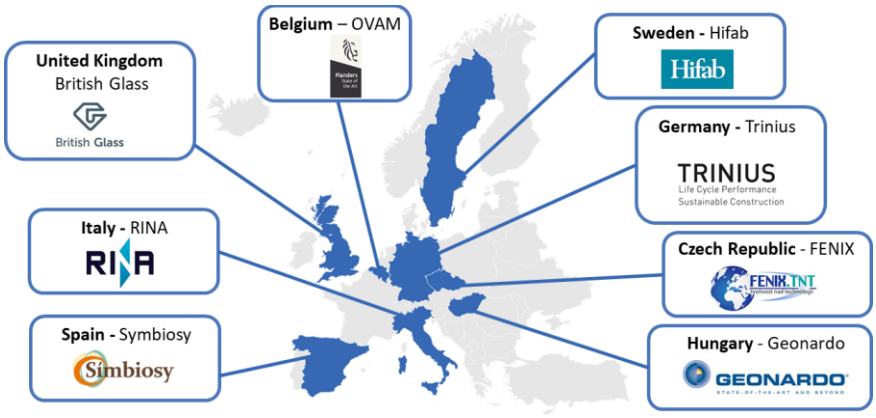

Figure 1: Framework of the replicability potential evaluation in different EU countries

Analogously, different criteria have been developed and used to evaluate the replicability potential of the FISSAC model, if applied to different products/sectors. Also in this case, for each product, the Evaluation Matrix was filled-in and a score (from 1 to 5) was assigned to each criteria.

This assessment represents a sort of pre-evaluation of the potential for different secondary raw materials and sector investigated. The material streams investigated are:

- Wood and plastic from Construction and Demolition Waste (C&DW);
- Gypsum;
- Copper and copper slags;
- Fly ashes.

In particular, as concerns Construction and demolition waste of wood and plastic, and gypsum, Sweden was assumed as reference country and a valuable contribution was given by RISE and HIFAB.

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2 FISSAC MODEL DEFINITION AND VALIDATION

The FISSAC project is an ambitious project aimed at improving the consciousness about circular economy and industrial symbiosis among different industrial sectors. The specific objectives of the project are manifold: it aims at demonstrating closed loop recycling processes and manufacturing processes, developing the eco-design of eco-innovative construction products and developing instruments to facilitate the instauration of IS establishment, such as the software platform and the living lab concept.

An extensive description of the model itself and of its main constituting elements is reported within D6.8 "*FISSAC model definition and validation*", together with a framework for its validation.

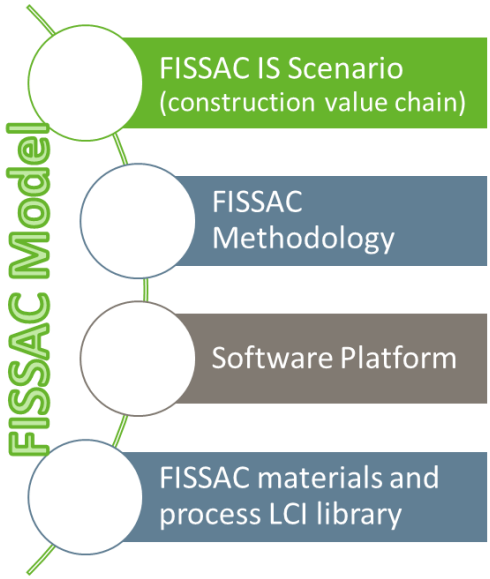

Figure 2: FISSAC Model

Summarising, it can be stated that the **FISSAC model** mainly consist of four different elements, as reported in Figure 2: the FISSAC IS scenario, the Methodology, the Software Platform and the FISSAC material, and process LCI library.

Basically the methodology is a part of the FISSAC model and describes the necessary steps to establish industrial symbiosis; within the FISSAC project these steps are realized and applied to the construction value chain and validated through different case studies. The FISSAC Platform, supporting various steps of the IS methodology including opportunity identification, opportunity assessment and network design, acts as an enabler of the IS methodology and helps the FISSAC IS Model to be replicable beyond construction value chain.

The real experience gained (reported within the library/database) as well as the main outcomes of the projects (e.g. the platform or the Living Lab concept) are part (together with the methodology) of the final model of the project.

Stakeholder interested in replicating the same model followed within the project can be guided and facilitated by the developed methodology to overcome technical barriers (transformations and adaptations of industrial and recycling processes) and non-technical barriers (social and cultural, legislative/regulatory, economic, organizational) as well as standardization concerns to implement and replicate industrial symbiosis in a local/regional dimension.

Among the objectives of the FISSAC projects, some are sector and materials specific (manufacturing processes and product validation) so they can be replicated in analogous contexts or taken as an example to replicate the same pathway in other contexts; other are more horizontal, and potentially applicable to all contexts: not only to the cases evaluated within the project, but also applicable to other sectors, products or in other countries. Indeed, the software platform and the living lab concept are tools that can be easily used in different contexts and are considered as valid instruments to facilitate the replicability process.

To provide a **validation of the project**, different instruments have been used, and different perspectives have been considered.

Thanks to the **case studies** carried out within the project, different industrial symbiosis opportunities have been tested and validated on real scale; the activities performed include the testing and the validation of the recycling processes, the eco-design, the manufacturing of the innovative products, etc. Some specific insights can be drawn for each case study: questionnaires have been compiled by the responsible partner to detect the main drivers and barrier, and the results are available within D6.8. It is not easy to generalise, since each industrial opportunity has its own peculiarities and the feasibility needs to be evaluated case by case. However, from the validation activities performed within the project, it is possible to derive some general considerations on strong and weak points of the developed model.

In this chapter, they have been summarised in a **SWOT analysis**; a SWOT (strengths, weaknesses, opportunities, and threats) analysis is a framework used to assess drivers and barriers, both internal and external to the system under evaluation.

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To fill the SWOT analysis, the main outcomes from the case studies have been complemented with other project results, able to give a more complete overview about driver and barriers: in particular, main outcomes from the different national Living Labs and feedback collected from external stakeholders have been taken into account.

The main results are reported within Figure 3.

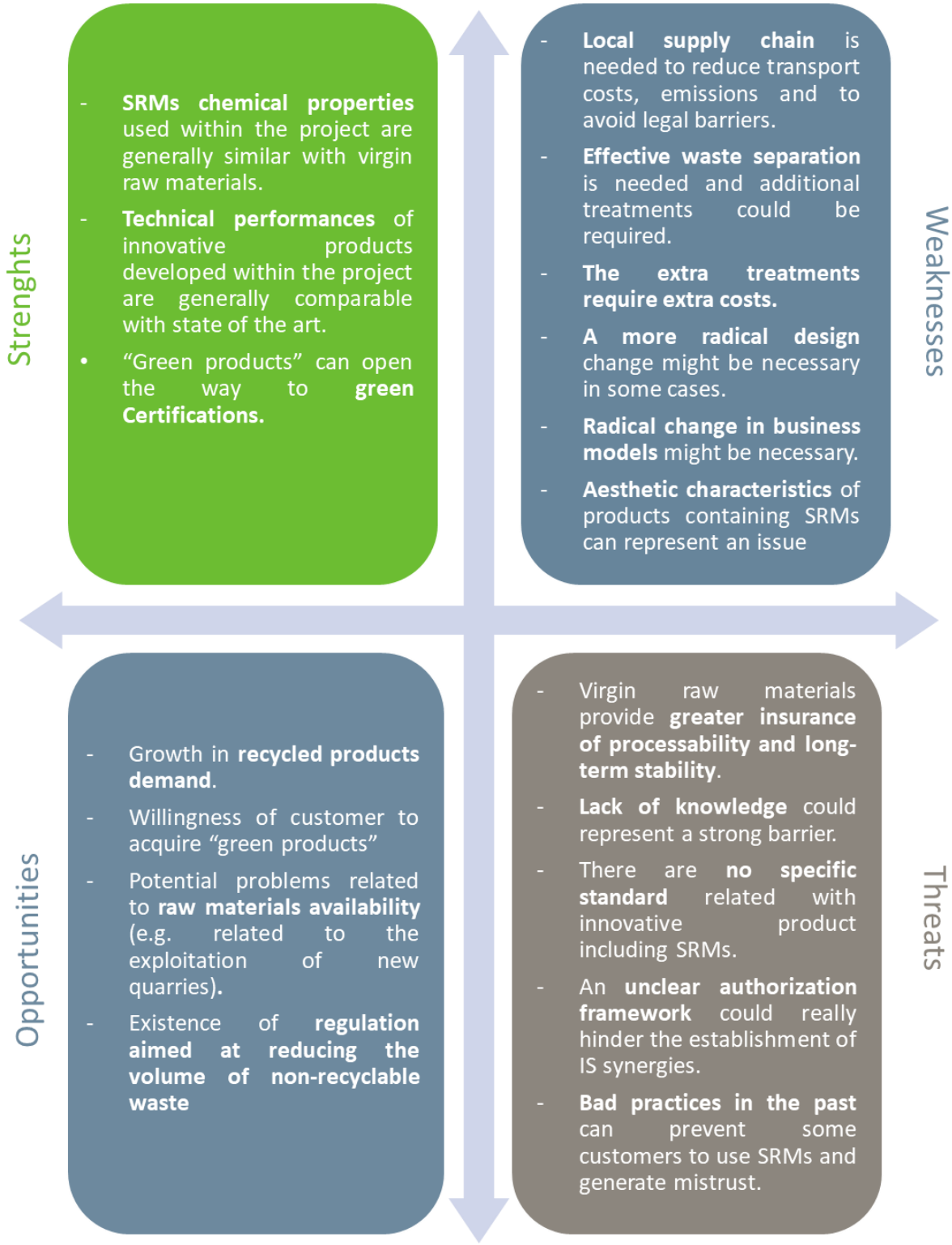

Figure 3: SWOT analysis

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In general, it can be stated that **the replicability of the industrial symbiosis opportunities investigated within the project is high**: even if the virgin raw materials provide greater insurance of processability and long-term stability, the SRMs chemical properties used within the project are generally similar with virgin raw materials ones and the technical performances of the innovative products are generally comparable with the state of the art.

Some **additional treatment** might be required to proper separate and recycle the waste, and ad-hoc solutions might be introduced: however, the ones developed and tested within the project have shown good results. In principle, it is important to perform a feasibility study to define if a **more radical change** might be necessary: a radical change would determine a higher initial investment, but in some cases it is necessary to ensure the fulfilment of quality and performances standards. In any case, the technical point of view has not represented a major barrier within the project.

The necessary investment to establish IS synergies can be encouraged by the growth in recycled products demand and by the willingness of customer to acquire "green products", which represent opportunities for the uptake of these innovative solutions. In addition, potential problems related to raw materials availability should make the use of SRMs more and more necessary.

The major obstacles identified within the project are related to non-technical aspects: regulatory and legislative issues, financial, economic and market-related obstacles and social, cultural and organizational aspects. First, it is worth mentioning that local supply chain is needed, not only to reduce transport costs and emissions, but also and to avoid logistic and legal barriers: **legal/regulatory frameworks** can vary also at regional level, and uncertainty about their interpretation could represent a strong barrier. Indeed, too heavy administrative burdens and excessively rigid environmental regulations can discourage industrial symbiosis initiatives. Therefore, a clearer and simpler regulatory framework has been indicated by several stakeholders as an urgent need, with special reference also to certification schemes for waste streams as by-products for its use as raw materials (end of waste criteria), which could simplify the exchange of waste among industries.

Considering the **economic point of view**, it has been underlined that SRMs often aren't less expensive than the virgin ones, but even less profitable, if no financing instrument or incentives are applied. Radical change in business models might be necessary, to overcome such barrier. However, circular business models are solid enough only if there is market demand behind – with this rationale, a Marketplace module has been included within the FISSAC platform, to facilitate the market uptake for secondary ram materials. The more the Platform (and the Marketplace) will be populated by facilities, the more this ambitious objective can be reached.

With reference to **social, cultural and organizational aspects**, two main aspects have been pointed out. The first one is about the necessity to create trust and collaboration among stakeholders: these elements are considered requirements without which it is impossible to initiate any IS opportunity. The answer of the FISSAC project to this point is mainly represented by the Living Lab concept, conceived as tool to gather the relevant stakeholder and start to build together new opportunities. The second aspect is about the general lack of skills and know-how of the involved stakeholders: trainings are necessary to pave the way for the transition from linear to circular economy, as well as success stories can represent strong enablers for stakeholders who are trying to replicate something similar. Training materials and exchange of experience can represent useful information for industrial stakeholders but, at the same time, they could also contribute to improve social acceptance of these solutions.

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3 FISSAC MODEL REPLICABILITY POTENTIAL IN DIFFERENT COUNTRIES

In this section the replicability potential of FISSAC Model in different EU countries is applied through the use of six criteria included in an Evaluation Matrix which was defined in the Deliverable D7.2 "Report on Industrial segmentation, criteria and correlation to the FISSAC first application".

It is worth mentioning that responsible of Living Lab (except for TCMB involved in a case study) provided a valuable support in filling-in the Evaluation Matrix for replicability potential in their respective countries.

Countries are eight and the partners involved are: Hifab (Sweden), Ovam (Belgium), IBT (Germany), Fenix (Czech Republic), Geonardo (Hungary), BGM (UK), Simbiosy (Spain), Rina C. (Italy). They assigned a score to each criterion and gave an explanation about the assigned score.

The following sections include the information gathered by FISSAC partners for each criterion for the eight above mentioned countries. At the end of each section, the Evaluation Matrix with the assigned score and the related explanation for each criterion is shown.

The following table shows the six criteria including their relevant description.

Table 1: Six criteria and the relevant description

Criteria	Description
Support of government to improve Industrial symbiosis and circular economy	Opportunities and drivers promoted by governments may act as determinant facilitators for the implementation of industrial symbiosis strategies and thus for a successful application of the FISSAC model. Main instruments through which governments can support industrial symbiosis include, among others, legislative framework i.e. laws, rules, decrees, etc., fiscal incentives, reduction of paperwork burden
Role of enterprises in promoting industrial symbiosis and circular economy	In countries where enterprises and industries are traditionally engaged and interested in the creation of synergies and linkages, the application of the FISSAC model can be easier and more fruitful than under circumstances in which there is no interest for industrial symbiosis strategies. Furthermore, stakeholders can play a significant role in encouraging the development and implementation of actions of governments in the perspective of symbiosis and circular economy
Clustering of industries based on territory	The location and level of aggregation of industrial areas on the territory influences the way and the possibility of implementing industrial synergies. For example, if industries are highly clusterized within a country i.e. they are concentrated in industrial areas, easily accessible, exchanges between them can be implemented with limited effort. On the other hand, if industries are typically spread in different locations, which can also be isolated, interconnections may turn complex from a logistic and technical point of view
Recovery and recycling rates	Values of recovery and recycling rates for material commonly monitored within the European Union, for those waste flows for which recovery targets are in force, may work as a powerful indicator of the possibility of implementing the FISSAC model within a European country. Indeed, to this rate aspects such as the attitude of governments, the availability of technological options for reprocessing waste and materials and economic feasibility, are connected
Awareness of industrial symbiosis and circular economy principles among citizens	Level of awareness about industrial symbiosis and circular economy principles among citizens are influential because they can support the spreading of these practices and the use of the FISSAC model also at very small scales (e.g. SMEs). Furthermore, high awareness may lead to a more conscious selection of environmentally friendly products by the consumers

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Criteria	Description
Skills on information technology	Considering that a main component of the FISSAC model is constituted by the web-based platform, it is important that potential end-users of the FISSAC model have the capabilities of interacting with technological equipment and have high levels of confidence with ICT tools

3.1 Flanders/Belgium

As regards Flanders/Belgium, it is worth mentioning that the information gathered for assigning the score in the Evaluation (replicability) matrix is based on:

- recent policy documents and measures to stimulate the transition to a circular economy;
- discussions during the Living Labs on expectations and relevant features of an ICT platform for Industrial Symbiosis;
- outcome of the Green Deal on circularity in the construction sector;
- outcome of the calls to promote innovative and circular projects;
- EU surveys.

Support of government to improve Industrial symbiosis and circular economy - Flanders/Belgium

In March 2016 the Flemish Government accepted the transversal policy paper "Vision 2050, a long term strategy for Flanders"[2]. This document represents a commitment to a clear vision for the future for the Flanders. The aim is that Flanders will be by 2050 a social, open, resilient and international region that creates prosperity and welfare in a smart, innovative and sustainable way, and where every individual counts. In its vision Flanders has identified seven transition priorities to realize this vision. The circular economy is one of these seven priorities. The scope of circular economy is not limited to materials but also covers water, energy, land and food.

The OVAM, the Public Waste Agency for Flanders, has worked for many years to enhance industrial symbiosis at regional level; to this end, workshops and get-togethers were organized. A symbiosis platform was developed. The regional Flemish symbiosis platform[3] is not limited to the construction sector. In other sectors matches between providers and users of secondary raw materials are sought. Material streams from other sectors frequently find users in the construction sector.

Findings for the establishment of the Flemish Symbiosis Platform have been used to feed the FISSAC model.

The Flemish government approved a concept paper in February 2017[4] which focuses on the circular city, circular purchasing (for which a 'green deal' has already been launched) and circular businesses.

Since 2017 several calls have been launched to financially stimulate eco-innovative projects. This should assist to accelerate the transition to a Circular Economy. More than 20% of the accepted proposals are linked to the construction sector.

Beginning 2019 the Flemish government initiated the "Green Deal Circular Construction". This was aimed at the construction sector. In response this call inspired more than 300 companies to make pledges to further the development of the circular economy in their working environment.

2 The EU Environmental Inplementation Review (EIR) 2019 – Country Report Belgium, European Commission (Flemish government, Vision 2050, 2016), https://ec.europa.eu/environment/eir/pdf/report_be_en.pdf

3 https://www.ovam.be/symbiose-0; https://www.smartsymbiose.com/#/; https://ovam.be/symbiose-veelgestelde-vragen

4 The EU Environmental Inplementation Review (EIR) 2019 – Country Report Belgium, European Commission (Flemish government, Transitie Circulaire Economie, 2017), https://ec.europa.eu/environment/eir/pdf/report_be_en.pdf

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Another program, entitled 'Smart Flanders' which supports 13 cities wishing to become 'smart cities', will run to the end of 2019[5]. The standout project entitled 'Green Light Flanders' is a network for digitization and sustainable LED-lighting'.

In March 2016, the Brussels' regional government adopted a circular economy regional plan (Be Circular) with 111 measures[5] setting out a strategy to transition from a linear to a circular economy by 2025.

Assigned score: **5** (see Evaluation Matrix table at the end of this section).

Role of enterprises in promoting industrial symbiosis and circular economy - Flanders/Belgium

Several sector federations and professional organizations participate in the partnership of Circular Flanders[5], the hub and inspiration for the Flemish Circular Economy. It is a space for networking and building public private partnerships in the circular economy. It also serves as a policy lab, supporting partners in the circular economy and sharing knowledge among participants supported by a center for policy research. Circular purchasing (or circular procurement) is one of the three strategic themes of Circular Flanders for the period 2017- 2018, next to "circular cities" and "circular entrepreneurship".

The Green Deal[6] for the Construction sector that was launched in February 2019, is a cooperation between OVAM, Circular Flanders and the VCB, the Flemish confederation for the construction sector. The Green Deal is a learning network. It has been set up to experiment and to share knowledge and experience. It will run over a period of 4 years. More than 300 companies, research institutes, federations of enterprises from the construction sector signed a clear commitment to further circular economy in their working environment.

Assigned score: **4** (see Evaluation Matrix table at the end of this section).

Clustering of industries based on territory - Flanders/Belgium

Flanders/Belgium is a very dense and urbanized region, with a well-developed transport infrastructure. Road transport largely dominates freight transport. The remaining transport is taken up by rail and waterways. Distances within the country are comparatively limited.

The production of secondary raw materials, either through recycling or the preparation, is evenly spread over the territory of the Flemish Region. This limits the need for transport both from the source and to the destination for end use. Matches are often found in local clusters of enterprises. In the construction sector there is a tendency towards amalgamation of activities linked to the different stages in the value chain. Demolition, transport, sorting and crushing are carried out by integrated companies. These are often the users of the secondary aggregates or other materials in building projects.

Belgium counts over 75,000 enterprises in the construction sector, most of them SME's.

Assigned score: **4** (see Evaluation Matrix table at the end of this section).

Recovery and recycling rates - Flanders/Belgium

According to the Eurostat ESMS Indicator Profile, the recovery rate of construction and demolition waste for Belgium amounts to 95%.

5 The EU Environmental Inplementation Review (EIR) 2019 – Country Report Belgium, European Commission (National Reform Programme 2018, p. 27), https://ec.europa.eu/environment/eir/pdf/report_be_en.pdf

6 Green Deal: https://vlaanderen-circulair.be/nl/onze-projecten/detail/green-deal-circulair-bouwen.

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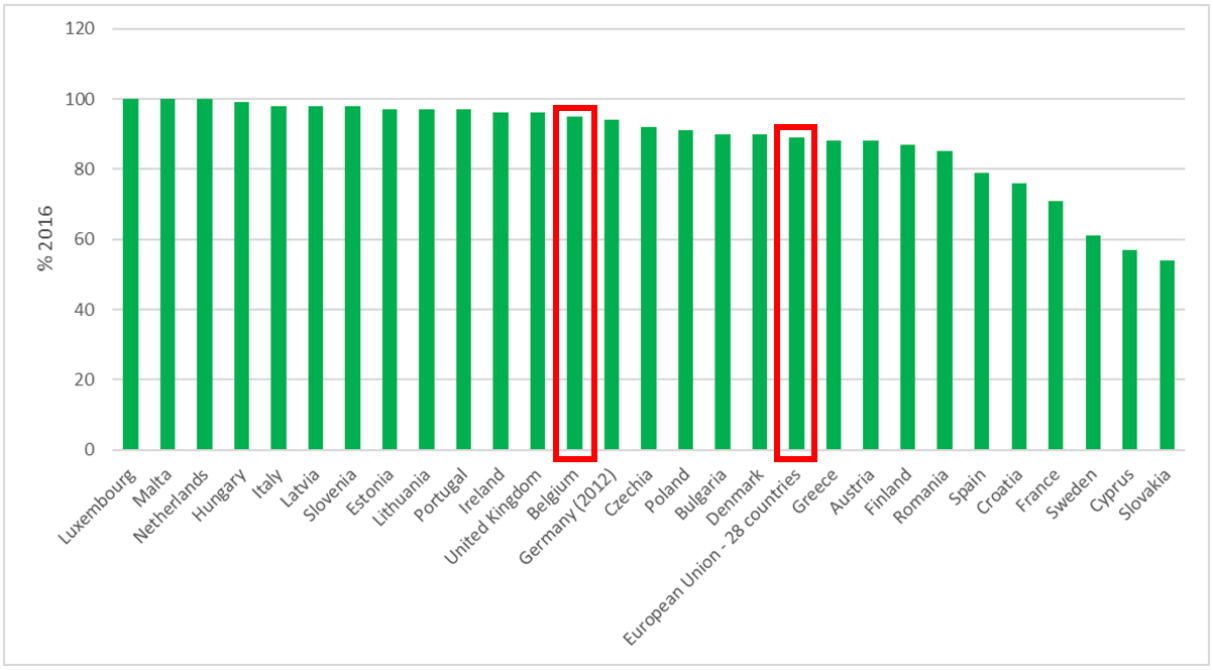

Figure 4: Eurostat data on recovery rate of construction and demolition waste (CDW) – Belgium vs EU

Already in 2013, more than 95% of the stony fraction of CDW was recycled to granulate and about 50 % of the non-stony fraction was recycled, even though with important differences between the non-stony fractions types of waste.

The indicator is the ratio of construction and demolition waste which is prepared for re-use, recycled or subject to material recovery, including through backfilling operations, divided by the construction and demolition waste treated as defined in Regulation (EC) No 2150/2002 on waste statistics.

The indicator covers the waste category 'Mineral waste from construction and demolition' (EWC-Stat 12.1). Only non-hazardous waste is taken into accounts.

The recycling rate for metals is very high. Useful application is given to wood waste from demolition sites. However, the share of recycling is a lot less. A large proportion is incinerated for energy recovery, especially when treated. For cellular concrete and gypsum sorting (at source) feed plants aimed at recycling these materials for use in the production of new building materials. The rates of recovery are high from building sites, less from demolition sites. The rates have been dropping due to a lower demand. For insulation materials the costs of collection and transport prohibit their full use as secondary raw materials.

Selective demolition is not compulsory, nor is the tracing of the debris and other waste streams by a monitoring organization forced upon the contractor. A pre-demolition audit is necessary to obtain a building permit. The information on the demolition waste streams can be brought into the symbiosis platforms.

Assigned score: **5** (see Evaluation Matrix table at the end of this section).

Awareness of industrial symbiosis and circular economy principles among citizens - Flanders/Belgium

Waste management and resource efficiency are key elements of EU environmental policy and the Europe 2020 strategy. The Flash Eurobarometer 388 (2013) seeks to understand citizens' perceptions, attitudes and practices related to the efficient use of resources and the generation and management of waste, as well as elements of the so-called "circular economy".

Belgium has a long history of Waste Management. Since 1981 a combination of instruments moved waste management further up in the waste hierarchy, promoting prevention and material recovery. As such Belgium scores high on the Waste-consciousness Behaviour index. With a 7.7 score (scale 0-11) it follows Austria as the second best.

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While there has not been (as yet) a survey on circular economy in Flanders or Belgium, there is an increasing interest for different aspects of circular economy over the last years: from repair-cafés, over second hand shops to different kinds of sharing initiatives (like care-sharing). Also in the media there is an increasing interest for circular economy.

Industrial symbiosis is a somewhat more complex aspect of CE. The public debate on industrial symbiosis is more limited to industrial stakeholders.

The interest for circular economy is linked to an increasing awareness for themes related to climate change. Some 'climate'-measures aimed at resource/energy efficiency have direct consequences for the construction sector (e.g. insulation norms).

Assigned score: **3** (see Evaluation Matrix table at the end of this section).

Skills on information technology - Flanders/Belgium

The Digital Economy and Society Index (DESI) is a composite index summarizing relevant indicators on Europe's digital performance and EU Member States' digital competitiveness. Overall Belgium scores well above the EU-average in the DESI-index. While it doesn't belong to the most performing (EU) countries, for most indicators it closely follows the lead countries.

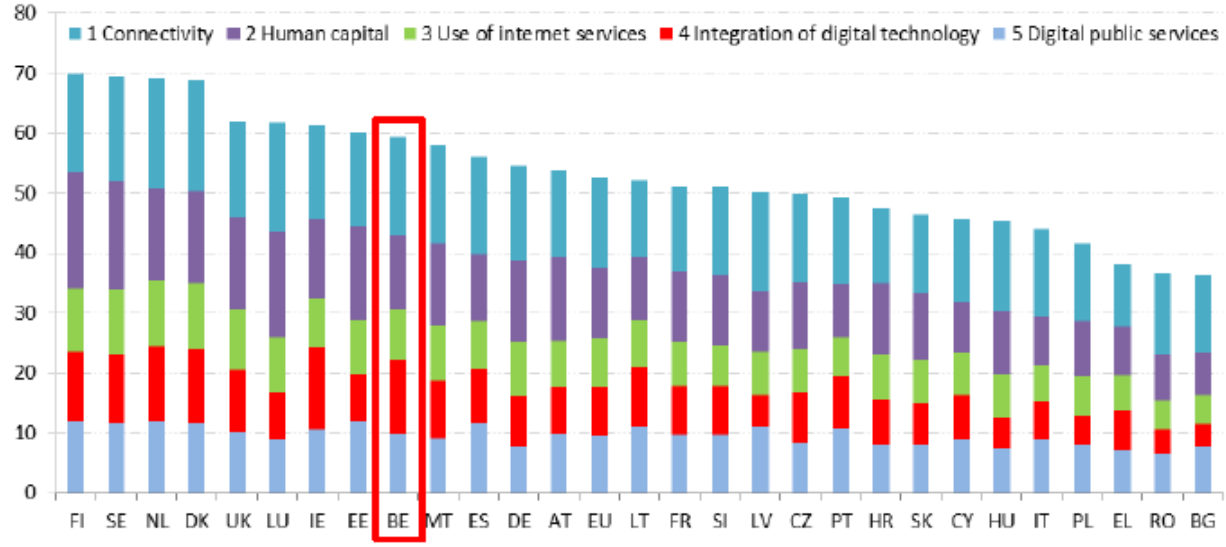

Figure 5: Digital Economy and Society Index (DESI) 2019 Ranking[7]

Belgium ranks 9th out of the 28 EU Member States in the European Commission Digital Economy and Society Index (DESI) 2019. Its score increased due to an improved performance in some of the DESI dimensions measured.

Belgium performs well in connectivity, thanks to the wide availability of fast and ultrafast fixed and mobile broadband networks and to the growing take-up, and has been successful in adopting digital technology. There are several strategies in place to digitize Belgian businesses. However, more investment is needed to boost the digitization of the Belgian economy, particularly by firms that have been lagging behind (mostly small and medium-sized enterprises and micro-firms), and in the public sector.

Although many innovative projects have been set up to boost digital skills, their impact on human capital in not yet reflected in the statistics. In the following figure and table country ranking and scores related to Belgium and Europe for each of the five dimensions of the DESI are shown.

The five dimensions are:

- Connectivity: including fixed broadband, mobile broadband, fast and ultrafast broadband and prices;
- Human capital: internet user skills and advanced skills;

7 Digital Economy and Society Index (DESI), 2019 Country Report - Belgium; https://ec.europa.eu/digital-single-market/en/scoreboard/belgium

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- Use of Internet: Citizen's use of Internet services and online transactions;
- Integration of digital technology: Business digitisation and e-commerce;
- Digital public services: e-Government and e-health.

For the above mentioned reasons, considering positive and negative aspects in the skills on information technologies, the assigned score for this criteria is 4 (see Evaluation Matrix table at the end of this section).

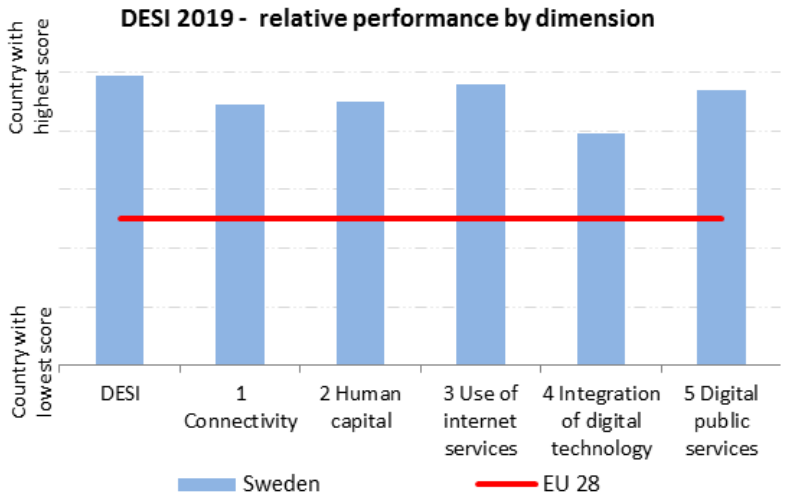

Figure 6: DESI 2019 – Relative Performance by Dimension (Belgium)[8]

Table 2: Evaluation Matrix for replicability potential in different EU countries (Flanders/Belgium)

Criterion	Grade	Description	Assigned score and explanation
Support of government to improve Industrial symbiosis and circular economy	1	Absence of support from the government	There is an excellent support from the Flemish government. For example, it has set itself a target to be fully circular in 2050. Circular Economy is one of the seven transition priorities of the Flemish Government.
	2	Insufficient support from the government	
	3	Fair support from the government	
	4	Good support from the government	
	5	Excellent support from the government	
Role of enterprises in promoting industrial symbiosis and circular economy	1	Absent	The role of enterprises is good. For example, several sector federations and professional organizations participate in the partnership of Circular Flanders which is a space for networking and building public private partnerships in the circular economy.
	2	Insufficient	
	3	Fair	
	4	Good	
	5	Excellent	
Clustering of industries on territory	1	Highly spread in isolated areas	Construction companies are situated all over the territory, often grouped in easy accessible areas. Distances in Flanders are rather limited.
	2	Mostly spread in isolated areas	
	3	Balanced distribution on territory	
	4	Mostly clustered in easily accessible areas	

[8] Digital Economy and Society Index (DESI), 2019 Country Report - Belgium; https://ec.europa.eu/digital-single-market/en/scoreboard/belgium

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Criterion	Grade	Description	Assigned score and explanation
	5	Highly clustered in easily accessible areas	
Recovery and recycling rates	1	Absence of information easily accessible and retrievable	Recovery and recycling rates are higher than the EU targets. According to the Eurostat ESMS Indicator Profile, the recovery rate of construction and demolition waste for Belgium amounts to 95%.
	2	Rates steadily below the EU targets for most of waste flows, and/or decreasing trends	
	3	Rates overall in line with the EU targets	
	4	Rates overall in line with the EU targets and increasing trends for most of waste flows	
	5	Rates above the EU targets and increasing trends for most of waste flows	
Awareness of industrial symbiosis and circular economy among citizens	1	No or very low awareness	The awareness of IS and CE among citizens is adequate. There is an increasing interest for circular economy. Industrial symbiosis is a somewhat more complex aspect of CE. The public debate on industrial symbiosis is more limited to industrial stakeholders.
	2	Low and inadequate awareness	
	3	Adequate awareness	
	4	Good awareness	
	5	Excellent awareness	
Skills on information technology	1	No or very low skills	There is a good skill on information technology. Belgium performs well in connectivity and has been successful in adopting digital technology. Overall Belgium scores well above the EU-average in the Digital Economy and Society Index (DESI).
	2	Low and inadequate skills	
	3	Adequate skills	
	4	Good skills	
	5	Excellent skills	

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3.2 Italy

As regards Italy, it is worth mentioning that the information gathered for assigning the score in the Evaluation (replicability) matrix is based on:

- recent policy documents and measures to stimulate the transition to a circular economy;
- discussions during the Living Labs on expectations and relevant features of an ICT platform for Industrial Symbiosis;
- EU surveys.

Support of government to improve Industrial symbiosis and circular economy - Italy

In November 2017, the Ministry of Environment and the Ministry of Economic Development published a joint document 'Towards a model of circular economy in Italy'[9]. This strategic document is functional to the implementation of the national strategy for sustainable development, which was adopted by the Italian government on 2 October 2017. Considering the importance of this document, which represents a valuable contribution towards promoting the circular economy in Italy, the Italian government decided to collect the contributions of all institutions, firms, experts and citizens who deal with the issue to develop a document that is the result of a shared and participatory process.

The circular economy is also a key component of 'Industria 4.0', the name given to the government's economic development plan. Circular economy appears as a clear priority in the update note for the 2018 budget[9].

Another significant development in Italy's promotion of the circular economy is the entry into force in June 2018 of 'Made Green in Italy', a voluntary system for assessing the environmental footprint of products[9]. Other important initiatives, such as the environmental footprint program, were mentioned in the 2017 Environmental Implementation Review (EIR).

The European Social Fund and the European Regional Development Fund (ERDF) are also supporting the improvement of the regions' capacity to plan and manage the transition of the local territorial systems towards the circular economy, respectively, through the use of integrated policy tools as well as with opportunities to invest in the circular economy. At the University of Tuscia in Civitavecchia (Roma) the first degree course in Circular Economy has started.

During the debate in the Living Labs a negative judgment about the support from the government raised due to the difficulties related to the development of new "end of waste criteria". End-of-waste criteria specify when certain waste ceases to be waste and obtains a status of a product (or a secondary raw material) and should be set for specific materials. These instruments should facilitate industries in the management of waste and secondary raw material, but the end of waste criteria already existing are very few and the development of new end of waste criteria is very slow (the participants have complained about the long procedure necessary to finalize the end of waste criteria related to the recycled aggregate; i.e: almost two years to finalize a single document).

In most cases the technical feasibility of waste utilization is assured, but the absence of end of waste criteria strongly limits the possibility to establish industrial symbiosis opportunities, since also the normal industrial practice is questioned. However, according to the latest news, the situation should change and regions should soon receive more autonomy in issuing or approving authorizations for end of waste, reducing time and facilitating the authorization process.

Another issues that came out during the discussion is that industries are often scared by previous experiences regarding misunderstandings in the definition of waste and secondary raw materials, which led also to legal disputes, in which the industries feel they have few guarantees.

According to the participants, a better digitalization of the waste traceability could facilitate industries: up to now, the SISTRI ("Sistema di controllo della tracciabilità dei rifiuti") system was not successfully implemented and it is not currently in operation, and the only instrument is the MUD ("Modello Unico di dichiarazione ambientale").

For the above mentioned reasons, considering positive and negative aspects in the support of Italian government, the assigned score for this criteria is **3** (see the Evaluation Matrix table at the end of this section).

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9 The EU Environmental Inplementation Review (EIR) 2019 – Country Report Italy, European Commission, https://ec.europa.eu/environment/eir/pdf/report_it_en.pdf

Role of enterprises in promoting industrial symbiosis and circular economy - Italy

The National Council of the Green Economy has encouraged the creation of the States General of the Green Economy, a grouping of 66 business organizations that, in collaboration with the Ministry of Environment and the Ministry of Economic Development, represent the green economy in Italy.

It is a programmatic platform promoting green economy through analysis of opportunities and obstacles and policies needed to improve performance of certain strategic sectors[10].

In November 2017, eight large Italian companies (Enel, Intesa Sanpaolo, Novamont, Costa Crociere, Salvatore Ferragamo group, Bulgari, Fater e Eataly) have launched an Alliance for Circular Economy and signed a 'poster' to identify and disseminate national best practices on circularity. Such an Alliance aims at reinforcing the commitment to continuous improvement of Italian companies in terms of innovation, competitiveness and environmental performance along the entire value chain.

In November 2018, Confindustria[11] presented the document 'The role of Italian industry in the circular economy' which highlights the crucial role that the industry can play to facilitate the transition towards the circular economy.

The States General of the Green Economy also works in collaboration with the Ministries of Environment and Economic Development. They meet yearly and presented the 2018 report on green economy[12] in the last meeting in November 2018.

Italy's Sustainable Development Foundation also produces regular reports on the green economy, and on 4 May 2018, it launched the Circular Economy Network with the support of 13 companies and consortia.

Furthermore, ENEA has launched in 2018 the Italian Circular Economy Stakeholder Platform[13] that, like the European one[14], is a network of networks with the objective of creating a point of national convergence of initiatives, experiences, criticalities, perspectives of the Italian system on circular economy.

On 21 April 2017 a cooperation agreement was signed for the constitution of an "Industrial Symbiosis National Network (SUN)" between ENEA and the Ministry of Environment, the Ministry for Economic Development, Confindustria, several Italian universities and various associations operating in the field of the environment.

This network is aimed at encouraging collaboration between different public and private users with the intention of promoting industrial symbiosis as instrument of eco-innovation and transition to a circular economy[10].

During the debate in the Living Labs it was found out that there are several industries which are involved in the development of solutions aimed at improving their circularity, however the main driver is the economic one: the industries start to look for alternative solutions when they face high costs, for example related to the landfill fees (e.g. higher than 150€/t), otherwise they are not incentivized to invest time and money in changing their usual process and procedures, especially if the dimension of the enterprise is small.

In this sense, synergies among different entities should really make the difference, distributing among them efforts in research and development related to circular economy and industrial symbiosis models. The limit to this kind of synergies is that every situation needs to be evaluated case by case, considering the peculiarity of that industry and evaluating the most adequate solutions. Another limit to the formation of a virtuous network is the difficulty in the exchange of confidential information, that industries are not willing to share.

All the participants agreed on the necessity to increase education and training on these topics for industries, to facilitate their role in promoting these models.

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10 Circular Policy Action Brief , World Business Council for Sustainable Development (WBCSD), October 2018

11 General Confederation of Italian Industry

12 The EU Environmental Implementation Review (EIR) 2019 – Country Report Italy, European Commission, https://ec.europa.eu/environment/eir/pdf/report_it_en.pdf

13 ENEA Italian Circular Economy Stakeholders Platform

14 i.e., the European Circular Economy Stakeholders Platform.

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For the above mentioned reasons, considering positive and negative aspects in the role of enterprises in promoting IS and CE, the assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Clustering of industries based on territory - Italy

In Italy there are several industrial areas where relevant clusters can be found but, considering the geography of the country, distances could also be quite long. Therefore, it is not easy to assign a single score for this criterion.

One of the main characteristics of clusters is their local/regional dimension. Many industrial clusters have existed for decades and have demonstrated a durable ability to renew and reinvent themselves. Made up of small companies, these industrial districts have very strong internal linkages, but communications with the outside are often much less developed.

During the debate in the Living Labs it was found out that the answer to this question depends also on the type of industries considered. In general, it was agreed that the proximity of similar industries can facilitate the adoption of circular economy and industrial symbiosis models, for example thanks to the possibility to share services and equipment which can be used in common. It was a shared opinion that synergies should be searched in a local context and not on large scale: the communication and the exchange of experience is fundamental in this sense, facilitating the possibility of identifying opportunities and their concretization. Industrial association can play a relevant role in creating networks and clusters of enterprises.

For the above mentioned reasons, the assigned score is **3** (see Evaluation Matrix table at the end of this section).

Recovery and recycling rates - Italy

According to the Eurostat ESMS Indicator Profile, the recovery rate of construction and demolition waste for Italy amounts to around 98%.

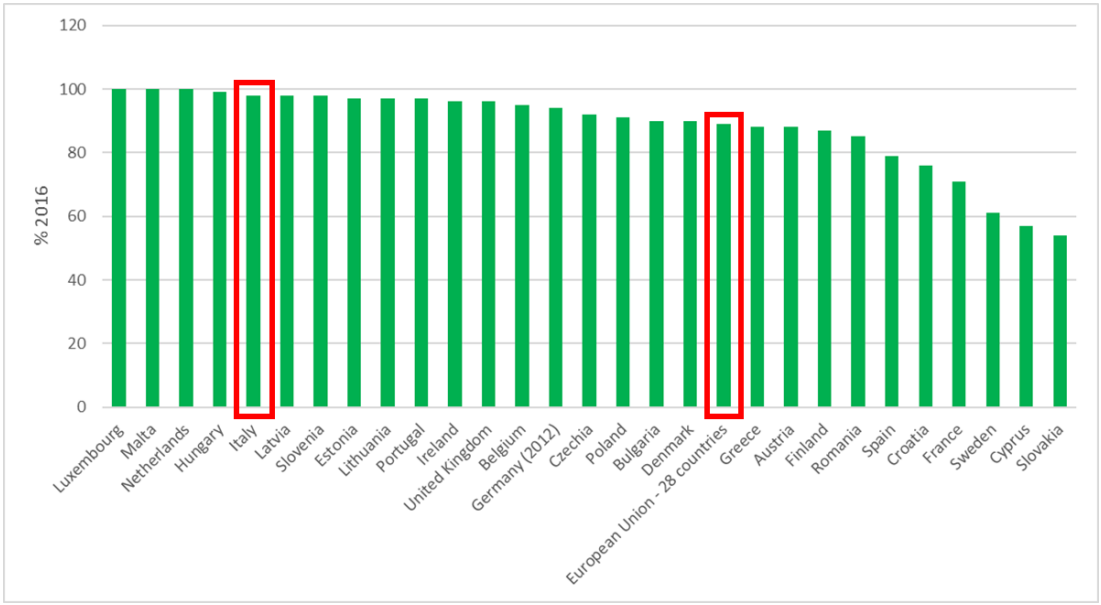

Figure 7: Eurostat data on recovery rate of construction and demolition waste (CDW) – Italy vs EU

Traditionally the demolition in Italy does not provide for a particular commitment in using selective demolition practices. In the everyday practice selective demolition is almost non-existent. This means that CDW from construction sites are particularly heterogeneous and that recycled aggregates produced by their treatment can contain unwanted materials in excessive amounts than allowed by the technical standards of the construction industry.

A step forward has been realized by the Decree of 11 January 2017 for the Green Public Procurement, which states that all the new construction works should include a selective demolition plan.

Italy lacks of any national or regional obligation for any kind of sorting (nor on-site nor in sorting facilities). The only requirement set in Italy includes the obligation for separate collection and management of hazardous waste from CDW

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operations. There are requirements for pre-demolition audits, but they are not mandatory and they are on regional basis (e.g. Veneto region).

Decree n° 102 of 3 August 2009 establishes that Ministero dell'Ambiente e della Tutela del Territorio e del Mare (MATTM) shall define and regulate the main features of SISTRI which is an advanced technological solution that allows an efficient and real time management of special waste (i.e. the waste generated by industrial activities), assuring its transparent traceability. Adhesion to SISTRI is compulsory for nodes of intermodal transportation, conveyors of hazardous waste, entities that deal with waste recovery or disposal.

In Italy a tax on landfilling is in force, but the current level of the tax on landfilling is not high enough for the development of the industry of recycled materials.

C&D hazardous waste has to be treated according to the same rules of other hazardous wastes. In addition, there are no obligations for drawing up of an asbestos or other hazardous waste inventory.

As of today there is only one material within CDW for which EoW criteria are being developed at national level: aggregates made from CDW for paving roads ("granulato da conglomerato bituminoso").

During the debate in the Living Labs it was found out that the answers to this criterion are as varied as the different waste considered by the participants: on one side, the main revealed problem of the electronic waste is their traceability (one proposed solution was to install GPS on the fridges, for example); on the other side, a key problem for textile waste is that they are difficult to separate in their components. In general, the main problem detected for all kind of waste is not their collection, recovery or recycling rate, rather than the grade of subsequent application: few are the waste used for high grade applications, even if the indicator aggregates all kind of applications, without distinguishing their grade. CDW, for example, are often used for low grade application. Summarizing, although in general the rate of recovery and recycling rates for the different type of waste are quite high for Italy, and often over the EU target, the participants expressed their doubts about the level of application (high or low), which should be better monitored.

For the above mentioned reasons, considering positive and negative aspects in the recovery and recycling rates, the assigned score for this criteria is **5** (see Evaluation Matrix table at the end of this section).

Awareness of industrial symbiosis and circular economy principles among citizens - Italy

Awareness of the circular economy concept and of the opportunities it can bring is growing in Italy. Some examples of this growing awareness are described in the report '100 Italian circular economy stories'[15], which lists best practices from large companies, small and medium sized enterprises (SMEs), local authorities and civil society.

Italy had a higher percentage of persons employed in circular economy sectors than the EU average in 2016 (2.05 in Italy, 1.73 in the EU)[15].

In the special Eurobarometer survey of October 2017 on attitudes of EU citizens towards the environment, 93 % of Italians said they were highly concerned about the effects of plastic products on the environment (the EU-28 average is 87 %), and 93 % of Italians said were concerned about the impact of chemicals (the EU-28 average is 90 %)[15]. Moreover, 79 % of Italians supported greater EU investment in environmental protection (this was less than the EU-28 average of 85 %). Italians appear to support circular economy initiatives and environmental protection measures.

During the debate in the Living Labs the participants focused on different aspects: not only on how much the citizens know about industrial symbiosis and circular economy, but also how much they are willing to change their habits to embrace more circular products or services. FISSAC project for example is aimed at developing new construction products incorporating recycled materials, but the willing of customers to acquire this kind of products is under question. It happens that customers refuse a certain product only because it includes recycled materials. To deal with this issue, information is considered even more important, because the mistrust related to the recycled materials is often linked to unjustified prejudices, which could be eradicated thanks to initiatives aimed at showing the differences among virgin and secondary raw materials and increasing public awareness.

In general, it seems that recently trends are changing, and different brands are ever more proposing sustainable solutions, in respect of which the social acceptance is gradually increasing. An example is represented by the textile

15 The EU Environmental Implementation Review (EIR) 2019 – Country Report Italy, European Commission, https://ec.europa.eu/environment/eir/pdf/report_it_en.pdf

luxury sector, which is considering proposing new business models related to its products, e.g. the possibility to rent them, rather than only to buy. Changes are expected in the near future.

For the above mentioned reasons, considering positive and negative aspects in the awareness of IS and CE principles among citizens, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Skills on information technology - Italy

The Digital Economy and Society Index (DESI) is a composite index summarizing relevant indicators on Europe's digital performance and EU Member States' digital competitiveness. Overall Italy scores are below the EU-average in the DESI-index.

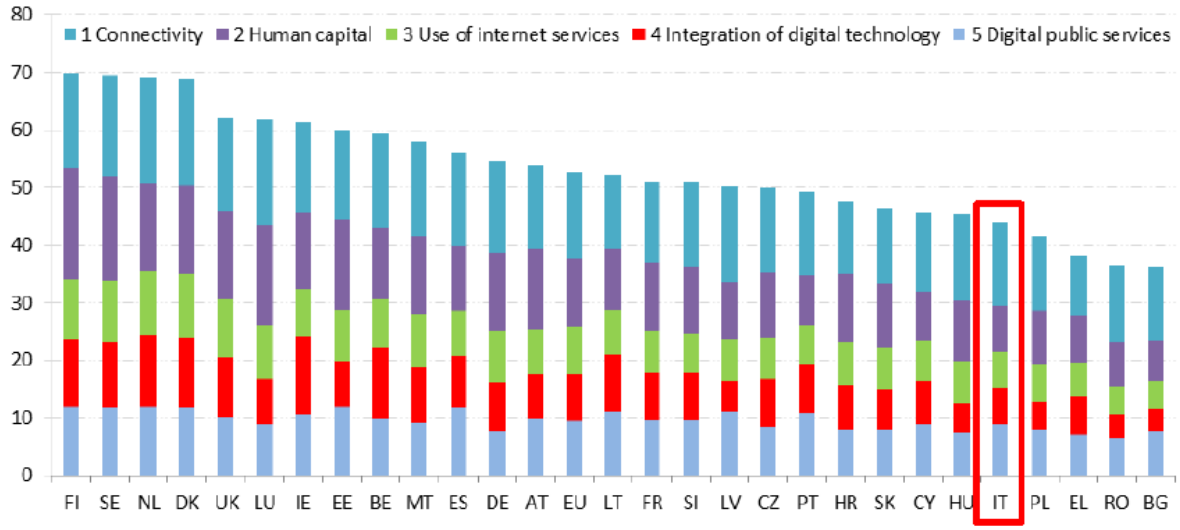

Figure 8: Digital Economy and Society Index (DESI) 2019 Ranking[16]

Italy ranks 24th out of the 28 EU Member States in the European Commission Digital Economy and Society Index (DESI) 2019. Italy performs relatively well, although still below the EU average, as regards Connectivity and Digital public services. Online public services and open data are readily available, and take-up of e-health services is good. Fast broadband coverage and take-up are progressing well (although the latter remains below average), while ultrafast connectivity is progressing far more slowly.

However, three out of ten people are not regular internet users yet, and more than half of the population still lacks basic digital skills. This shortfall in digital skills is also reflected in low use of online services, with which little progress has been made.

In the following figure and table country ranking and scores related to Italy and Europe for each of the five dimensions of the DESI are shown. The five dimensions are:

- Connectivity: including fixed broadband, mobile broadband, fast and ultrafast broadband and prices;
- Human capital: internet user skills and advanced skills;
- Use of Internet: Citizen's use of Internet services and online transactions;
- Integration of digital technology: Business digitisation and e-commerce;
- Digital public services: e-Government and e-health

16 Digital Economy and Society Index (DESI) 2019 Country Report - Italy https://ec.europa.eu/digital-single-market/en/scoreboard/italy

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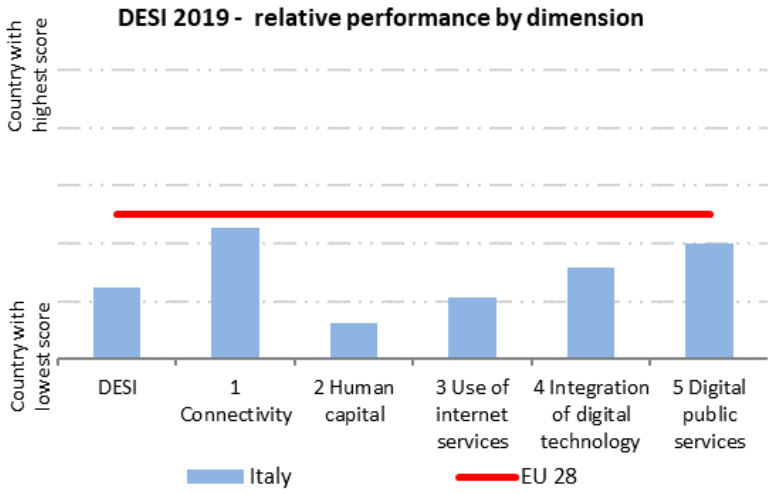

Figure 9: DESI 2019 – Relative Performance by Dimension (Italy)[17]

With an overall Connectivity score of 57.6, Italy ranks 19th among EU countries; it has moved up seven positions in the ranking by comparison with last year's DESI ranking. In the Human capital dimension, Italy ranks 26th among EU countries and is thus below the EU average. The basic and advanced digital skills levels of Italians are below the EU average. Overall, the use of internet services remains well below the EU average. 19 % of people living in Italy, almost double the EU average, have still never used the internet. As regards the Integration of digital technology by businesses, Italy ranks 23rd among EU countries, well below the EU average; it ranks the same as in DESI 2018. There has been some progress in the use of cloud services and e-commerce. However, Italian enterprises continue to lag behind in taking advantage of the opportunities offered by online commerce.

As regards Digital public services, Italy ranks 18th among EU Member States. The country performs very well in open data and e-health services. However, there is a low level of online interaction between public authorities and the public.

During the debate in the Living Labs no major barriers have been identified by the participants, with reference to the ICT skills. However, it has been pointed out the importance of digitalization of industries (industry 4.0), since it could really facilitate the use of platform or similar instruments. A problem identified, indeed, is that industries has low awareness of the amount and type of waste and by-products they produce and consequently the related data collection process is difficult. Sensors or digital twin concept could really fasten these operations, creating a direct link between the industry materials availabilities and the potential marketplace.

For the above mentioned reasons, considering positive and negative aspects in the skills on information technology, the assigned score for this criteria is **3** (see the Evaluation Matrix table shown below).

Table 3: Evaluation Matrix for replicability potential in different EU countries (Italy)

Criterion	Grade	Description	Assigned score and explanation
Support of government to improve Industrial symbiosis and circular economy	1	Absence of support from the government	There is a support from government for the promotion of the circular economy. For example, the publication of a joint document "Towards a model of circular economy in Italy", and the entry into force of 'Made Green in Italy', a voluntary system for assessing the
	2	Insufficient support from the government	
	3	Fair support from the government	
	4	Good support from the government	

[17] Digital Economy and Society Index (DESI), 2019 Country Report - Italy https://ec.europa.eu/digital-single-market/en/scoreboard/italy

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Criterion	Grade	Description	Assigned score and explanation
	5	Excellent support from the government	environmental footprint of products. A negative judgment is due to the difficulties related to the development of new “end of waste criteria”.
Role of enterprises in promoting industrial symbiosis and circular economy	1	Absent	The role of enterprises is good. For example, some Italian companies launched an Alliance for Circular Economy and signed a ‘poster’ to identify and disseminate national best practices on circularity. Another example is the constitution of an "Industrial Symbiosis National Network (SUN)" between ENEA, the Ministry of Environment, Confindustria and associations aimed at encouraging collaboration between different public and private users to promote industrial symbiosis as instrument of eco-innovation and transition to a circular economy.
	2	Insufficient	
	3	Fair	
	4	Good	
	5	Excellent	
Clustering of industries on territory	1	Highly spread in isolated areas	In Italy there are several industrial areas where relevant clusters can be found but, considering the geography of the country, distances could also be quite long. Also the type of industries considered must be taken into account. In general, the proximity of similar industries can facilitate the adoption of circular economy and industrial symbiosis models, for example thanks to the possibility to share services and equipment which can be used in common.
	2	Mostly spread in isolated areas	
	3	Balanced distribution on territory	
	4	Mostly clustered in easily accessible areas	
	5	Highly clustered in easily accessible areas	
Recovery and recycling rates	1	Absence of information easily accessible and retrievable	Recovery and recycling rates are higher than the EU targets. According to the Eurostat ESMS Indicator Profile, the recovery rate of construction and demolition waste for Italy amounts to 98%. The main problem detected for all kind of waste is not the recovery or recycling rate (quite high for Italy), but the grade of subsequent application which should be better monitored.
	2	Rates steadily below the EU targets for most of waste flows, and/or decreasing trends	
	3	Rates overall in line with the EU targets	
	4	Rates overall in line with the EU targets and increasing trends for most of waste flows	
	5	Rates above the EU targets and increasing trends for most of waste flows	
Awareness of industrial symbiosis and circular economy among citizens	1	No or very low awareness	Awareness of the circular economy concept and of the opportunities it can bring is growing in Italy. It is not only important on how much the citizens know about industrial symbiosis and circular economy, but also how much they are willing to change their habits to embrace more circular products or services.
	2	Low and inadequate awareness	
	3	Adequate awareness	
	4	Good awareness	
	5	Excellent awareness	
	1	No or very low skills	

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Criterion	Grade	Description	Assigned score and explanation
Skills on information technology	2	Low and inadequate skills	Overall Italy scores are below the EU-average in the Digital Economy and Society Index (DESI). Italy ranks 24th out of the 28 EU Member States in the European Commission DESI 2019. It must be pointed out the importance of digitalization of industries (industry 4.0), since it could really facilitate the use of platform or similar instruments.
	3	Adequate skills	
	4	Good skills	
	5	Excellent skills	

3.3 Spain/Catalonia

The information gathered for the replicability matrix is based on:

- Recent policy instruments to stimulate the transition to a circular economy in Catalonia
- Recent reports about the circular economy in Catalonia
- Perceptions and conclusions arisen from the Living Labs Barcelona
- EU surveys

Support of government to improve Industrial symbiosis and circular economy - Spain- Catalonia

The Government of Catalonia has been boosting the local circular economy quite intensively within the past years, for example, by launching the Catalan Strategy on Green and Circular Economy, the Catalan Waste and Resource Management and Prevention Programme, the Catalan Eco-design Strategy, or the National agreement for the Catalan Industry. In fact, the first industrial symbiosis pilot scheme was launched in Catalonia (promoted by the Catalan Waste Agency and coordinated by the Manresa City Council with the collaboration of the Bages Waste Treatment Consortium). Some other examples of concrete initiatives/instruments/tools are:

- **Catalunya Circular - The Observatory for Circular Economy in Catalonia:** The aim of the online platform is to become a central point of reference for circular economy in Catalonia. Besides providing useful knowledge and information on CE, *Catalunya Circular* offers an opportunity to raise awareness about the work done by Catalan businesses/entities by publishing details of their CE initiatives. All initiatives are geolocalised on an interactive map.
- The **Circular Economy at the Barcelona's Metropolitan Area - The DREAM project:** The Barcelona's Metropolitan Area has been implementing different initiatives during the last years in the areas of energy, water, waste, urban greenery, mobility, housing, local economic development.
- Both the **Waste Agency of Catalonia (ARC)** and the **Agency of Business Competitiveness of the Government of Catalonia (ACCIÓ)** launch every year different support programs to boost circular innovation within the industrial sector:
    - The **Innovation Coupons**, a direct financial rebate for subcontracting advanced technological services with certified suppliers that can support companies to incorporate the circular economy into their products or processes.
    - The **Industrial Research and Experimental Development "*Nuclis*"** are conceived to develop circular economy solutions individually or in collaboration with other local and international companies through R&D projects.

In 2018, the ARC granted 1.8 million euros to support 66 business projects linked with the promotion of circular economy. The yearly provided grants cover projects targeting waste recovery, eco-design, recycling, industrial symbiosis, reuse and remanufacture projects.

For the above mentioned reasons, considering positive and negative aspects in the support of Government, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

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Role of enterprises in promoting industrial symbiosis and circular economy - Spain- Catalonia

Although enterprises should certainly play a key role, their implication for real implementation of circular business models is currently insufficient. The Spanish economy is mainly composed of small and medium enterprises and they face some important challenges:

- **A lack of awareness and limited access to knowledge:** only a small minority of the SMEs, which are active in the region are aware of the benefits of adopting circular economy strategies and practices**.**
- **Lack of willingness and financial support for investing in circular practices:** a fair amount of SMEs are not willing to invest in circular practices. It is harder for SMEs to identify the business case for circular practices and business models and they often face difficulties in acquiring financing to implement circular practices.
- **Little demand for circular products in the marketplace:** the regional authority can thereby play an important role by developing green and circular public procurement practices.

For the above mentioned reasons, considering positive and negative aspects in the role of enterprises, the assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

Clustering of industries based on territory - Spain- Catalonia

Catalonia's location in the Mediterranean and its well-developed transport infrastructure have provided the region with a top rank strategic position favoring intense relations with the Mediterranean territories as well as the continental Europe.

Some of Catalonia's key economic industries are services, construction & demolition and agriculture.

Catalonia's cluster policy is part of the Catalan multi-faceted, pro-business economic policy to promote Catalonia as a business location. Currently, there are 30 clusters in Catalonia's Cluster Program, home to 2,300 entities and more than 309,000 workers accounting for a turnover of over 74 billion euros. The clusters are divided by the following sectors: food, mobility, advanced manufacturing, water and energy, design manufacturing, health, digital and cross-cutting industries.

For the above mentioned reasons, considering positive and negative aspects in the clustering of industries, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Recovery and recycling rates - Spain- Catalonia

According to the Eurostat data on recovery rate of construction and demolition waste, Spain's recycling rates are slightly lower than the average.

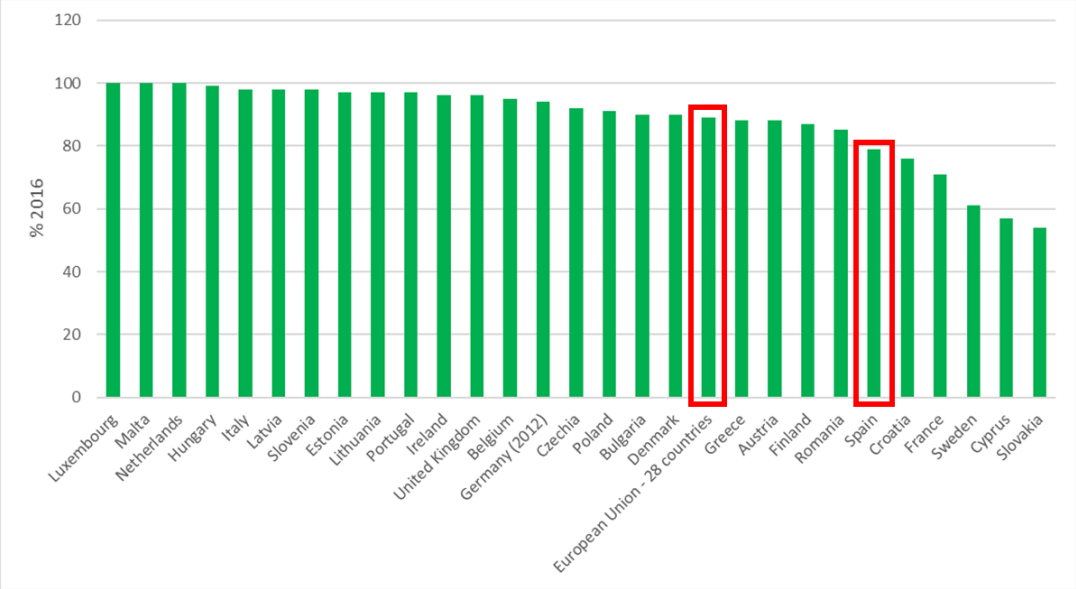

Figure 10: Eurostat data on recovery rate of construction and demolition waste (CDW) – Spain vs EU

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The indicator is the ratio of construction and demolition waste which is prepared for re-use, recycled or subject to material recovery, including through backfilling operations, divided by the construction and demolition waste treated as defined in Regulation (EC) No 2150/2002 on waste statistics. The indicator covers the waste category 'Mineral waste from construction and demolition' (EWC-Stat 12.1). Only non-hazardous waste is taken into account.

For the above mentioned reasons, considering positive and negative aspects in the recovery and recycling rates, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Awareness of industrial symbiosis and circular economy principles among citizens - Spain- Catalonia

According to the recent report released by the Creafutur Foundation ("Citizens and the circular economy - Current situation and prospects for the future"), Spanish citizens believe that they themselves (49.4%) are less responsible for environmental problems than the EU (60.6%), the Government (56.8%) and companies (54.3%).

Sustainable awareness does not imply change of habits: 73.4% of Spaniards agree that, despite being concerned about the environment, they are not sufficiently concerned to change to more sustainable habits. Only 15.1% claim to be interested in and concerned about environmental problems and act accordingly.

The Creafutur study was carried out with two main objectives: to analyse the behaviours, attitudes, perceptions and motivations of Spanish citizens regarding sustainability and the adoption of circular economy practices (such as reusing, repairing, consuming remanufactured products and recycling); and to identify good local and international practices aimed at accelerating the implementation of the circular economy.

The analysis included 2,534 citizen surveys, a compilation of private initiatives that are benchmark in the implementation of circular business models, interviews with experts in the fields of sustainability and the circular economy, and a reference trip to Scotland to interview public institutions and companies leading the transition to a circular economy.

For the above mentioned reasons, considering positive and negative aspects in the awareness of IS and CE, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Skills on information technology - Spain- Catalonia

The Digital Economy and Society Index (DESI) is a composite index summarizing relevant indicators on Europe's digital performance and EU Member States' digital competitiveness.

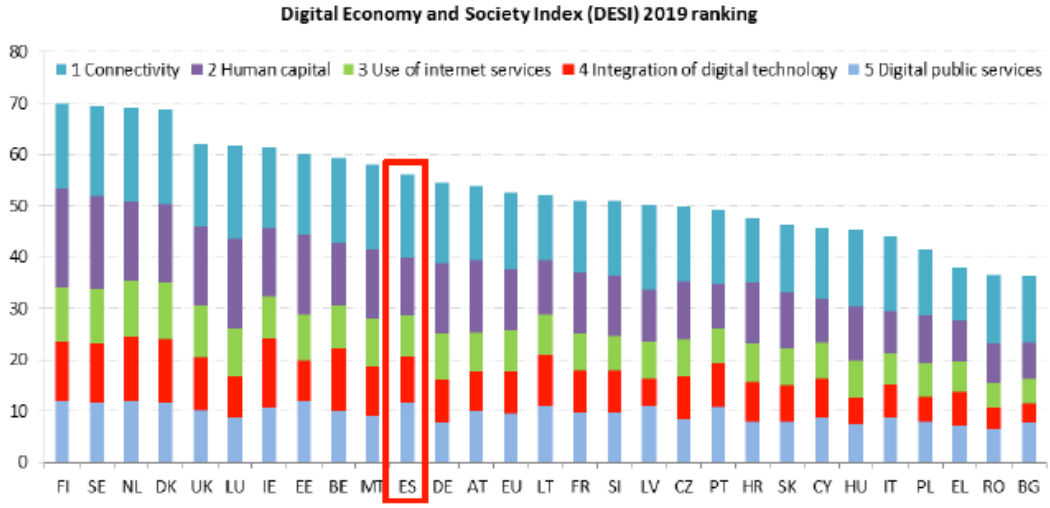

Figure 11: Digital Economy and Society Index (DESI) 2019 Ranking[18]

[18] Digital Economy and Society Index (DESI) 2019 Country Report - Spain https://ec.europa.eu/digital-single-market/en/scoreboard/spain

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

Spain ranks 11st out of 28 EU Member States in the Digital Economy and Society Index (DESI) 2019.

The improvement is due to a better performance in some of the DESI dimensions measured, namely Connectivity and Digital Public Services. Spain performs well in connectivity, thanks to the wide availability of fast and ultrafast fixed and mobile broadband networks and to the increasing take-up. With regards to Human capital, Spain ranks at the same level as last year, and still scores below the EU average in this dimension.

In particular, around one fifth of people in Spain are not yet online and close to half of them still lack basic digital skills. Despite growing demand on the labour market, the supply of ICT specialists is still below the EU average. Most progress has been made with Connectivity. As regards the Integration of digital technologies, while more Spanish businesses use social media and big data than in previous years, but cloud and e-commerce stagnated compared with last year.

Spain is doing best in the area of digital public services, having implemented its e-government strategy in good time. It ranks fourth in the EU in this area.

For the above mentioned reasons, considering positive and negative aspects in the skill on information technology, the assigned score for this criteria is 3 (see Evaluation Matrix table at the end of this section).

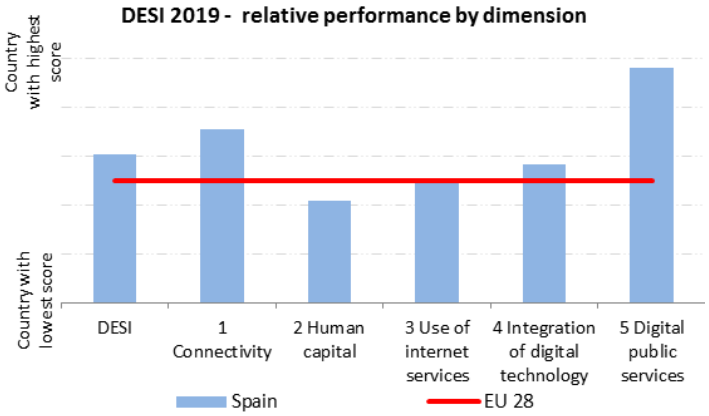

Figure 12: DESI 2019 – Relative Performance by Dimension (Spain)[18]

Table 4: Evaluation Matrix for replicability potential in different EU countries (Spain)

Criterion	Grade	Description	Assigned score and explanation
Support of government to improve Industrial symbiosis and circular economy	1	Absence of support from the government	The Government of Catalonia has been boosting the local circular economy quite intensively within the past years, for example, by launching the Catalan Strategy on Green and Circular Economy, the Catalan Waste and Resource Management and Prevention Programme, the Catalan Eco-design Strategy, or the National agreement for the Catalan Industry
	2	Insufficient support from the government	
	3	Fair support from the government	
	4	Good support from the government	
	5	Excellent support from the government	
Role of enterprises in promoting industrial symbiosis and circular economy	1	Absent	Although enterprises should certainly play a key role, their implication for real implementation of circular business models is currently insufficient. The Spanish economy is mainly composed of small and medium enterprises and they face some important challenges
	2	Insufficient	
	3	Fair	
	4	Good	
	5	Excellent	
Clustering of industries on territory	1	Highly spread in isolated areas	Catalonia's cluster policy is part of the Catalan multi-faceted, pro-business economic policy to promote Catalonia as a business location. Currently,
	2	Mostly spread in isolated areas	
	3	Balanced distribution on territory	

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Criterion	Grade	Description	Assigned score and explanation
	4	Mostly clustered in easily accessible areas	there are 30 clusters in Catalonia's Cluster Program. Clusters are divided by the following sectors: food, mobility, advanced manufacturing, water and energy, design manufacturing, health, digital and cross-cutting industries.
	5	Highly clustered in easily accessible areas	
Recovery and recycling rates	1	Absence of information easily accessible and retrievable	According to the Eurostat data on recovery rate of construction and demolition waste, Spain's recycling rates are slightly lower than the average
	2	Rates steadily below the EU targets for most of waste flows, and/or decreasing trends	
	3	Rates overall in line with the EU targets	
	4	Rates overall in line with the EU targets and increasing trends for most of waste flows	
	5	Rates above the EU targets and increasing trends for most of waste flows	
Awareness of industrial symbiosis and circular economy among citizens	1	No or very low awareness	Sustainable awareness does not imply change of habits: 73.4% of Spaniards agree that, despite being concerned about the environment, they are not sufficiently concerned to change to more sustainable habits. Only 15.1% claim to be interested in and concerned about environmental problems and act accordingly.
	2	Low and inadequate awareness	
	3	Adequate awareness	
	4	Good awareness	
	5	Excellent awareness	
Skills on information technology	1	No or very low skills	Spain ranks 11st out of 28 EU Member States in the Digital Economy and Society Index (DESI) 2019. The improvement is due to a better performance in some of the DESI dimensions measured, namely Connectivity and Digital Public Services. Spain performs well in connectivity, thanks to the wide availability of fast and ultrafast fixed and mobile broadband networks and to the increasing take-up.
	2	Low and inadequate skills	
	3	Adequate skills	
	4	Good skills	
	5	Excellent skills	

3.4 Sweden

The information gathered for the replicability matrix is based on:

- recent policy documents and measures to stimulate the transition to a circular economy;
- Swedish national surveys
- Outcomes from living labs

Support of government to improve Industrial symbiosis and circular economy - Sweden

In 2018, the Swedish government decided to set up a circular economy delegation with the aim of strengthening the national and regional transition of society to a resource-efficient, circular and bio-based economy. The delegation is an advisory body to the government with placement at the Swedish Agency for Economic and Regional Growth (Tillväxtverket). The task of the delegation is to carry out a platform, a knowledge center and a coordinating force for

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the transition. The delegation shall also, in collaboration with relevant actors, identify obstacles to the transition and act as a catalyst.

Delegations tasks are to:

- develop a strategy for a transition to a circular and bio-based economy at various levels in society,
- be a point of contact between relevant actors,
- identify obstacles, needs for education, information and advice and propose cost-effective measures to the government,
- gather and share knowledge about ongoing initiatives and facilitate collaboration between them,
- designate reference groups to support the work of the delegation,
- create an innovative, competitive and sustainable business at national and regional level,
- create a transition that can contribute to the national environmental goals, strengthen Swedish competitiveness and increase Sweden's contribution to the implementation of Agenda 2030.

By September 2019, the delegation has worked on a project plan and practical parts of the delegation and has not yet come out with the exact strategy plan.

The Nordic Council of Ministers and the Nordic Council are the main forums for official Nordic co-operation, which involves Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland and Åland. The vision is to make the Nordic region the most sustainable and integrated region in the world. Nordic Working Group for Circular Economy (NCE) is one of five main topics that the council is working with. The mandate of the Nordic Working Group for Circular Economy (NCE) includes contributing to activities and exchanges of information that will promote the transition to a circular economy in the Nordic Region. The Group also wishes to influence the EU and global players, for example by helping to identify solutions that will reduce consumption of raw materials, waste, emissions and energy by recycling products, including for new purposes[19].

In 2018, IVL (Swedish Environmental Research Institute) together with Linköping University, RISE (Research Institutes of Sweden) and Hifab, has developed a **Roadmap for Increased Uptake of Industrial Symbiosis in Sweden**. It sets forth ways in which industrial symbiosis can be developed and spread in Sweden. The aim of a Roadmap for IS in Sweden is to highlight key components and actions that will significantly contribute to the development, identification and realisation of industrial symbiosis exchanges between two or more parties. The Roadmap lays out a path in terms of actions over time, for IS to be fostered in conjunction with supportive concepts such as the circular economy.

Roadmaps for fossil free competitiveness. Based on the decision by the parliament to make Sweden climate neutral by 2045, the Fossil Free Sweden initiative has encouraged business sectors to draw up their own roadmaps as to how they will be fossil free while also increasing their competitiveness. In these roadmaps, the industries describe when and how they will be fossil free, what technological solutions need to be developed, what investments need to be made and what obstacles need to be removed. The roadmaps also contain proposals regarding commitments for the stakeholders and political solutions.

Within the framework, the roadmap for construction and civil engineering sector has also been established. Development from linear to circular processes is also seen as one of the five key factors for achieving a carbon-neutral value chain. Goals for the following years are[20]:

- 2020–2022: Key players within the Construction and civil engineering sector have mapped their emissions and established carbon goals.
- 2025: Greenhouse gas emissions clearly demonstrate a declining trend.
- 2030: 50 percent reduction in greenhouse gas emissions
- 2040: 75 percent reduction in greenhouse gas emissions
- 2045: Net zero greenhouse gas emissions

In Sweden, it is also possible to apply for various **investing funds from Swedish government** to work with innovation and circular economy/circular material flows etc. One option is for example Vinnova, Sweden's government agency for

19 https://www.norden.org/en/nordic-working-group-for-circular-economy-NCE

20 http://fossilfritt-sverige.se/in-english/roadmaps-for-fossil-free-competitiveness/roadmap-the-construction-and-civil-engineering-sector-summary/

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innovation, that funds innovation projects and the research needed to develop new solutions. They stimulate collaborations between companies, universities and other higher education institutions, public services, civil society and other actors, but also strengthening international cooperation. In Vinnova, tomorrow's sustainable economy is one of the focus areas where the key is the sustainable society through circular and bio-based economy [21].

For the above mentioned reasons, considering positive and negative aspects in the support of government to improve Industrial symbiosis and Circular economy, the assigned score for this criteria is 3 (see Evaluation Matrix table at the end of this section).

Role of enterprises in promoting industrial symbiosis and circular economy - Sweden

There are over 400 companies, organizations and municipalities who have signed the **Roadmap for fossil free competitiveness** (described above) and want to work towards climate neutral industries. Those companies are from 13 different industries and sectors, including aggregates industry, cement industry, concrete industry, the construction and civil engineering sector, steel industry [22]. Moreover, more than 100 actors have signed the Roadmap for The Construction and Civil Engineering Sector. In order to join the itinerary work, it must be anchored in the management team that they will contribute to achieving the goals stated in the itinerary and that they will work with the relevant calls described in the document [23]. This shows a large interest among Swedish companies to move towards more sustainable sector.

Some big building companies are promoting circular economy and are taking strong actions towards that. For example, NCC and Skanska – two biggest building companies in Sweden. NCC tried for some years to build up a platform (Loop Rocks) to sell used materials like soil, stones and filling materials. However, after failing to broaden ownership in Loop Rocks, the business is now closed down. Nevertheless, the company has a goal that by 2020 70% of NCC's building and construction waste will be reused or recycled and waste per SEK is reduced.

In 2017, Skanska got a price as the most sustainable company by Sustainable Brand Index. Among other ways in which the company is working sustainability, they developed a "Green map" in 2010. Today it a one of the most important tool to drive the business towards a more sustainable and ecological construction. The green map is a strategic tool used throughout the Group and is established by the top management as a way of describing what they mean by green construction, as well as measuring and following up development in four areas: energy, climate, materials and water.

For the above mentioned reasons, considering positive and negative aspects in the role of Enterprises in promoting Industrial symbiosis and Circular economy, the assigned score for this criteria is 3 (see Evaluation Matrix table at the end of this section).

Clustering of industries based on territory - Sweden

Some of the companies are clustered nearby, for example furniture companies, but in general the companies are distributed over the whole country, for example metal production in the north and gypsum plasterboards in the south. Also plastic and wood companies are distributed over the whole country.

For the above mentioned reasons, the assigned score for this criteria is 3 (see Evaluation Matrix table at the end of this section).

Recovery and recycling rates - Sweden

Similarly to EU, Sweden has a target to recycle 70% of building and demolition waste by 2020. The recycling rate for non-hazardous building and demolition waste was calculated for the years 2012, 2014 and 2016 consistently at approximately 50%. However, the data base is rather uncertain. Large flows of construction and demolition waste are not included for various reasons, not least the flows where recycling is estimated to be very high. These include crushed concrete and other waste such as asphalt, which is taken care of by smaller treatment plants. The fact that the amount

[21] https://www.vinnova.se/en/m/circular-and-bio-based-economy/

[22] http://fossilfritt-sverige.se/in-english/roadmaps-for-fossil-free-competitiveness/

[23] https://www.sverigesbyggindustrier.se/fardplan2045/vilka-ar-med__8186

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of wood waste increased clearly in 2016 also does not contribute to the recycling target, since in Sweden, energy is largely recycled to a large extent.[24]

The Swedish Environmental Protection Agency estimates that Sweden does not reach the target of at least 70 percent recycling of construction and demolition waste.

For the above mentioned reasons, considering positive and negative aspects in the recovery and recycling rates, the assigned score for this criteria is 2 (see Evaluation Matrix table at the end of this section).

Awareness of industrial symbiosis and circular economy principles among citizens - Sweden

One year ago there was a survey showing that 30% of people in Sweden know the definition of industrial symbiosis and circular economy. However, we believe that, within a year, it has become better since there has been a lot of coverage by media around the topic, especially circular economy. Circular economy is also firmly on the agenda on two of Swedens 8 governing parties (Miljöpartiet och Centerpartiet) – and, as it was the election year 2018, the concept got a share of coverage.

However, similarly to Belgium, industrial symbiosis is one of the most complex aspect of CE and not many people are familiar with that. The public debate is more around circular economy and industrial symbiosis in more around universities and industries, municipalities who are already working with that. For example, in Roadmap for Increased Uptake of Industrial Symbiosis in Sweden, the authors point out that good examples of industrial symbiosis in the area of resources and waste exist in Sweden, but the knowledge is local and specific and there is no generalized structure for development and dissemination.

For the above mentioned reasons, considering positive and negative aspects in the Awareness of IS and CE principles among citizens, the assigned score for this criteria is 3 (see Evaluation Matrix table at the end of this section).

Skills on information technology - Sweden

The Digital Economy and Society Index (DESI) is a composite index summarizing relevant indicators on Europe's digital performance and EU Member States' digital competitiveness. According to DESI, Sweden ranks 2nd out of the 28 EU Member States. Among all dimensions, Sweden ranks highest in Human capital (2nd) with 77 % of the population having at least basic digital skills and 46 % advanced skills. Sweden also has the second highest number of ICT specialists in the EU (6.6 %), but still suffers from a lack of professionals with advanced digital skills.[25]

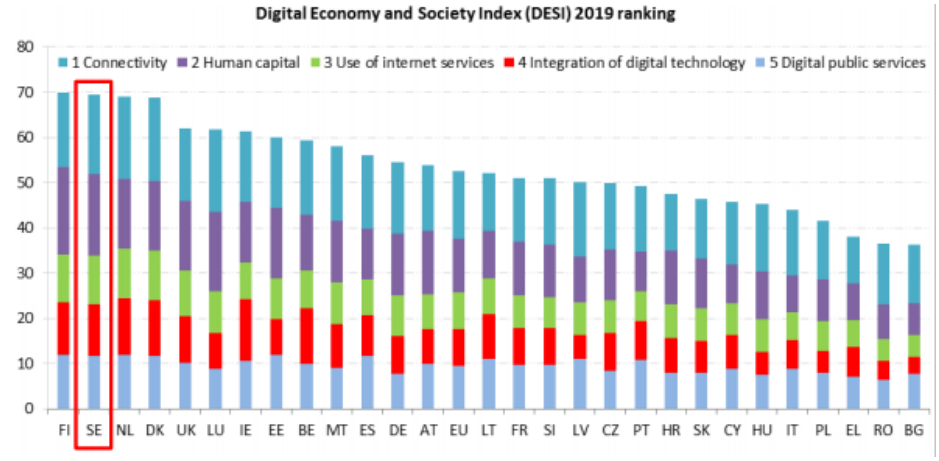

Figure 13: Digital Economy and Society Index (DESI) 2019 Ranking[26]

[24] https://www.boverket.se/sv/byggande/hallbart-byggande-och-forvaltning/miljoindikatorer---aktuell-status/avfall/

[25] https://ec.europa.eu/digital-single-market/en/desi

[26] Digital Economy and Society Index (DESI) 2019 Country Report - Sweden https://ec.europa.eu/digital-single-market/en/scoreboard/sweden

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According to a survey done by Svensk Byggtjänst, the construction sector in Sweden is the worst industry in the country in terms of digitalisation. On one hand, 62% of 300 companies who took part of the survey, is well aware of what digitalisation means and only 6% of companies have low knowledge of the concept of digitalization. On the other hand, less than half of them can offer digitization services in their range of services. And only 35 percent state that they are currently actively working on digitalization in business and business plans.[27] However, digitalisation of the sector has become important and bigger actors already work with that. For example, NCC has developed a Building Information Modelling to visualize timescales, coordinate work, calculate quantities, etc. Moreover, NCC is working also with drones to photograph their construction sites.

For the above mentioned reasons, considering positive and negative aspects in the skills on information technologies, the assigned score for this criteria is 3 (see Evaluation Matrix table at the end of this section).

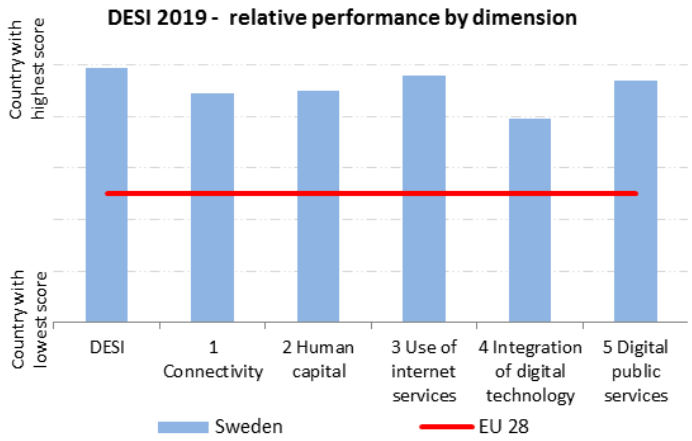

Figure 14: DESI 2019 – Relative Performance by Dimension (Sweden)[28]

Table 5: Evaluation Matrix for replicability potential in different EU countries (Sweden)

Criterion	Grade	Description	Assigned score and explanation
Support of government to improve Industrial symbiosis and circular economy	1	Absence of support from the government	In 2018, the Swedish government decided to set up a *circular economy delegation* with the aim of strengthening the national and regional transition of society to a resource-efficient, circular and bio-based economy. In 2018, IVL (Swedish Environmental Research Institute) together with Linköping University, RISE (Research Institutes of Sweden) and Hifab, has developed a *Roadmap for Increased Uptake of Industrial Symbiosis in Sweden*
	2	Insufficient support from the government	
	3	Fair support from the government	
	4	Good support from the government	
	5	Excellent support from the government	
Role of enterprises in promoting industrial symbiosis and circular economy	1	Absent	There are over 400 companies, organizations and municipalities who have signed the Roadmap for fossil free competitiveness (described
	2	Insufficient	
	3	Fair	
	4	Good	

27 http://info.byggtjanst.se/rs/626-CSV-637/images/d5_digtaliseringsundersokning.pdf

28 Digital Economy and Society Index (DESI), 2019 Country Report - Sweden https://ec.europa.eu/digital-single-market/en/scoreboard/sweden

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Criterion	Grade	Description	Assigned score and explanation
	5	Excellent	above) and want to work towards climate neutral industries. Some big building companies are promoting circular economy and are taking strong actions towards that. For example, NCC and Skanska – two biggest building companies in Sweden
Clustering of industries on territory	1	Highly spread in isolated areas	Some of the companies are clustered nearby, for example furniture companies, but in general the companies are distributed over the whole country, for example metal production in the north and gypsum plasterboards in the south.
	2	Mostly spread in isolated areas	
	3	Balanced distribution on territory	
	4	Mostly clustered in easily accessible areas	
	5	Highly clustered in easily accessible areas	
Recovery and recycling rates	1	Absence of information easily accessible and retrievable	Similarly to EU, Sweden has a target to recycle 70% of building and demolition waste by 2020. The recycling rate for non-hazardous building and demolition waste was calculated for the years 2012, 2014 and 2016 consistently at approximately 50%. However, the data base is rather uncertain. The Swedish Environmental Protection Agency estimates that Sweden does not reach the target of at least 70 percent recycling of construction and demolition waste.
	2	Rates steadily below the EU targets for most of waste flows, and/or decreasing trends	
	3	Rates overall in line with the EU targets	
	4	Rates overall in line with the EU targets and increasing trends for most of waste flows	
	5	Rates above the EU targets and increasing trends for most of waste flows	
Awareness of industrial symbiosis and circular economy among citizens	1	No or very low awareness	A recent survey showing that 30% of people in Sweden know the definition of industrial symbiosis and circular economy. Industrial symbiosis is one of the most complex aspect of CE and not many people are familiar with that. Good examples of industrial symbiosis in the area of resources and waste exist in Sweden, but the knowledge is local and specific and there is no generalized structure for development and dissemination.
	2	Low and inadequate awareness	
	3	Adequate awareness	
	4	Good awareness	
	5	Excellent awareness	
Skills on information technology	1	No or very low skills	Sweden ranks 2nd out of the 28 EU Member States. Among all dimensions, Sweden ranks highest in Human capital (2nd) with a high percentage of the population having at least basic digital skills. Sweden also has the second highest number of ICT specialists in the EU, but still suffers from a lack of professionals with advanced digital skills.
	2	Low and inadequate skills	
	3	Adequate skills	
	4	Good skills	
	5	Excellent skills	

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3.5 Germany

Support of government to improve Industrial symbiosis and circular economy - Germany

The Circular Economy Action Plan emphasizes the need to move towards a life-cycle-driven 'circular' economy, reusing resources as much as possible and bringing residual waste close to zero.

One key program to promote the transition to a circular economy is the 2016-2019 ProgRess II resource efficiency programme[29], which is now in its second phase.

The national program for sustainable consumption (*Nationales Programm für nachhaltigen Konsum*)[41], introduced in 2016, seeks to give consumers more information on the impacts of their consumption, while mapping alternatives to increase efficiency and sustainable consumption. The programme sets out action in six areas to help Germany achieve its sustainable consumption objectives.

Another important feature is due to the number of EU Ecolabel products and EMAS-licensed in a country; this number can give a rough measurement of the circular economy transition. These two indicators also show the commitment of public authorities to policies that support the circular economy. Germany is put fourth after Spain, Italy and France as regards the licences registered in the EU Ecolabel scheme.

For the above mentioned reasons, the assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Role of enterprises in promoting industrial symbiosis and circular economy - Germany

Regional networks show a good integration of public and private activities, where also potential benefits to local enterprises are recognized as incentives.

The number of investing firms is increasing, this indicates that German SMEs are catching up when it comes to using the opportunities of resource efficiency. Germany stands out for the balance between public and private sources. Enterprises rely little on private-sector consultants and much more on the public administration and business associations. This makes the latter largely responsible for developing the next generation of support instruments for more advanced aspects of the circular economy. Companies' openness to cooperating with external partners is a strength in this respect.

For the above mentioned reasons, the assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Clustering of industries on territory - Germany

There are industrial areas with a strong focus on industrial activities, mostly historically rooted in local resource availability (coal and steel industry). On the other hand there are industrial clusters directly established due to the processes (e.g. chemical industry, mechanical or car manufacturing). The third typical example are local structures related to infrastructure aspects, e.g. harbour areas with industrial activities within those premises.

For the above mentioned reasons, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Recovery and recycling rates - Germany

According to the Eurostat ESMS Indicator Profile, the recycling and recovery rate of construction and demolition waste for Germany are slightly higher than the average.

The indicator is the ratio of construction and demolition waste which is prepared for re-use, recycled or subject to material recovery, including through backfilling operations, divided by the construction and demolition waste treated as defined in Regulation (EC) No 2150/2002 on waste statistics.

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29 The EU Environmental Inplementation Review (EIR) 2019 – Country Report Germany, European Commission, https://ec.europa.eu/environment/eir/pdf/report_germany_en.pdf

The key drivers of Germany's environment policy provide impetus for eco-innovation in the country. Its population is highly receptive to environment-friendly consumption, its dependency on imported resources drives efforts to better use secondary resources, and it engages in extensive inter- and trans-disciplinary research relating to social-ecological challenges.

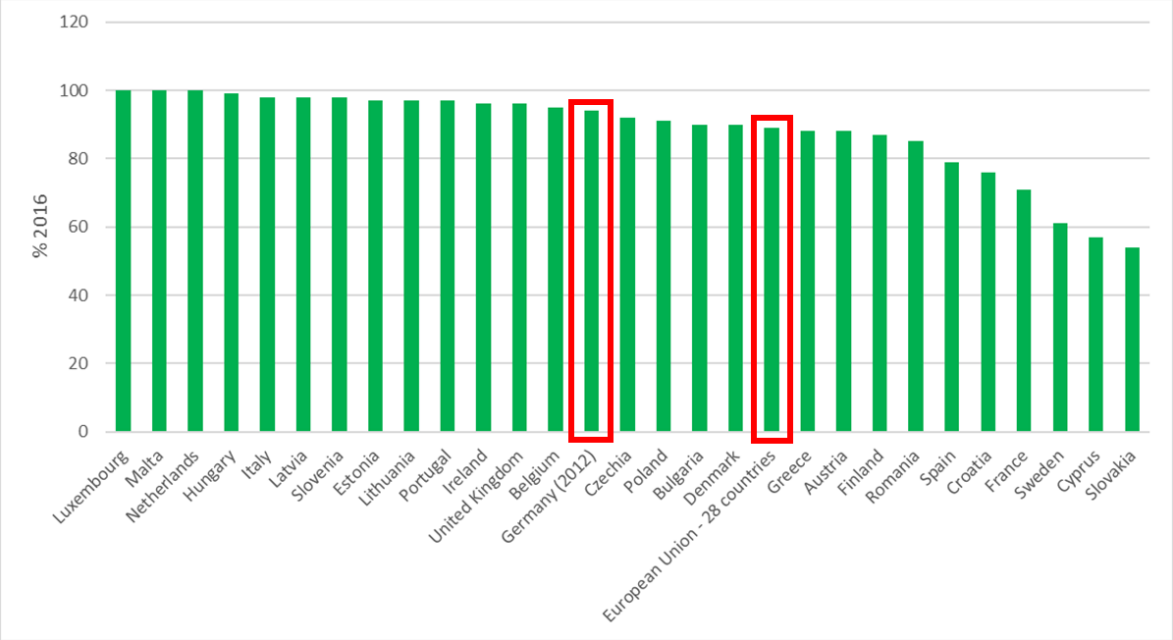

Figure 15: Eurostat data on recovery rate of construction and demolition waste (CDW) – Germany vs EU

For the above mentioned reasons, the assigned score for this criteria is **5** (see Evaluation Matrix table at the end of this section).

Awareness of industrial symbiosis and circular economy among citizens - Germany

It is important to note that, in general, the "Circular Economy awareness level" among citizens is more widespread and established than Industrial Symbiosis. Industrial symbiosis is one of the most complex aspect of CE and not many people are familiar with that. In any case, however, the awareness of the content and goals of the IS concept can be considered to largely be in place.

The public debate is more around circular economy and industrial symbiosis in more around universities and industries, municipalities who are already working with it. In fact, German municipalities are generally involved in EU initiatives on environment protection and climate change. In 2011, Hamburg became the first German city to win the Green Capital Award and Essen was awarded the title in 2017.

For the above mentioned reasons, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Skills on information technology - Germany

Germany ranks 12th out of the 28 EU Member States in the European Commission Digital Economy and Society Index (DESI) 2019.

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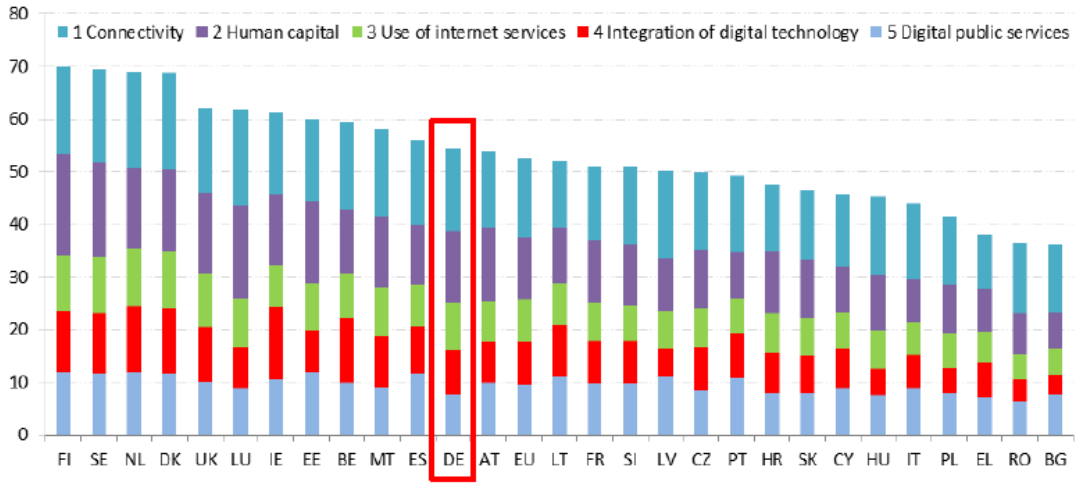

Figure 16: Digital Economy and Society Index (DESI) 2019 Ranking (Germany)[30]

Germany performs well in most DESI dimensions, thanks to the wide availability and high take-up of basic fixed broadband. The country performs above average in digital skills and has increased its score in the Integration of digital technologies by enterprises.

As regards digital skills, Germany is among the EU's top performers. The share of ICT specialists has also increased since 2017. Among all dimensions, Germany ranks highest (ninth) in the Use of internet services, as Germans are keen to engage in online activities; only 5 % of them have never used the internet.

The country's greatest digital challenge is to improve online interaction between public authorities and members of the public. Germany ranks 26th in the use of e-government services, with only 43 % of internet users being e-government users, while a mere 7% of individuals use e-health services.

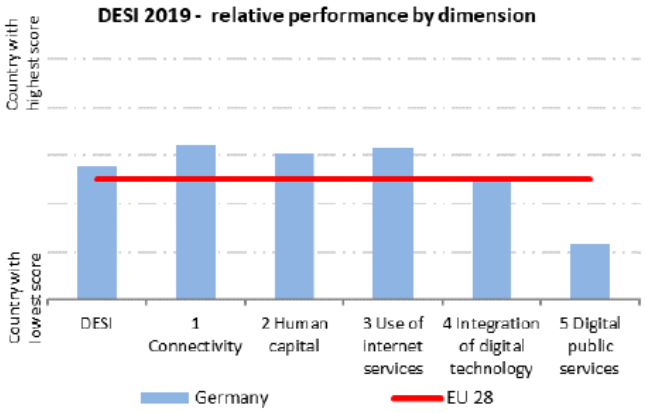

Figure 17: DESI 2019 – Relative Performance by Dimension (Germany)[30]

For the above mentioned reasons, the assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

[30] Digital Economy and Society Index (DESI), 2019 Country Report - Germany https://ec.europa.eu/digital-single-market/en/scoreboard/germany

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Table 6: Evaluation Matrix for replicability potential in different EU countries (Germany)

Criterion	Grade	Description	Assigned score and explanation
Support of government to improve Industrial symbiosis and circular economy	1	Absence of support from the government	The Circular Economy Action Plan emphasizes the need to move towards a life-cycle-driven 'circular' economy, reusing resources as much as possible and bringing residual waste close to zero. One key program to promote the transition to a circular economy is the 2016-2019 ProgRess II resource efficiency program. Support is provided by government both from national and federal point of view. The commitment of public authorities to policies that support the circular economy is also active.
	2	Insufficient support from the government	
	3	Fair support from the government	
	4	Good support from the government	
	5	Excellent support from the government	
Role of enterprises in promoting industrial symbiosis and circular economy	1	Absent	Regional networks show a good integration of public and private activities; also potential benefits to local enterprises are recognized as incentives. The number of investing firms is increasing; this indicates that German SMEs are catching up when it comes to using the opportunities of resource efficiency.
	2	Insufficient	
	3	Fair	
	4	Good	
	5	Excellent	
Clustering of industries on territory	1	Highly spread in isolated areas	There are industrial areas with a strong focus on industrial activities, mostly historically rooted in local resource availability (coal and steel industry). On the other hand, there are industrial clusters directly established due to the processes (e.g. chemical industry, mechanical or car manufacturing
	2	Mostly spread in isolated areas	
	3	Balanced distribution on territory	
	4	Mostly clustered in easily accessible areas	
	5	Highly clustered in easily accessible areas	
Recovery and recycling rates	1	Absence of information easily accessible and retrievable	According to the Eurostat ESMS Indicator Profile, the recycling and recovery rate of construction and demolition waste for Germany are slightly higher than the average.
	2	Rates steadily below the EU targets for most of waste flows, and/or decreasing trends	
	3	Rates overall in line with the EU targets	
	4	Rates overall in line with the EU targets and increasing trends for most of waste flows	
	5	Rates above the EU targets and increasing trends for most of waste flows	
Awareness of industrial symbiosis and circular economy among citizens	1	No or very low awareness	Circular Economy awareness level among citizens is more widespread and established than Industrial Symbiosis. Industrial symbiosis is one of the most complex aspect of CE and
	2	Low and inadequate awareness	
	3	Adequate awareness	
	4	Good awareness	

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Criterion	Grade	Description	Assigned score and explanation
	5	Excellent awareness	not many people are familiar with that. In any case, however, the awareness of the content and goals of the IS concept can be considered to largely be in place.
Skills on information technology	1	No or very low skills	Germany ranks 12nd out of the 28 EU Member States in the European Commission Digital Economy and Society Index (DESI) 2019.
	2	Low and inadequate skills	
	3	Adequate skills	
	4	Good skills	
	5	Excellent skills	

3.6 United Kingdom

Support of government to improve Industrial symbiosis and circular economy - UK

The measures promoted by the government, aimed to improve Circular economy and Industrial symbiosis, are various; the main measures are described below. It is worth mentioned that the circular (secondary) use of material in the United Kingdom was 17.2 % in 2016 (EU-28 average 11.7 %).

The 2016 updated **Greening Government Commitment** includes commitments to increase the sustainability of the government estate. The target to reduce overall waste arising by 32 % is particularly relevant for the circular economy, as is the target to increase recycling to 59 % of all waste[31].

In 2017, the **London Waste and Recycling Board** published a strategic roadmap entitled 'Towards a Circular Economy', which sets out London's route to a circular economy.

In 2017, the **Welsh government's economic action plan** introduced the circular economy as a key target for investments. In particular, the action plan set up a GBP 6.5 million capital fund for 2019-2020 to promote the circular economy in the country[43].

The **LIFE REBus project** aims to create more resource efficient business models. After a trial phase in the UK and the Netherlands, more than 62,000 ton of materials have been saved. Scaling up the benefits could result in 184 million ton of direct material savings and 172 million ton of material being diverted (for reuse, recycling, etc.) in the EU.

The Government funded **National Industrial Symbiosis Program (NISP)** which provided a consultancy service that linked businesses with a waste material to other businesses that were able to use this material in their processes. Attempts were made to set up symbiosis industrial parks but these did not move beyond the feasibility stage.

Innovate UK and the waste & resources action programme (WRAP) are especially active in encouraging sustainable resource use, including waste prevention, reuse, recovery and recycling. These initiatives aim to create a circular economy and help develop new markets for existing waste products ("the great recovery project", REALCAR, Zero Waste Scotland).

There are several smaller regional bodies in the UK that work with local businesses to increase environmental awareness for example ENTRESS in the West Midlands that works with small enterprises to develop symbiosis.

31 The EU Environmental Inplementation Review (EIR) 2019 – Country Report United Kingdom, European Commission, https://ec.europa.eu/environment/eir/pdf/report_uk_en.pdf

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Furthermore, the number of EU Ecolabel products and EMAS-licensed in a country can give a rough measurement of the circular economy transition. These two indicators also show the commitment of public authorities to policies that support the circular economy. As of September 2018, the UK had 110 products and 26,20 licences registered in the EU

Ecolabel scheme, out of a total of 71,707 products covered by 2,167 licences in the EU.

For the above mentioned reasons, the assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Role of enterprises in promoting industrial symbiosis and circular economy - UK

Only 4 % of British companies have not taken any resource efficiency measures recently – the lowest rate in the EU-28. Moreover, only 12% express the intention not to take any further measures. The Eurobarometer also shows that British SMEs are the most ambitious in terms of minimizing waste and increasing recycling in the future.

The main drivers for eco-innovation in the UK are the growing market demand for eco-industry and clean-tech sector products, building and construction sector.

However, there are barriers to eco-innovation. The main are: i) the cost of virgin versus secondary materials; ii) difficulty in accessing financing and capital investment; and iii) mainstream accounting and financial reporting procedures, which often do not favor circular business models.

Another difficulty is that industrial symbiosis initiatives are limited in mainstream industry. Individual companies set up relationships between themselves when an established secondary raw material source is already known to be functional in another industry, for example the use of steel furnace slag in the glass industry, or the use of power station ash in cement manufacture.

For the above mentioned reasons, the assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

Clustering of industries on territory - UK

UK Industry sectors are spread around the country rather than in clusters. However, most heavy industry (for example, Steel, Glass, paper manufacturing, power generation) tends to be in the North of England, South Wales and Southern Scotland.

For the above mentioned reasons, the assigned score for this criteria is 3 (see Evaluation Matrix table at the end of this section).

Recovery and recycling rates - UK

The UK is among the best performing Member States on resource efficiency (how efficiently the economy uses material resources to produce wealth) with 3.63 EUR/kg in 2017 (EU average 2.04).

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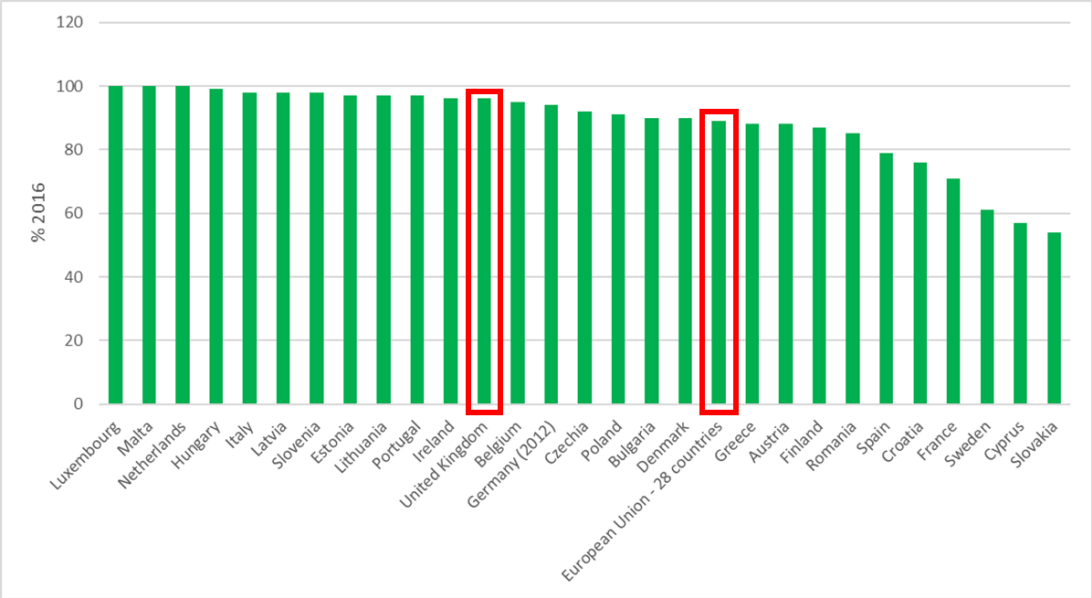

Figure 18: Eurostat data on recovery rate of construction and demolition waste (CDW) – UK vs EU

As regards Construction and Demolition waste (CDW), the recovery and recycling rate of the United Kingdom is higher than the average European Union recovery and recycling rate, as shown in the figure above.

For the above mentioned reasons, the assigned score for this criteria is **5** (see Evaluation Matrix table at the end of this section).

Awareness of industrial symbiosis and circular economy among citizens - UK

There is a general awareness of environmental issues and recycling, but a limited specific awareness of industrial symbiosis and circular economy, even if in the last decades circular economy has become an increasingly topic of debate in the UK.

For the above mentioned reasons, the assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

Skills on information technology - UK

The United Kingdom ranks fifth out of the 28 EU Member States in the European Commission Digital Economy and Society Index (DESI) 2019.

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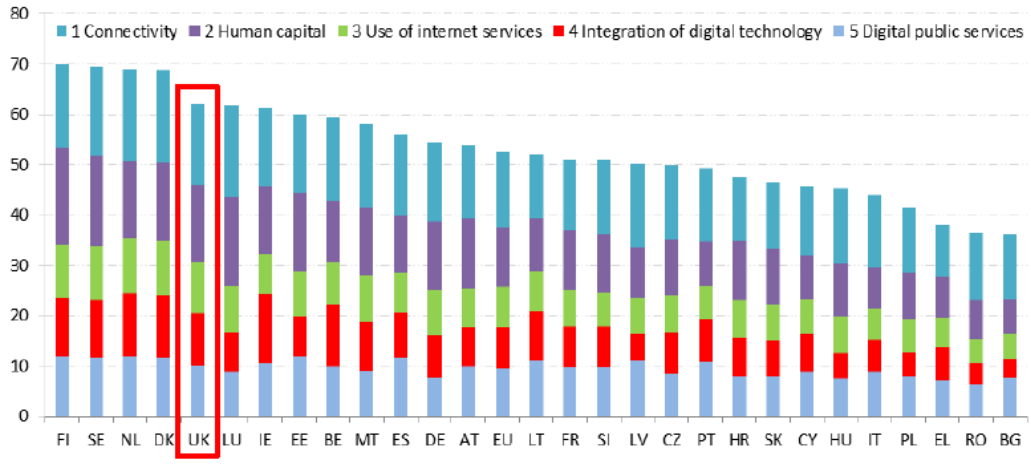

Figure 19: Digital Economy and Society Index (DESI) 2019 Ranking (UK)[32]

In Connectivity the UK ranks 10th, above the EU average. However, while it performs well in most indicators, on ultrafast broadband coverage and take-up it lags behind. In Human capital the UK ranks sixth with a large share of people in the UK having basic digital skills or above. However, strong demand for ICT specialists on the labor market has led to supply shortages and measures put in place to combat this have not yet had a significant impact.

In the Integration of digital technology by businesses the UK ranks seventh. While use of social media and cloud services are high, uptake of electronic information sharing is low. Uptake of other technologies is average. Finally, in Digital public services the UK ranks 11th, performing somewhat above average for the EU. The UK Digital Strategy was published in March 2017. The strategy has seven strands addressing: connectivity, digital skills and inclusion, the digital sectors, the wider economy, a safe and secure cyberspace, digital government and data.

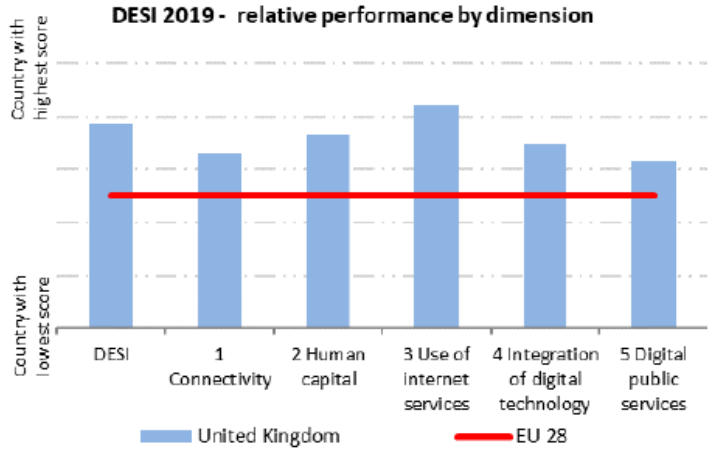

Figure 20: DESI 2019 – Relative Performance by Dimension (UK)[32]

For the above mentioned reasons, the assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

[32] Digital Economy and Society Index (DESI), 2019 Country Report - UK https://ec.europa.eu/digital-single-market/en/scoreboard/united-kingdom

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Table 7: Evaluation Matrix for replicability potential in different EU countries (UK)

Criterion	Grade	Description	Assigned score and explanation
Support of government to improve Industrial symbiosis and circular economy	1	Absence of support from the government	There are several government funding initiatives in the UK aimed at developing technology and education in Industrial Symbiosis and circular economy.
	2	Insufficient support from the government	
	3	Fair support from the government	
	4	Good support from the government	
	5	Excellent support from the government	
Role of enterprises in promoting industrial symbiosis and circular economy	1	Absent	Industrial symbiosis initiatives are limited in mainstream industry. Individual companies set up relationships between themselves where an established secondary raw material source is already known to be functional in another industry. Despite many drivers for eco-innovation, there are barriers.
	2	Insufficient	
	3	Fair	
	4	Good	
	5	Excellent	
Clustering of industries on territory	1	Highly spread in isolated areas	Most heavy industry (for example, Steel, Glass, paper manufacturing, power generation) tends to be in the North of England, South Wales and Southern Scotland.
	2	Mostly spread in isolated areas	
	3	Balanced distribution on territory	
	4	Mostly clustered in easily accessible areas	
	5	Highly clustered in easily accessible areas	
Recovery and recycling rates	1	Absence of information easily accessible and retrievable	As regards Construction and Demolition waste (CDW), the recovery and recycling rate of the United Kingdom is higher than the average European Union recovery and recycling rate
	2	Rates steadily below the EU targets for most of waste flows, and/or decreasing trends	
	3	Rates overall in line with the EU targets	
	4	Rates overall in line with the EU targets and increasing trends for most of waste flows	
	5	Rates above the EU targets and increasing trends for most of waste flows	
Awareness of industrial symbiosis and circular economy among citizens	1	No or very low awareness	There is general awareness of environmental issues and recycling. But limited specific awareness of symbiosis and circular economy.
	2	Low and inadequate awareness	
	3	Adequate awareness	
	4	Good awareness	

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Criterion	Grade	Description	Assigned score and explanation
	5	Excellent awareness	
Skills on information technology	1	No or very low skills	The United Kingdom ranks fifth out of the 28 EU Member States in the European Commission Digital Economy and Society Index (DESI) 2019.
	2	Low and inadequate skills	
	3	Adequate skills	
	4	Good skills	
	5	Excellent skills	

3.7 Czech Republic

Support of government to improve Industrial symbiosis and circular economy - Czech Republic

The country has no specifically dedicated national circular economy strategy or roadmap yet. Preparations for establishing a national circular economy strategy called "Circular Czech Republic 2040" are still at an early stage, adoption is scheduled for 2021 by the Government. Nevertheless, some of the circular economy measures are addressed in the existing strategies. For example, transitioning to a circular economy is one of the main objectives in the country's new Waste Management Plan for the 2015-2024 period. Another document is the Secondary raw material policy, which deals with an effective and sustainable using of secondary raw materials as a substitution of primary sources.
CR has some circular economy initiatives in place. The main challenges that the country faces on eco-innovation and the circular economy are related to the research and innovation system. Eco-innovation and circular economy developments in Czech Republic are primarily focused on buildings and infrastructure, sustainable transport, and several environmental topics (water efficiency, waste management and resource efficiency).

There are barriers to successful introduction of the IS in CR; for example, the legislation (the waste cannot be sold or donated, only if it is treated and becomes secondary product). All non-treated by-products are considered waste, which can be used by a company that produce it only.

For the above mentioned reasons, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Role of enterprises in promoting industrial symbiosis and circular economy - Czech Republic

Czech companies (especially construction companies) generally do not use recycled materials, the change could occur if the public procurement (but also private projects) would state that the requirements are to use recycled materials. Moreover, investors do not require recycled materials and proper handling (separation and recycling) of the construction waste.

There is a substantial interest in the Czech business community in investing in resource efficiency. External cooperation is rather frequent and companies support the idea of getting assistance to cooperate better with partners.
It is important to affirm that 26 % of Czech companies deem support to enable them to cooperate with other companies to be useful, among the highest in the EU.

For the above mentioned reasons, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section

Clustering of industries on territory - Czech Republic

Czech industry is mostly spread in isolated areas, which are called industry zones, which are supported by the state.

For the above mentioned reasons, the assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section.

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Recovery and recycling rates - Czech Republic

The circular use of secondary material in Czech Republic was 7.6 % in 2016 (below the EU-28 average at 11.7% — however, this has been steadily increasing since 2010).

More than half of the total waste production in the CR is construction and demolition waste. However, these are almost completely utilized at present, around 98%.

The Waste Management Plan of the CR for 2015-2024 sets a target for construction and demolition waste: to increase by at least 70% by weight the rate of preparation for re-use and recycling of construction and demolition waste and other types of material recovery, including backfills.

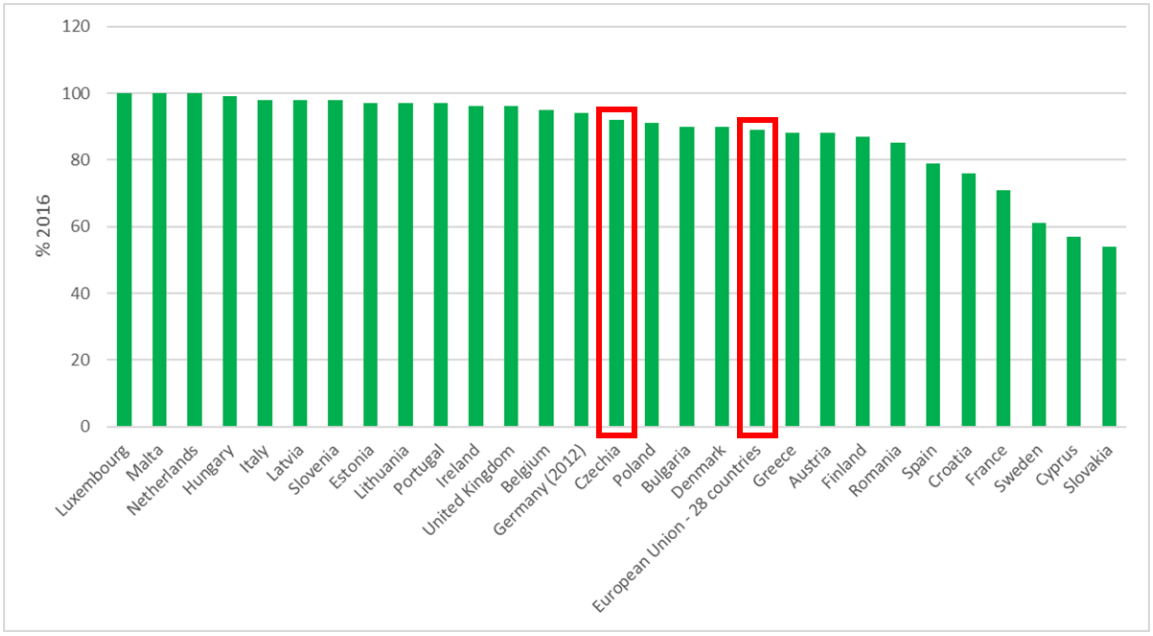

Figure 21: Eurostat data on recovery rate of construction and demolition waste (CDW) –Czechia vs EU

For the above mentioned reasons, the assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section

Awareness of industrial symbiosis and circular economy among citizens - Czech Republic

The education and public research systems have taken some steps to address the challenges of eco-innovation and circular economy.

An important role in the awareness of CE is covered by the Institute of Circular Economy in Prague (web portal, motivation, organization of workshops, conferences involving all stakeholders – Ministry, Universities, Industry companies, Municipality representatives, wide public, media, etc.).

For the above mentioned reasons, the assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section

Skills on information technology - Czech Republic

Czechia ranks 18th out of the 28 EU Member States in the European Commission Digital Economy and Society Index (DESI) 2019.

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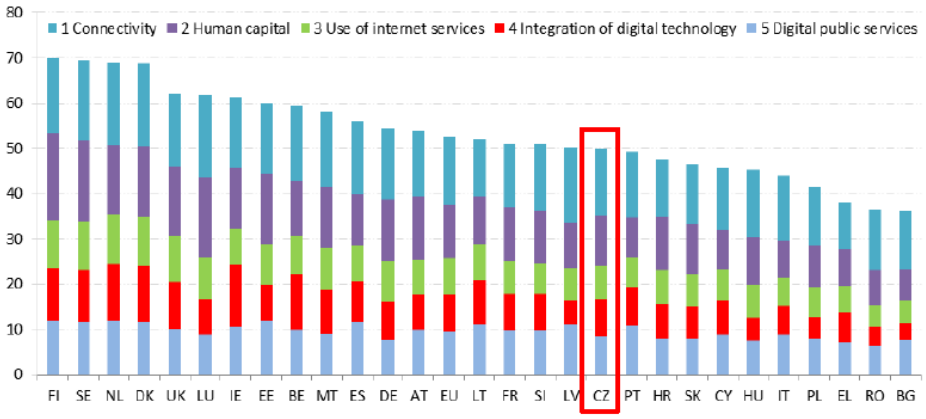

Figure 22: Digital Economy and Society Index (DESI) 2019 Ranking (Czech Republic)[33]

Among all dimensions, Czechia ranks highest in the integration of digital services domain especially thanks to high scores in e-commerce and online shopping. Czechia improved concerning digital public services but still scores below the EU average. More than half of Czech internet users use now e-government services and Czechs are among the EU leaders in reading news online. 4G coverage is one of the best in the EU and Czech SMEs still maintain one of the highest share of turnover from e-commerce in the EU.

However, the insufficient level of digital skills in the population remains an issue and the digitalization of businesses is not progressing as fast as it could. Czechia's new digital strategy ('*Digitální Česko*'1) has been adopted in October 2018 and is divided into 3 chapters: 1/ digitalization of public services, 2/ Czechia in digital Europe and 3/ Digital economy and society.

The government has appointed a new Chief Digital Officer for IT and digitalization in charge of coordinating actions foreseen in the strategy. For the implementation, he closely collaborates with ministries of industry and trade, interior, employment, education and healthcare.

For the above mentioned reasons, the assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section

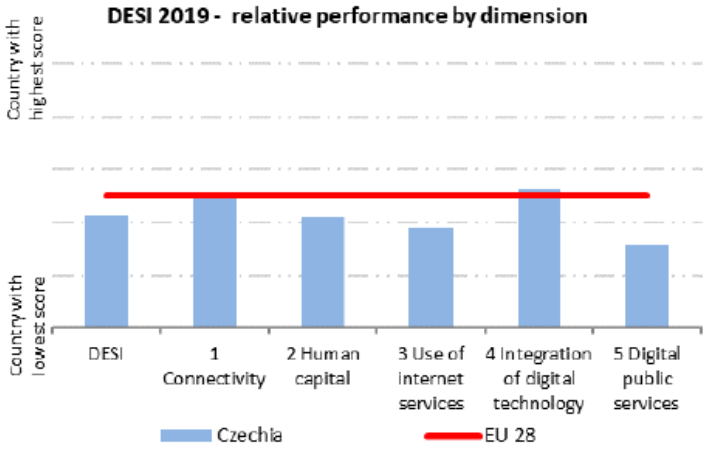

Figure 23: DESI 2019 – Relative Performance by Dimension (Czech Republic)[33]

[33] Digital Economy and Society Index (DESI), 2019 Country Report – Czech republic https://ec.europa.eu/digital-single-market/en/scoreboard/czech-republic

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Table 8: Evaluation Matrix for replicability potential in different EU countries (Czech Republic)

Criterion	Grade	Description	Assigned score and explanation
Support of government to improve Industrial symbiosis and circular economy	1	Absence of support from the government	The country has no specifically dedicated national circular economy strategy or roadmap yet. Nevertheless, some of the circular economy measures are addressed in the existing strategies. CR has some circular economy initiatives in place. The main challenges that the country faces on eco-innovation and the circular economy are related to the research and innovation system. The main barrier to successful introduction of the IS in CR is the legislation.
	2	Insufficient support from the government	
	3	Fair support from the government	
	4	Good support from the government	
	5	Excellent support from the government	
Role of enterprises in promoting industrial symbiosis and circular economy	1	Absent	Czech companies (especially construction companies) generally do not use recycled materials. Moreover, investors do not require recycled materials and proper handling (separation and recycling) of the construction waste. Companies support the idea of getting assistance to cooperate better with partners; 26 % of Czech companies deem support to enable them to cooperate with other companies to be useful, among the highest in the EU.
	2	Insufficient	
	3	Fair	
	4	Good	
	5	Excellent	
Clustering of industries on territory	1	Highly spread in isolated areas	Czech industry is mostly spread in isolated areas.
	2	Mostly spread in isolated areas	
	3	Balanced distribution on territory	
	4	Mostly clustered in easily accessible areas	
	5	Highly clustered in easily accessible areas	
Recovery and recycling rates	1	Absence of information easily accessible and retrievable	The circular use of secondary material in Czech Republic was 7.6 % in 2016 below the EU-28 average at 11.7%, however, this has been steadily increasing since 2010. The Waste Management Plan of the CR for 2015-2024 sets a target for construction and demolition waste.
	2	Rates steadily below the EU targets for most of waste flows, and/or decreasing trends	
	3	Rates overall in line with the EU targets	
	4	Rates overall in line with the EU targets and increasing trends for most of waste flows	

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Criterion	Grade	Description	Assigned score and explanation
	5	Rates above the EU targets and increasing trends for most of waste flows	
Awareness of industrial symbiosis and circular economy among citizens	1	No or very low awareness	The education and public research systems have taken some steps to address the challenges of eco-innovation and circular economy. An important role in the awareness of CE is covered by the Institute of Circular Economy in Prague.
	2	Low and inadequate awareness	
	3	Adequate awareness	
	4	Good awareness	
	5	Excellent awareness	
Skills on information technology	1	No or very low skills	Insufficient level of digital skills in the population.
	2	Low and inadequate skills	
	3	Adequate skills	
	4	Good skills	
	5	Excellent skills	

3.8 Hungary

Support of government to improve Industrial symbiosis and circular economy - Hungary

There is a lack of a clear and coherent governmental support for promoting circular economy initiatives, including industrial symbiosis for companies. A new waste management strategy is being drafted by the Ministry of Innovation and Technology, which may bring some improvements.

Since the Hungarian Foundation for Circular Economy and CEEWeb for Biodiversity organised a conference “Circular Hungary” in 2017, there have been few circular economy initiatives. However, in November of 2018 the "Circular Economy Platform" was established by the Business Council for Sustainable Development in Hungary, the Embassy of the Kingdom of the Netherlands, and the Ministry of Innovation and Technology. The platform's goal is to build a network of forward-thinking companies that can exchange knowledge and forward the cause of a circular economy. Hungary is lagging behind in the area of circular economy. Barriers include a lack of widespread resource-efficient strategic thinking and outdated research infrastructure. Rather than planning for a national strategy, the government is planning to integrate circular economy principles into the economic development strategy[34].

Hungary’s fourth (2015-2020) national environmental program is a strategic six-year plan for environmental and nature protection. It encompasses several different strategies and could therefore be a good starting point for the transition towards a circular economy. This program identifies resource efficiency as a priority.

In spring 2018, the Ministry of Agriculture’s Department for Environmental Development and Strategy submitted the proposal to prepare a circular economy action plan and an interministerial expert group was set up to this end.

Examining the 10 indicators in the circular economy monitoring framework, in 2016, the circular (secondary) use of material in Hungary was 6.4 %, an increase on previous years (EU-28 average 11.7 %). Hungary is above the EU average on the number of people employed in the circular economy (1.93 % of total employment in 2016 compared to an EU average of 1.73 %).

[34] Ecopreneur.EU- European Sustainable Business Federation. Circular Economy Update - Overview of Circular Economy in Europe, 2019- Final report

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For the above mentioned reasons, the assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section.

Role of enterprises in promoting industrial symbiosis and circular economy - Hungary

The Hungarian business community's interest in investing in resource efficiency and circular economy is steady, but informing businesses of available opportunities is a challenge. Hungary has several initiatives to provide information, advice and incentives to companies on resource efficiency/circular economy challenge. The proportion of Hungarian SMEs that take resource-efficiency measures is still below the EU average, as is the proportion of SMEs that offer green products and services.

With some few exceptions, enterprises are neither aware, nor incentivized to promote CE and IS. However, creative and forward-looking companies are seeking to become more resource efficient and use different circular business models. These companies are mostly in the recycling sector, with special focus on the secondary use of demolition materials.

For the above mentioned reasons, the assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section

Clustering of industries on territory - Hungary

Clusters can be mostly found in industrial and easily accessible areas in Hungary.

For the above mentioned reasons, the assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section

Recovery and recycling rates - Hungary

Examining the 10 indicators in the circular economy monitoring framework, in 2016, the circular (secondary) use of material in Hungary was 6.4 %, an increase on previous years (EU-28 average 11.7 %).

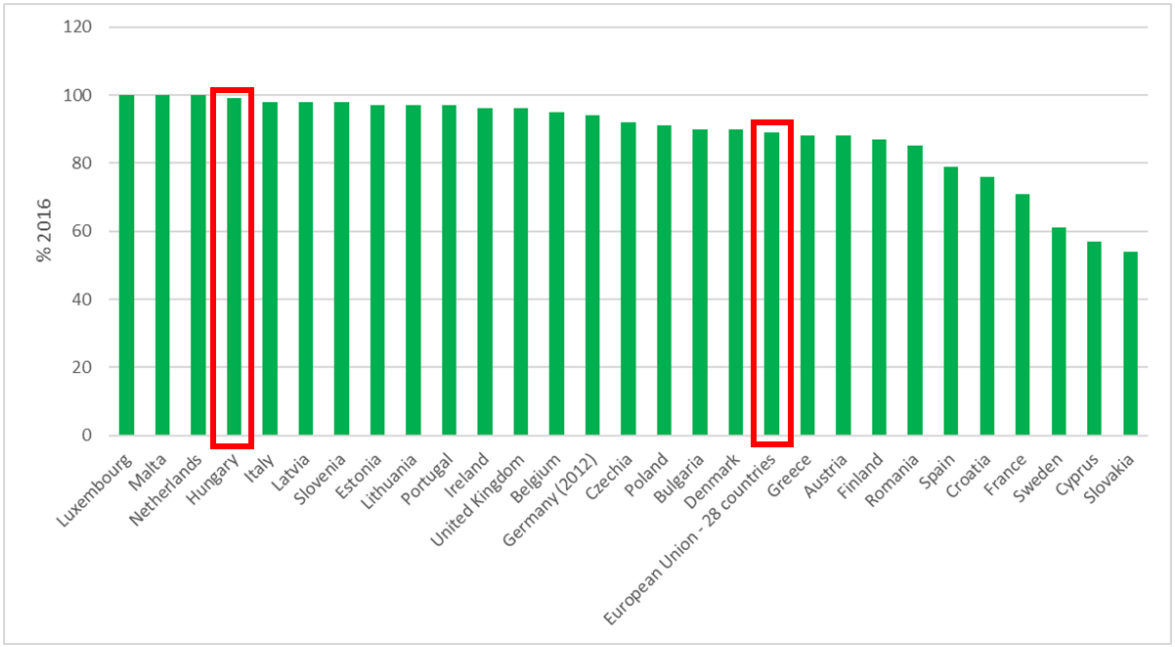

Figure 24: Eurostat data on recovery rate of construction and demolition waste (CDW) – Hungary vs EU

As regards Construction and Demolition waste (CDW), the recovery and recycling rate of Hungary is higher than the average European Union recovery and recycling rate, as shown in the figure above.

For the above mentioned reasons, the assigned score for this criteria is **5** (see Evaluation Matrix table at the end of this section).

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Awareness of industrial symbiosis and circular economy among citizens - Hungary

The general awareness of the concept and importance of a circular economy is low. The country has no specifically dedicated national circular economy strategy or roadmap yet.
The assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

Skills on information technology - Hungary

Hungary ranks 23rd out of 28 EU Member States in the Digital Economy and Society Index (DESI) 2019.

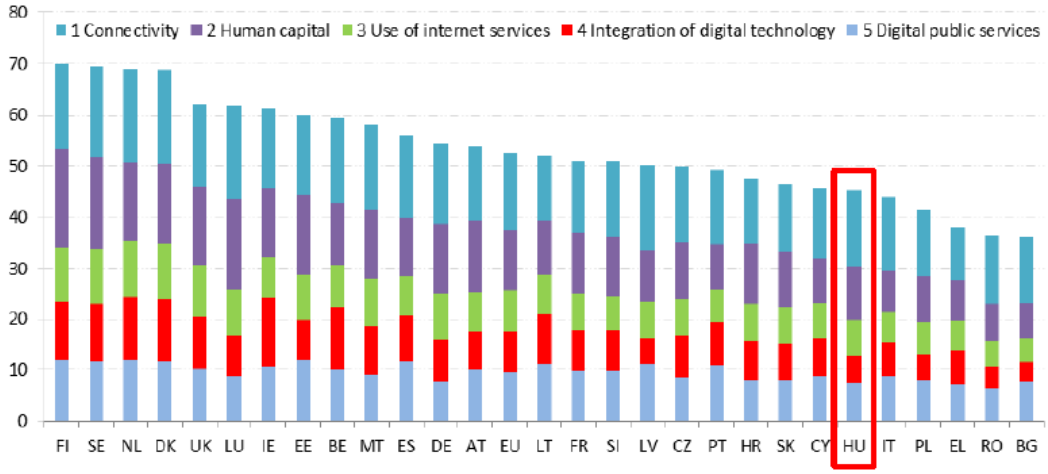

Figure 25: Digital Economy and Society Index (DESI) 2019 Ranking (Hungary)[35]

Hungary performs best (slightly above the EU average) in the broadband Connectivity dimension, thanks to its widespread adoption of fast and ultrafast broadband and to its high coverage of next generation access (NGA) and ultrafast broadband infrastructure. The most challenging areas remain Digital public services and the Integration of digital technology in businesses. In both of these dimensions, Hungary scores well below the EU average, and it is among the worst performing Member States. The quality of e-government services is low and take-up is below average. Only 14 % of companies (the lowest share in the EU) use an enterprise resource planning software package to share information between different functional areas. The use of e-commerce, big data and cloud services shows a similar pattern. As regards Human capital, Hungary has a high proportion of ICT graduates and a close to average share of ICT specialists, though there is room for improvement as regards internet user skills.

In 2014, Hungary adopted its National Info-communication Strategy 2014-2020. In 2019, the country adopted its 5G strategy and it is planned to develop strategies on the Hungarian content industry, the health industry, artificial intelligence, fintech and blockchain. The implementation of several large-scale projects has continued. Examples include the Superfast Internet Program, the Modern Enterprises Program, the Support for Business Digital Development Program and developments in e-government and e-health. On 31 October 2018, an Artificial Intelligence Coalition was established by 124 founders.

[35] Digital Economy and Society Index (DESI), 2019 Country Report - Hungary https://ec.europa.eu/digital-single-market/en/scoreboard/hungary

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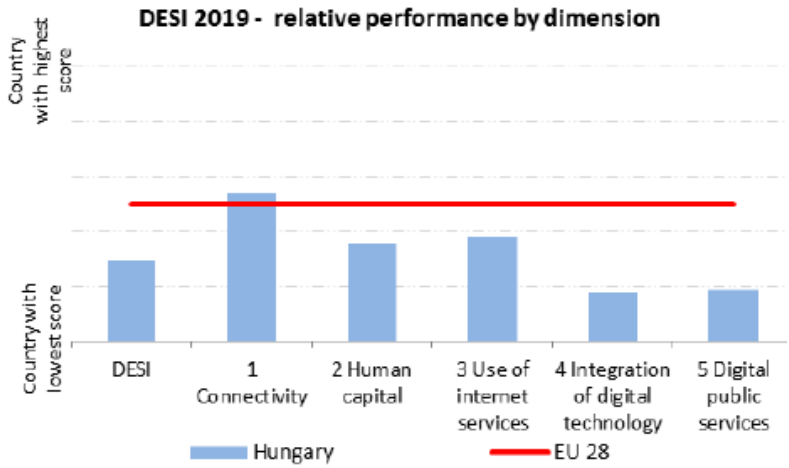

Figure 26: DESI 2019 – Relative Performance by Dimension (Hungary)[35]

For the above mentioned reasons, the assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Table 9: Evaluation Matrix for replicability potential in different EU countries (Hungary)

Criterion	Grade	Description	Assigned score and explanation
Support of government to improve Industrial symbiosis and circular economy	1	Absence of support from the government	Hungary is lagging behind in the area of circular economy. There is a lack of a clear and coherent governmental support for promoting circular economy initiatives, including industrial symbiosis for companies. In November of 2018 the "Circular Economy Platform" was established by the Business Council for Sustainable Development in Hungary, the Embassy of the Kingdom of the Netherlands, and the Ministry of Innovation and Technology. The platform's goal is to build a network of forward-thinking companies that can exchange knowledge and forward the cause of a circular economy.
	2	Insufficient support from the government	
	3	Fair support from the government	
	4	Good support from the government	
	5	Excellent support from the government	
Role of enterprises in promoting industrial symbiosis and circular economy	1	Absent	The proportion of Hungarian SMEs that take resource-efficiency measures is still below the EU average. With some few exceptions, enterprises are neither aware, nor incentivized to promote CE and IS.
	2	Insufficient	
	3	Fair	
	4	Good	
	5	Excellent	
Clustering of industries on territory	1	Highly spread in isolated areas	
	2	Mostly spread in isolated areas	

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Criterion	Grade	Description	Assigned score and explanation
	3	Balanced distribution on territory	Clusters can be mostly found in industrial and easily accessible areas in Hungary.
	4	Mostly clustered in easily accessible areas	
	5	Highly clustered in easily accessible areas	
Recovery and recycling rates	1	Absence of information easily accessible and retrievable	As regards Construction and Demolition waste (CDW), the recovery and recycling rate of Hungary is higher than the average European Union recovery and recycling rate.
	2	Rates steadily below the EU targets for most of waste flows, and/or decreasing trends	
	3	Rates overall in line with the EU targets	
	4	Rates overall in line with the EU targets and increasing trends for most of waste flows	
	5	Rates above the EU targets and increasing trends for most of waste flows	
Awareness of industrial symbiosis and circular economy among citizens	1	No or very low awareness	The general awareness of the concept and importance of a circular economy is low.
	2	Low and inadequate awareness	
	3	Adequate awareness	
	4	Good awareness	
	5	Excellent awareness	
Skills on information technology	1	No or very low skills	Hungary ranks 23rd out of 28 EU Member States in the Digital Economy and Society Index (DESI) 2019. Hungary performs best (slightly above the EU average) in the broadband Connectivity dimension, thanks to its widespread adoption of fast and ultrafast broadband.
	2	Low and inadequate skills	
	3	Adequate skills	
	4	Good skills	
	5	Excellent skills	

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4 FISSAC MODEL REPLICABILITY POTENTIAL IN DIFFERENT SECTORS

In this section the replicability potential of FISSAC Model in different products/sectors is applied through the use of different criteria included in an Evaluation Matrix which was defined in the Deliverable D7.2 "Report on Industrial segmentation, criteria and correlation to the FISSAC first application".

The following table shows the criteria including their relevant description.

Table 10: Criteria and the relevant description

Criteria	Description
Existence of already established networks (industries, IS consultancy organizations, research, civil society, organizations, public authorities and policy makers):	In the baseline of FISSAC model, it has been identified the necessity to firstly establish and further develop a network of stakeholders, focused on sharing best practices and other Industrial symbiosis experiences, as starting point for the IS establishment. If a structured network of stakeholder already exists, it can play a fundamental role in the replicability of the FISSAC model
Existence of innovative non-technological processes and initiatives	The needs to rely on a solid network of relationships and to build trust among stakeholders are important conditions for the instauration of industrial symbiosis. Existence of innovative non-technological processes and initiatives to co-develop and promote the IS opportunity, such as workshops or Living Labs can really facilitate this aspect – within the FISSAC project Living Labs have been recognized as an important tool to detect and analyze drivers and barriers of IS
Previous industrial Symbiosis experiences in the sector	If the sector under evaluation has already implemented industrial symbiosis experience and it is already familiar with circular economy concepts, the adoption of the FISSAC model is facilitated
Existence of previous and current IS initiatives at European and international level, for the specific waste material stream	Within FISSAC project, different applications have been identified for different industrial waste streams to be used for the production of innovative building products. Other initiatives or projects could be exploited to gain an understanding about other possible applications and they could represent a starting point for the replicability of the FISSAC model in different sectors
Specific regulation on waste management	The lack of distinction between wastes and secondary materials in EU-based regulations can deeply obstacle the exchange, reuse and recycle of wastes between companies. With this respect, the presence of a clear regulation framework dealing with the use of the specific waste material streams can strongly foster IS establishment
Existence of technological processes able to transform waste into secondary raw materials	Certain types of waste, before their utilisation in another sector, need a technological processing able to transform them into secondary raw materials, guaranteeing the desired performances. In these cases, the existence of viable technological processes to treat the waste is a prerequisite for the IS establishment
Technical and non-technical barriers affecting IS opportunity already identified:	Different technical and non-technical barriers can be encountered when evaluating the possibility to establish an IS opportunity – their prompt identification is the first step for their resolution

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Criteria	Description
Availability of studies related to the environmental, H&S and economic impacts of the IS opportunity	Environmental and economic benefits can leverage the IS establishment – studies demonstrating the positive effects of the IS can really encourage its implementation, whilst issues on health and safety aspects can represent a critical factor for the feasibility of the solution
Availability of studies related to social acceptance of this secondary raw material	Social engagement and acceptance have been tackled within the FISSAC project, since they have been recognized as important issues for the success of IS – studies demonstrating the social acceptance through the establishment of certain IS process can encourage its implementation;
Possibility to use FISSAC ICT Tool	The FISSAC ICT tool is an instrument conceived to facilitate IS establishment – the possibility to use the tool can promote the IS, enlarging the network and evaluating the associated impacts

These criteria are applied to different sectors, specifying also the scope and extension of the application: indeed, on the basis of the country/region considered, the results could vary. In particular, the sectors considered in the following chapters are:

- Construction and demolition waste of WOOD and PLASTIC – Sweden
- GYPSUM – Sweden
- COPPER SLAG - Europe with some focus on Germany
- FLY ASHES - Europe with some focus on several European countries

The last criterion, "Possibility to use FISSAC ICT Tool", is not applied in this assessment, since the tool has recently been launched and it has not been specifically tested by stakeholders belonging to these sectors.

4.1 Construction and demolition waste of wood and plastic - Sweden

This evaluation is focusing in Sweden and only on the construction materials of wood and plastics used on the construction aiming at their integration on industrial symbiosis systems. Plastics and wood are used in construction in several applications. Their recyclability is relatively high.

Plastic is being used in the construction industry mainly as an insulating material. There are several applications of plastic film that can be used as a moisture barrier or foamy plastic as thermal insulation material. The main plastic films are made from polyethylene, while the main insulative plastic foam is made from either polyurethane or polystyrene. Other applications in construction are cables and electrical installations due to their electrical insulation properties and pipes for the safe and hygienic transportation of water. All of them are petroleum-based products and their recyclability relays on their collection and shorting procedure. Plastic materials are durable and resistant to corrosion.

The amount of wood used in construction is increasing in Sweden due to the new regulations about safety and new design. The wooden structures now can become higher and bigger with the new regulations and several stories buildings can be build. Wood is one of the most abundant raw material in Sweden, therefore the construction industry is using it both for interior and facade design. Only in 2012, 300,000 tons of wood waste from construction and demolition waste was collected in Sweden[36]. In Sweden, the wood fraction from the construction and demolition waste is significant due the large share of wood in the construction of houses. Wood waste can be recycled or reused if the quality of the waste is good. Sometimes the pre-treatment of wood materials containing nails and paint is labour intensive, which may not be the most favoured option. On the other hand, production of biomass and wood chips, can be often the best economically and environmentally option considering the climatic conditions. Only some large timber structures and

[36] Construction and Demolition Waste Management in Sweden. *Waste Manag - An Integr Vis*. 2012;(September). doi:10.5772/46110

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interiors (doors, windows) can be reused today. Therefore, the IS of the wood construction and demolition waste is limited due to its labor intensive nature.

The grading is based on literature review of the current situation in Sweden about the construction industry and more specifically in the sector of plastic and wood construction materials. The results are also based on interviews performed with experts in the fields of recycling, construction and researchers working in the field of circular economy.

Existence of already established networks (industries, IS consultancy organizations, research, civil society, organizations, public authorities and policy makers) - Construction and demolition waste of WOOD and PLASTIC - Sweden

Sweden is a good example of establishing networks among similar business fields. Sharing knowledge and exchanging ideas is a fundamental principal followed by most Swedish industries. The recycling companies are the ones usually starting those initiatives by trying to make profit from the waste streams. More analytically, there are two known examples in Sweden, based on two recyclers.

Ragn Sells has established a network among the bigger construction companies such as Peab in order to improve its environmental profile. Under this cooperation, the recycling company has managed to improve the performance of its own recycling company (Swerock Recycling), towards the concept of circular economy. Moreover, Ragn Sells and Suez has established a digital system in order to monitor material flows for improving the reuse of material such as wood and plastic[37]. Construction companies have also built a network that help them to reuse the wooden pellets. Instead of recycling them, with the coordination of the company Byggpall they can now reuse them at multiple construction sites. Last but not least, the biggest agency in Sweden that works with waste “Avfall Sverige” has initiate discussions about the reuse of wood materials.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Existence of innovative non-technological processes and initiatives - Construction and demolition waste of WOOD and PLASTIC - Sweden

Rise has been focusing on initiatives that can foster industrial symbiosis of construction materials. More specifically, the “In Future Wood” initiative aims to improve the circulation of wooden materials through innovative design. Under this project, several companies are participating, which can potentially lead to a network of stakeholders in the future[38]. Another bright example of non-technological initiative is the closing the loop project also in RISE. This project aims to reduce, among others, construction waste and increase life span of construction materials. This initiative has created a warehouse where used construction materials are stored waiting for small construction companies to reuse them.

Assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Previous industrial Symbiosis experiences in the sector - Construction and demolition waste of WOOD and PLASTIC - Construction and demolition waste of WOOD and PLASTIC - Sweden

The research group of Environmental Management and Technology division from the Linkpöping University is currently working on a project in the concept of "industrial symbiosis" in order to raise the profile of industrial symbiosis networks in Sweden. This is the only weak experience that the concept of IS has in Sweden. All the reports are focusing on other industrials and internal connections for sharing energy and materials, while only a few are mentioning the construction industry, which is the case in FISSAC project. The regional reports are mentioning that the bottom ash of the incineration plants can be used by the construction industry, while no material flow from the construction industry is mentioned.

Assigned score for this criteria is **1** (see Evaluation Matrix table at the end of this section).

[37] https://www.ragnsells.se/inspireras/peab-hallbarhet/

[38] https://www.infuturewood.info/news/

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Existence of previous and current IS initiatives at European and international level, for the specific waste material stream - Construction and demolition waste of WOOD and PLASTIC - Sweden

Industrial symbiosis systems require a constant material flow, which is difficult to establish on the materials of this study. Both wood and plastics are materials that are considered to be cheap and not so much effort has been made in order to be included in closed cycles. Therefore, there is an absence of previous IS initiatives.

Assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

Specific regulation on waste management - Construction and demolition waste of WOOD and PLASTIC - Sweden

Sweden is completely following the directive 2011/753/EU on calculating the waste derived from construction industry and until the year 2020 will meet the 2008/98/EG regulation[39]. Since the total percentage of recycling at specific fractions is set to 50%, it is noticeable to mention that some construction companies in Sweden has reported already 75% of recycling on their construction sites. Unfortunately, the new directive does not include any mandatory percentage on reuse in order to give the industrial sector incentives for moving towards a circular flow of the materials. Moreover, the energy grid of Sweden also includes incineration of waste, which acts as drawback for enhancing the circulation of materials with high heating value such as plastics and wood. Since waste incinerators use wood chips for energy production, incineration of used plastic or wood materials is difficult to be avoided without the proper regulation/legislation.

Assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Existence of technological processes able to transform waste into secondary raw materials - Construction and demolition waste of WOOD and PLASTIC - Sweden

Plastic

Plastic recycling in Sweden is advanced including several companies that are focusing on sorting of plastic fractions in order to be used as a raw material in production. Stena recycling for example is treating the plastic waste mechanically and the sorting process is based on several sorting categories. Then the thermoplastics can be sold to companies in order to be included in the manufacturing process of new materials. The new Stena Nordic Recycling Center established in Swedish west coast is using a new recycling process to separate and recover Low Density Polyethylene (LDPE) and convert them to pellets. Then these pellets can be used for production of plastic bags or garbage bags[40].

Van Werven, a company with several recycling facilities in UK, Belgium, Holland and Poland has also one sorting facility in Sweden. The facility focuses on separation of plastic fractions, washing them and res-ell them for production of new materials targeting into high quality products. The plastic construction waste collected are HDPE pipes, PVC pipes and PE-PP interior pipes. This company also claims that they cooperate with manufactures in order to help them to implement new innovations along the road to circular economy.

Assigned score for this criteria is **5** (see Evaluation Matrix table at the end of this section).

[39] Swedish Environmental Protection Agency. *Avfall i Sverige 2016*.; 2018

[40] https://www.stenarecycling.se/hallbar-atervinning/atervinning-av-material/plastatervinning/

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Figure 27: Plastic treatment and recycling

Wood

One of the main drawbacks is that there is not a company that produces woodchips boards. Sweden is raw wood producer, therefore materials such as woodchips boards with lower quality or aiming to substitute raw wood are not produced in Sweden. For the industrial symbiosis, based on the FISSAC model, there should be one industry that would benefit from the construction waste. In case of wood and inside the geographical boundaries of Sweden, there is a lack of this kind of industry. Therefore, there is an absence of technological process for connecting the industrial symbiosis. Moreover, due to the specific climate conditions in Sweden, the incineration of wooden structures and waste in general is the most preferable option since it can provide with the needs for heating and wood waste is still considered to be CO_2 neutral.

Assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

Technical and non-technical barriers affecting IS opportunity already identified - Construction and demolition waste of WOOD and PLASTIC – Sweden

Plastic

As mentioned on the previous question, the plastic recycling is well established business in Sweden. There are several examples of companies recycling the plastic fractions and others that use plastics from secondary sources and promoting this idea improving their environmental profile. Electrolux, for example, has launched an entire series of product made from 70% of recycled plastic. These examples are just a few, showing that there are no significant barriers affecting the IS opportunity.

Assigned score for this criteria is **5** (see Evaluation Matrix table at the end of this section).

Wood

The basic barrier affecting the IS opportunity is the lack of legislation in order to promote these IS initiatives. Since the wood is used for heat and energy production in Sweden in combination with the abundance of wood source, the motivation toward a circulation of wooden material is absent. Therefore, wooden materials from the construction constitute the feeding of incinerators.

Assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

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Availability of studies related to the environmental, H&S and economic impacts of the IS opportunity - Construction and demolition waste of WOOD and PLASTIC - Sweden

There are several studies focusing on the benefits of the IS opportunity. Almost in any Swedish university there is a group working on environmental issues and one field of interest is Industrial Symbiosis. Linköpning University has a national founded project in order to map IS of the Swedish industry[41]. Chalmers university recently published a study focusing on the opportunities that can arise from IS[42]. The department of industrial ecology at KTH has organised a master's programme in Sustainable Technology is based on the concept of industrial ecology and IS systems as well as several researchers and PhD student are working in similar fields [43,44]. Thus, IS studies and its benefits have been very well communicated in Sweden.

Assigned score for this criteria is **5** (see Evaluation Matrix table at the end of this section).

Availability of studies related to social acceptance of this secondary raw material - Construction and demolition waste of WOOD and PLASTIC - Sweden

The social acceptance of the secondary material is a not so well-defined variable that influence the applicability of the IS. Even though, there are not so many studies dealing with this issue, it is documented and discussed since 2012 on study related specifically to "Sustainable Waste Management" performed from several Swedish institutes, universities and organisations[45]. There are also other studies that discuss the social acceptance related to IS but other topics such as biofuels compared with fossil fuels[46]. Moreover, there is a report describing the social factors that can influence the implementation of the IS systems[47]. All they conclude that the acceptance of the secondary raw materials may be low.

Assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

[41] http://www.industriellekologi.se/symbiosis/index.html

[42] Axelsson L, Blomé S. Identifying opportunities for bottom-up industrial symbiosis. 2017

[43] Ammenberg J, Eklund M, Feiz R, Helgstrand A, Marshall R. Improving the CO2 performance of cement, part III: the relevance of industrial symbiosis and how to measure its impact. *J Clean Prod*. 2015;98:145-155. doi:10.1016/J.JCLEPRO.2014.01.086

[44] Aid G. *Operationalizing Industrial Ecology in the Waste Sector : Roles and Tactics for Circular Value Innovation*.; 2017. doi:10.3384/diss.diva-137464

[45] Finnveden G, Ekvall T, Arushanyan Y, et al. Policy instruments towards a sustainable waste management. *Sustainability*. 2012;5(3):841-881. doi:10.3390/su5030841

[46] Mirata M, Eklund M, Gundberg A. Industrial symbiosis and biofuels industry: business value and organisational factors within cases of ethanol and biogas production. *Swedish Knowl Cent Renew Transp Fuels*. 2017;(11):54.

[47] Nordregio, Johnsen IHG, Berlina A, et al. *The Potential of Industrial Symbiosis as a Key Driver of Green Growth in Nordic Regions*.; 2015. http://www.nordregio.se/en/Publications/Publications-2015/The-potential-of-industrial-symbiosis-as-a-key-driver-of-green-growth-in-Nordic-regions/

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Table 11: Evaluation matrix for replicability potential in different sectors - Construction and demolition waste of wood and plastic - Sweden

Criterion	Grade	Description	Assigned score and explanation
Existence of already established networks (industries, IS consultancy organizations, research, civil society, organizations, public authorities and policy makers)	1	Previous failed experiences of establishing a network	Sweden is a good example of establishing networks among similar business fields. Sharing knowledge and exchanging ideas is a fundamental principal followed by most Swedish industries. The recycling companies are the ones usually starting those initiatives by trying to make profit from the waste streams.
	2	Absence of a network	
	3	Existence of a network	
	4	Existence of different networks	
	5	Existence of a very strong local network	
Existence of innovative non-technological processes and initiatives	1	Previous failed experiences of establishing innovative non-technological processes and initiatives	The "In Future Wood" initiative aims to improve the circulation of wooden materials through innovative design. Under this project, several companies are participating, which can potentially lead to a network of stakeholders in the future
	2	Absence of previous initiative	
	3	Example of a previous initiative	
	4	Example of different initiatives	
	5	Existence of numerous consolidated initiatives	
Previous industrial Symbiosis experiences in the sector	1	Previous IS experiences with very weak results	The research group of Environmental Management and Technology division from the Linkpöping University is currently working on a project in the concept of "industrial symbiosis" in order to raise the profile of industrial symbiosis networks in Sweden. This is the only weak experience that the concept of IS has in Sweden
	2	Previous IS experiences with weak results	
	3	Previous IS experiences	
	4	Previous IS experiences with good results	
	5	Previous IS experiences with very good results	
Existence of previous and current IS initiatives at European and international level, for the specific waste material stream	1	Previous failed experiences for the specific waste material stream	Industrial symbiosis systems require a constant material flow, which is difficult to establish on the materials of this study. Both wood and plastics are materials that are considered to be cheap and not so much effort has been made in order to be included in closed cycles. Therefore, there is an absence of previous IS initiatives.
	2	Absence of previous initiative	
	3	Example of a previous initiative	
	4	Existence of numerous initiatives	
	5	Existence of numerous successful initiatives	

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Criterion	Grade	Description	Assigned score and explanation	
Specific regulation on waste management	1	Existence of a specific regulation, hindering the utilization of the specific waste stream	Sweden is completely following the directive 2011/753/EU on calculating the waste derived from construction industry and until the year 2020 will meet the 2008/98/EG regulation. Since the total percentage of recycling at specific fractions is set to 50%, it is noticeable to mention that some construction companies in Sweden has reported already 75% of recycling on their construction sites.	
	2	Absence of specific and clear regulations		
	3	Existence of a specific regulation, not already implemented		
	4	Existence of a specific regulation, already implemented		
	5	Existence of a specific regulation, promoting the utilization of the specific waste stream		
Existence of technological processes able to transform waste into secondary raw materials	1	Previous failed experience in developing technological processes	**Plastic (5)** Plastic recycling in Sweden is advanced including several companies that are focusing on sorting of plastic fractions in order to be used as a raw material in production.	**Wood (2)** One of the main drawbacks is that there is not a company that produces woodchips boards. Therefore, there is an absence of technological process for connecting the industrial symbiosis
	2	Absence of technological processes		
	3	Existence of one viable technological processes		
	4	Existence of different viable technological processes		
	5	Existence of different consolidated viable technological processes		
Technical and non-technical barriers affecting IS opportunity already identified	1	No information related to technical and non-technical barriers	**Plastic (5)** Plastic recycling is well established business in Sweden. There are several examples of companies recycling the plastic fractions or using plastics from secondary sources	**Wood (2)** The basic barrier affecting the IS opportunity is the lack of legislation in order to promote these IS initiatives. Moreover, wood is used for heat and energy production, thus the motivation toward a circulation of wooden
	2	Some barriers already identified		
	3	Some barriers already identified and some solutions proposed		
	4	Few barriers already identified		
	5	No significant barriers		

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Criterion	Grade	Description	Assigned score and explanation
			material is absent.
Availability of studies related to the environmental, H&S and economic impacts of the IS opportunity	1	No available studies	There are several studies focusing on the benefits of the IS opportunity. Almost in any Swedish university there is a group working on environmental issues and one field of interest is Industrial Symbiosis
	2	Availability of studies demonstrating several criticalities	
	3	Availability of studies demonstrating some critical issues	
	4	Availability of studies demonstrating good performances	
	5	Availability of studies demonstrating huge benefits from ecological and economical perspective	
Availability of studies related to social acceptance of this secondary raw material	1	No available studies	The social acceptance of the secondary material is a not so well-defined variable that influence the applicability of the IS. Even though, there are not so many studies dealing with this issue. These studies conclude that the acceptance of the secondary raw materials may be low.
	2	Availability of studies demonstrating very low acceptance	
	3	Availability of studies demonstrating low acceptance	
	4	Availability of studies demonstrating high acceptance	
	5	Availability of studies demonstrating very high acceptance	

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4.2 Gypsum – Sweden

Existence of already established networks (industries, IS consultancy organizations, research, civil society, organizations, public authorities and policy makers) – Gypsum – Sweden

Some networks (Sotenäs symbiosis, Helsingborg symbiosis) and partnerships exist, but more coordination is needed for increased recycling. There are also some research institutes active in finding solutions about Industrial Symbiosis and Circular Economy (IVL, RISE, Linköping university).

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Existence of innovative non-technological processes and initiatives – Gypsum – Sweden

Each actor of the gypsum recycling value chain has a vision and a plan that affect differently the recycling of gypsum. Some may have very similar vision and plans like, for instance, Construction Trade Organizations and Construction companies, Research Institutes and consulting firms. Indeed, NCC vision is "to renew their industry and to provide superior sustainable solutions"; Sverige Byggindustrier vision is "using economically and ecologically sound methods that are socially sustainable, and that have among the lowest life cycle costs in the world"; Hifab vision is to "offer project management consultancy for a sustainable development"; RISE vision is to "ensure the competitiveness of the Swedish business community on an international level and contribute to a sustainable society".

For the gypsum recycling companies, like Suez and Renova, the vision is to minimize gypsum waste and go up the gypsum waste "pyramid" with customers.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Previous industrial Symbiosis experiences in the sector – Gypsum – Sweden

Networking and joint development work takes place in project form but it is not integrated into the business.

Assigned score for this criteria is **1** (see Evaluation Matrix table at the end of this section).

Existence of previous and current IS initiatives at European and international level, for the specific waste material stream - Gypsum

At European level, the following initiative "Gypsum-to-Gypsum (GtoG)": from Production to Recycling, a Circular Economy for the European Gypsum Industry with the Demolition and Recycling Industry" was developed involving numerous partners (demolition companies, recycling companies, manufacturing facilities and the European Federation of producers of gypsum products, universities) in order to achieve higher recycling rates thus helping to achieve a resource efficient economy.
The main innovation in this project is that it established a circular economy for a whole waste stream. It has provided a workable example of a cradle-to-cradle solution by informing manufacturers, construction companies, demolition companies and recyclers so that they can work together to maximize the resource efficiency of gypsum.
Eight countries were involved in this initiative: Belgium, France, Germany, Greece, The Netherlands, Poland, Spain, United Kingdom.

Assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Specific regulation on waste management – Gypsum – Sweden

The implementation of EU directives/norms at a Swedish national level may make less relevant the development of new and more stringent national standards. Regulation not allows to use gypsum as combustible fraction as it contributes acidification when incinerated. Guidelines state that plaster should be sent to recycling when it is not contaminated and when there is a recycling facility within reasonable distance.

Gypsum waste must not be disposed with mixed waste containing organic material such as cardboard, paper, wood, plastic, etc. However, new laws and incentives to recycle gypsum should be developed since it is still much cheaper today to not recycle, by opting for landfilling for instance, than to recycle gypsum from construction sites.

Assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

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Existence of technological processes able to transform waste into secondary raw materials – Gypsum – Sweden

There are market players who specialize in gypsum recycling and have technology to achieve high levels of purification. However, these players are few, which means that the waste can be transported long distances for material recycling. This is difficult to motivate for both cost and environmental reasons.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Technical and non-technical barriers affecting IS opportunity already identified – Gypsum – Sweden

There are few recycling companies specializing in gypsum. Moreover, a challenge is communication and a long value chain of a building market. Important actors, generally, do not communicate with each other, for example the one who designs a new house could not be in contact with a company that demolishes a house in order to see what kind of materials can be reused/recycled.

Another challenge is related to pricing, costs and conditions on the market. Considering costs, one barrier is transport cost; for example, south of Sweden and main cities are well covered, but the issue raises further out and more to north (places where leaving gypsum waste are few).

Assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

Availability of studies related to the environmental, H&S and economic impacts of the IS opportunity – Gypsum – Sweden

There are studies related to the environmental, H&S and economic impacts of the Industrial Symbiosis opportunity. For example, study about industrial Symbiosis in Sotenäs[48] and in Malmö[49]. Moreover, Linköping University has a department that works on Industrial Symbiosis. A lot of Swedish actors refer to Kalundborg Symbiosis that has proven economic and environmental benefits.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Availability of studies related to social acceptance of this secondary raw material – Gypsum – Sweden

There are not specific studies about social acceptance of using secondary gypsum. Based on the living labs carried out in Sweden, there are a lot of actors who like the idea of using reused/recycled gypsum/gypsum plasterboards and who would like to have a well working system and a value chain. Moreover, they are also rather positive about it and this is important.

However, most of those actors do not want to take the step their own because they think it is too risky or they think that it is someone's else job to do. Another important aspect is the cost; in fact, primary gypsum is cheaper than the recycled one.

Assigned score for this criteria is **1** (see Evaluation Matrix table at the end of this section).

[48] http://www.symbioscentrum.se/download/18.7e1b737d162226c72d05e957/1522926925452/SlutrapportIndustriellSymbios.PDF

[49] http://deladenergi.se/startsida/

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Table 12: Evaluation matrix for replicability potential in different sectors – Gypsum – Sweden

Criterion	Grade	Description	Assigned score and explanation
Existence of already established networks (industries, IS consultancy organizations, research, civil society, organizations, public authorities and policy makers)	1	Previous failed experiences of establishing a network	Some networks and partnerships exist, but more coordination is needed on the solutions for increased recycling.
	2	Absence of a network	
	3	Existence of a network	
	4	Existence of different networks	
	5	Existence of a very strong local network	
Existence of innovative non-technological processes and initiatives	1	Previous failed experiences of establishing innovative non-technological processes and initiatives	Each actor of the gypsum recycling value chain has a vision and a plan that affect differently the recycling of gypsum. Some may have very similar vision and plans like, for example, Construction Trade Organizations and Construction companies, Research Institutes and consulting firms.
	2	Absence of previous initiative	
	3	Example of a previous initiative	
	4	Example of different initiatives	
	5	Existence of numerous consolidated initiatives	
Previous industrial Symbiosis experiences in the sector	1	Previous IS experiences with very weak results	Networking and joint development work takes place in project form, but it is not integrated into the business.
	2	Previous IS experiences with weak results	
	3	Previous IS experiences	
	4	Previous IS experiences with good results	
	5	Previous IS experiences with very good results	
Existence of previous and current IS initiatives at European and international level, for the specific waste material stream	1	Previous failed experiences for the specific waste material stream	An initiative "Gypsum-to-Gypsum (GtoG)": from Production to Recycling, a Circular Economy for the European Gypsum Industry with the Demolition and Recycling Industry" was developed involving many partners (i.e.: demolition and recycling companies, manufacturing facilities and the European Federation of producers of gypsum products) to achieve higher recycling rates.
	2	Absence of previous initiative	
	3	Example of a previous initiative	
	4	Existence of numerous initiatives	
	5	Existence of numerous successful initiatives	
Specific regulation on waste management	1	Existence of a specific regulation, hindering the utilization of the specific waste stream	The implementation of EU directives/norms at a Swedish national level may make less relevant the development of new
	2	Absence of specific and clear regulations	

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Criterion	Grade	Description	Assigned score and explanation
	3	Existence of a specific regulation, not already implemented	and more stringent national standards
	4	Existence of a specific regulation, already implemented	
	5	Existence of a specific regulation, promoting the utilization of the specific waste stream	
Existence of technological processes able to transform waste into secondary raw materials	1	Previous failed experience in developing technological processes	There are market players specialized in gypsum recycling that have technology to achieve high levels of purification. However, these players are few, which means that the waste can be transported long distances for material recycling. This is difficult to motivate for both cost and environmental reasons
	2	Absence of technological processes	
	3	Existence of one viable technological processes	
	4	Existence of different viable technological processes	
	5	Existence of different consolidated viable technological processes	
Technical and non-technical barriers affecting IS opportunity already identified	1	No information related to technical and non-technical barriers	There are few recycling companies specializing in gypsum. Moreover, a challenge is communication and a long value chain of a building market. Another barrier is related to costs and conditions on the market.
	2	Some barriers already identified	
	3	Some barriers already identified and some solutions proposed	
	4	Few barriers already identified	
	5	No significant barriers	
Availability of studies related to the environmental, H&S and economic impacts of the IS opportunity	1	No available studies	There are studies related to the environmental, H&S and economic impacts of the Industrial Symbiosis opportunity. For example, study about industrial Symbiosis in Sotenäs and in Malmö.
	2	Availability of studies demonstrating several criticalities	
	3	Availability of studies demonstrating some critical issues	
	4	Availability of studies demonstrating good performances	
	5	Availability of studies demonstrating huge benefits from ecological and economical perspective	
Availability of studies related to social acceptance of this secondary raw material	1	No available studies	There are not specific studies about social acceptance of using secondary gypsum. Based on the living labs carried out in Sweden, there are a lot of actors who like the idea of using reused/recycled
	2	Availability of studies demonstrating very low acceptance	
	3	Availability of studies demonstrating low acceptance	

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Criterion	Grade	Description	Assigned score and explanation
	4	Availability of studies demonstrating high acceptance	gypsum/gypsum plasterboards. However, most of those actors do not want to take the step their own because they think it is too risky.
	5	Availability of studies demonstrating very high acceptance	

4.3 Copper Slag - Europe with some focus on Germany

Existence of already established networks (industries, IS consultancy organizations, research, civil society, organizations, public authorities and policy makers) - COPPER SLAG - Europe with some focus on Germany

At European level, the European Copper Institute (ECI) and its network of national associations in Europe, collectively part of the Copper Alliance, pursue its commitment to defending and promoting growth markets for copper, ensure fair market access for copper products, and support the copper industry's license to operate.

One of their purpose is to fit into the European Commission's circular economy goal, reinforcing recycling of copper, including the collection of scrap. This is an established and working system, starting from local collectors, involving a chain of processing, trading and transport, and then being used in the copper production in or outside Europe[50].

Furthermore, the important role of the International Copper Association (ICA) must be considered: it seeks to create joint projects with shared resources and responsibilities with many partners, including, internally, copper manufacturer and wire and cable industry members and, externally, governments, inter-governmental organizations, Non-governmental Organizations (NGOs), foundations and others.

These alliances are a support for both the goals of Copper Alliance members/partners and policies, regulations, standards and activities which benefit copper and society.

Considering copper slags, the European Association representing metallurgical slag producers and processors (EUROSLAG[51]) has a fundamental role in Europe, representing organizations and companies concerned with all aspects of manufacturing and utilization of ferrous slag products. The association deals with promotion of slag as a product, enables exchange of information and research as well as facilitates the interaction with governing bodies.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Existence of innovative non-technological processes and initiatives - COPPER SLAG - Europe with some focus on Germany

Year 2019 was quite rich in changes and initiatives to try to better ensure the support for a responsible production. Firstly, the Responsible Business Alliance (RBA), on behalf of its Responsible Minerals Initiative (RMI), and the International Copper Association, Ltd. (ICA), have signed a Memorandum of Understanding to jointly advance the responsible production and trade of copper. The RMI and ICA aim to harmonize expectations for responsible practices in the copper value chain by applying existing industry norms covering major environmental, social and governance issues.

Secondly, in April, ICA introduced a new assurance program for responsible copper production, the Copper Mark[52], offering a voluntary program to support the copper industry's contribution to the United Nations' Sustainable Development Goal (SDG) 12 on Responsible Consumption and Production.

[50] European Copper Institute (ECI) - Annual Report 2015

[51] http://www.euroslag.com

[52] https://coppermark.org/rmi-and-ica-partner-to-advance-responsible-copper-production-and-trade/

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ICA uses the RMI's Risk Readiness Assessment (RRA) for Copper Mark implementation. The Copper Mark is available to copper mines, smelters and refiners in its first application launched in 2020.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Previous industrial Symbiosis experiences in the sector - COPPER SLAG - Europe with some focus on Germany

In the construction sector, recycled copper has an important role in the improvement of technological, environmental and economic aspects. The use of copper slags as secondary raw materials implies a lower use of virgin materials and substantial savings of the amount of energy required for cement production. Many authors published papers about copper slag utilization in building material industries in Europe.

Focusing on applications, when copper slag is used as a raw material for clinker production, it can act as both iron adjusting and mineralizing component and also improves the grindability of the clinker. While, when it is used as a cement replacement or an aggregate replacement, cement, mortar and concrete have good performance in comparison with ordinary Portland cement.

Furthermore, granulated copper slag is used as a replacement for sand in concrete mixes.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Existence of previous and current IS initiatives at European and international level, for the specific waste material stream - COPPER SLAG - Europe with some focus on Germany

The German ***Aurubis AG*** is one of Europe's largest copper producers of copper cathodes and other copper products, a service provider for the automotive supply, chemical and waste-management industries, and the largest global copper recycler. In addition to copper-alloy scrap, the firm also recycles copper-bearing residues from foundries and semis fabricators, shredder materials, galvanic slimes, slags, ashes and filter dust. It utilizes scrap as input in the convertors and anode furnaces of its primary and secondary smelting processes and alloy scrap and residues in its Kayser Recycling System (KRS)[53].

In the smelting units in Lünen, recyclable raw materials are used almost exclusively, including both traditional recyclable raw materials (copper scraps and other scraps, slimes, and residues) and increasing quantities of complex materials (electrical and electronic scraps). Aurubis's Hamburg site is one of the world's state-of-the-art primary and secondary copper smelters. Approximately 400,000 ton of pure copper is produced from copper ores and very complex recyclable materials.

It sources most of its secondary raw materials from Germany and other EU countries. Compared to primary raw materials, secondary raw materials are largely purchased on the basis of short-term supply contracts. Furthermore, Aurubis makes its customers into suppliers with its "closing the loop" approach: four examples of these partnerships are shown in the following:

- ***Grillo Werke AG*** (Germany) produces zinc sulfate from the KRS oxide, produced in Aurubis recycling center in Lünen. Other elements are separated at Grillo and disposed of appropriately. Aurubis takes back the resulting residue, which contains copper, tin, and lead, thus closing the recovered material cycle.
- ***E.R.N. Elektro-Recycling Nord GmbH*** (Hamburg) operates crushing and separating facilities as a certified waste management company. Non-ferrous metal and precious metal fractions are recovered from used, previously dismantled electrical and electronic devices, which are delivered to the steel and aluminum industry as well as within the Aurubis Group to the copper smelters in Hamburg and Lünen.
- ***Cablo Metall-Recycling und Handel GmbH*** (Fehrbellin) specializes in recycling used cable made of copper and aluminum and produces high-quality metal granules tailored specifically to customer needs. The company also fabricates plastic parts from cable insulation.
- ***Deutsche Telekom AG*** (Germany), through its partner TEQPORT Services GmbH, gives old cables with a copper content of around 50 % as waste to Aurubis. The copper granules are used by Aurubis to make copper

[53] https://sustainablecopper.org/best-practices/closing-the-loop-for-the-circular-economy/

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products such as continuous cast copper wire rod, which is used to make new cables, for example, thus closing the copper material cycle. The plastics are processed molding to make products with a high-finish quality that are very dimensionally stable, such as bases for road traffic signs.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Specific regulation on waste management -- COPPER SLAG - Europe with some focus on Germany

At European level, it is important to mention the Circular Economy package, in particular the Directive 2008/98/EC (Waste Framework Directive), changed in some points with Directive 2018/851/EC. Furthermore, European standards for today's use of slag in the construction sector and as fertilizer harmonised the requirements given in national standards relevant for the building industry.

Considering Germany, at national level, waste management finds its legal framework in the German Waste Management Act **(**KrWG). According to §1 the main aim of the KrWG is to ensure with a circular economy the protection of natural resources, as well as human and environment during the generation and treatment of waste. The KrWG stressed on product responsibility by defining responsibilities along the product life cycle and offering incentives to manufacture durable products. Between 2008 and 2015, the German circular economy industry grew by 7.3% annually, and it is estimated that it will grow a further 5.2% per year through to 2025.

The regulations regarding the presence of lead inside copper products are also very important for the recycling sector.

Firstly, Restriction of Hazardous Substances (RoHS) sets limit values for lead, cadmium, and several other chemicals in specified types of electrical and electronic equipment, including a lead maximum content of 0.1%. An exemption was granted for lead in copper and brass alloys allowing up to 4% lead by weight, because cannot be identified, scientifically or technically, practicable alternatives.

Secondly, the Commission Regulation (EU) 2016/1179 assigns to powder form lead a Specific Concentration Limit (SCL) of ≥0.03% for effects on development: mixtures in powder form which contain 0.03% or more lead must be classified as reproduction category 1A (hazard class and category code). A generic concentration limit (GCL) of ≥ 0,3 % for the massive form is assigned.

Copper is considered as non-hazardous waste. In fact, it does not cause environmental or human health problems if the lead content does not exceed the limit value of 0,3%.

As the last aspect to consider, according to REACH, a Safety Data Sheet (SDS) must be provided for:

- all lead metal grades in massive form, including ingots;
- alloys and other mixtures in massive form which contain ≥ 0.3% lead[54];
- lead powder;
- mixtures in powder form which contain ≥ 0.03% lead.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Existence of technological processes able to transform waste into secondary raw materials - COPPER SLAG - Europe with some focus on Germany

The Fraunhofer Institute has developed a dynamic model of global copper stocks and flows which allows a detailed analysis of recycling efficiencies, copper stocks in use, dissipated and landfilled copper.

Based on this model, it is estimated that two thirds out of the 550 million tonnes of copper produced since 1900 are still in productive use. The following diagram provide an example of simulation results.

[54] Katrien Delbeke, Position Paper, European Copper Institute, January 2014

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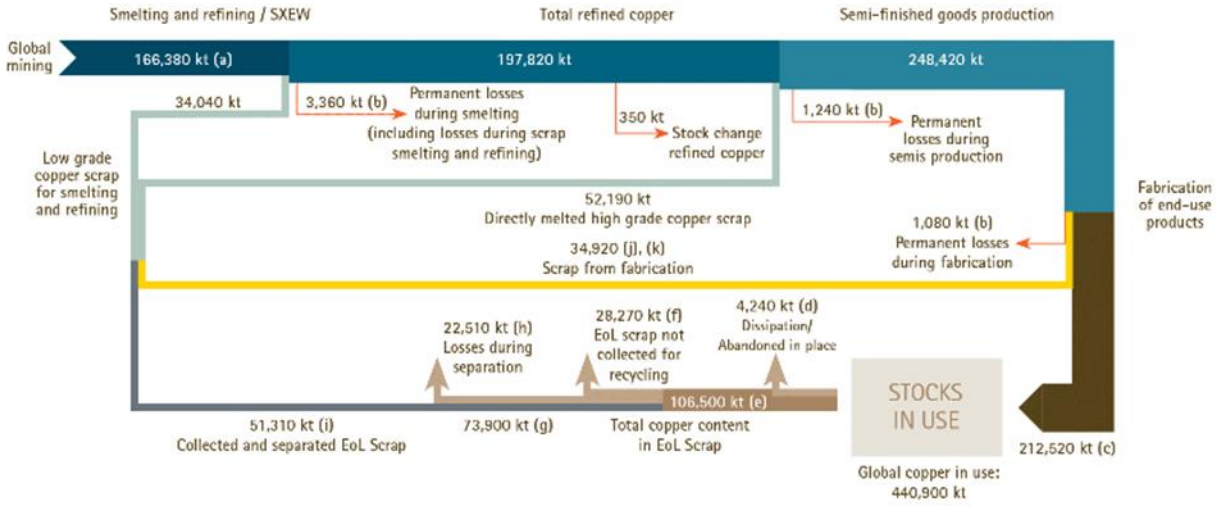

Figure 28: Example of simulation results about dynamic model of global copper stocks and flows developed by the Fraunhofer Institute

Focusing on recycle of copper, one of the processes is recovery of metal values from copper slag and reuse of residual secondary slag. A paper[55] on this topic established that the copper slag, a waste material, can be successfully processed to generate reusable products through pyrometallurgical processing.

The slags from a copper smelter can vary widely in terms of the composition which is strongly dependent on the ore quality and the operating conditions of the smelter. Recovery of various metallic elements may be accomplished by similar process steps.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Technical and non-technical barriers affecting IS opportunity already identified - COPPER SLAG - Europe with some focus on Germany

Based on the results of the project "Regulatory barriers for the Circular Economy" concluded in 2016, there are many barriers identified for copper recycling and potential industrial symbiosis, as shown below.

1. *Sometimes lead is used as a carrier material, which can result in lead content in the copper-scrap*: technically this presents no problem to the smelters. However, currently it is discussed to introduce Limits (max. 0,03%) for lead content in the CLP-regulation. Toxicity of lead depends, however, on the form in which the metal is presented.
2. *The geographical focus of the EU Emission Trading Scheme:* having an ETS only in the European area puts the European industry at a disadvantage in comparison to the rest of the world. The emissions will be produced somewhere else.
3. *National implementation of Waste Framework Directive*: different implementations between the Member States leading to a situation in which the classification (as waste or product) of material (in particular, important for by-products) can vary between regions/countries and thereby leading to administrative burdens (and costs) and uncertainty for recyclers.
4. *Interpretation and administration of Waste Shipment Regulation*: there is a link to the Waste Framework Directive and the classification as waste/product, thus mainly relevant for by-products. The current design of the administration of waste shipment results in high administrative efforts and costs. There are still too high levels of illegal exports. Transit countries can hinder the efficient flow of end-of-life-material-streams.
5. *Missing design for recycling:* the trend towards miniaturization and complex product design, for example in electronic devices, leads to in general a higher number of different materials that are used in lower concentrations inside products. This increases the difficulty to recover the different materials and increases

[55] Recovery of metal values from copper slag and reuse of residual secondary slag, Sarfo P., 2017

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the technological requirements of the recovery technologies, which are associated with higher cost of recovery.

6. *Uncertainty of regulatory application and development:* uncertainty of the regulatory development is detrimental to investments, because of difficulties in making investment plans, while uncertainty of regulatory application is mainly associated with costs to the economic actors. This is an issue for companies of all sizes, the effects will be most detrimental for small enterprises.
7. *Implementation of the Waste Framework Directive (WFD) obligation to separately collect scrap*: for a high quality recycling process, it is important to pursue as little of contaminations (aluminium and bismuth) in the processes.
8. *Market prices for commodities and energy* (Economic/ Financial barrier): low prices for energy and ores decrease the incentives to recycle.

The exact economic effects of the above mentioned barriers are difficult to estimate, but the interviews, carried out in this project, suggested that the associated costs are likely to affect small recycling companies (SMEs) most.

Recycling facilities in Europe operate with high standards of environmental and health protection, under these preconditions illegal exports may have adverse effects on the environment as well as on human health. A better enforcement of the Waste Shipment Regulation is likely to be beneficial for the environment as well as for the European economy.

The other barriers discussed above mainly impact the profitability of the recycling sector in the EU. If this would result in a lower recycling rate of copper scrap, this is associated with more use of virgin materials, with more energy usage in the production process and with comparatively higher CO_2 emissions.

The following diagram, realized by the Fraunhofer Institute, shows a simplified value chain of copper use and recycling, with underlined regulatory barriers, competition points and circular streams.

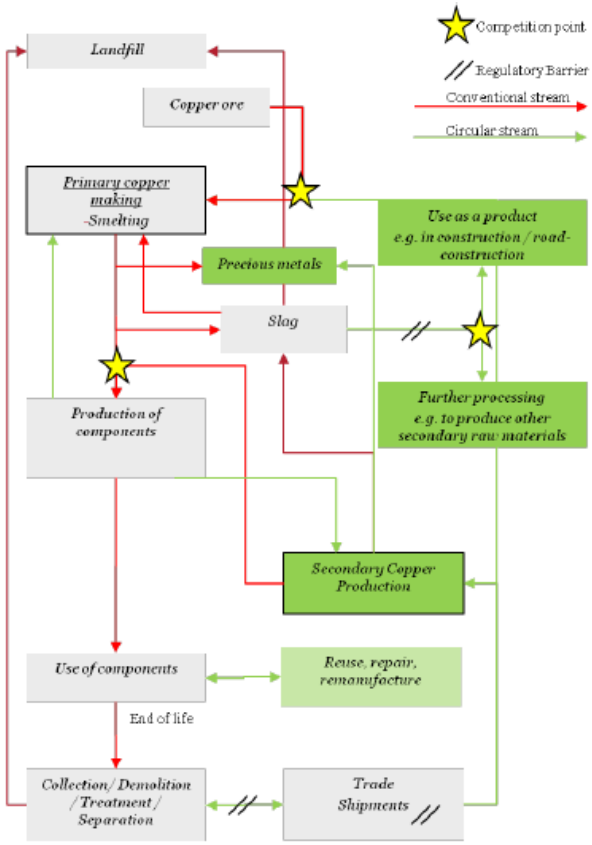

Figure 29: Simplified value chain of copper use and recycling

Assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

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Availability of studies related to the environmental, H&S and economic impacts of the IS opportunity - COPPER SLAG - Europe with some focus on Germany

Recycled copper, when recycled in the best quality, cannot be distinguished from primary copper, therefore no problems exist to place recycled copper on the market. Copper can be recycled repeatedly without any loss of performance. A simulation model used by the Fraunhofer Institute for Systems and Innovation Research (ISI) found that, for the period from 2005 to 2014, slightly more than 50% of copper demand in Europe is covered by recycling new and old scrap[56]. Europe leads the world when it comes to copper recycling and the industry is now working to go even further.

The recycling of copper is linked to positive environmental effects: recycling requires up to 85% less energy than primary production and, globally, this saves 40 million tonnes of CO_2 annually[57].

Industrial Symbiosis, in particular developed in national context, is an important opportunity from environmental, H&S and economic point of view.

Environmental: Industrial Symbiosis can act as a guarantee for recycling, strengthening and expanding savings of energy and reduction of CO_2;

H&S: more recycling means both less use of virgin raw materials and less exploitation of mining workers;

Economic: through the Industrial Symbiosis, further profit possibilities between companies can be developed.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Availability of studies related to social acceptance of this secondary raw material - COPPER SLAG - Europe with some focus on Germany

There are not specific studies related to social acceptance of this secondary raw material.

Copper does not cause environmental or human health problems if the lead content does not exceed the limit value of 0,3%.

Assigned score for this criteria is **1** (see Evaluation Matrix table at the end of this section).

Table 13: Evaluation matrix for replicability potential in different sectors – Copper slag - Europe with some focus on Germany

Criterion	Grade	Description	Assigned score and explanation
Existence of already established networks (industries, IS consultancy organizations, research, civil society, organizations, public authorities and policy makers)	1	Previous failed experiences of establishing a network	At European level there is the European Copper Institute (ECI) and its network of national associations in Europe, collectively part of the Copper Alliance. Furthermore, the important role of the International Copper
	2	Absence of a network	
	3	Existence of a network	
	4	Existence of different networks	

[56] Fraunhofer Institute for Systems and Innovation Research (ISI) https://www.isi.fraunhofer.de/en/presse/2017/presseinfo-28-2017-kupferstoffstrom-modell.html

[57] European Copper Institute Copper Alliance - Copper and the Circular Economy, https://copperalliance.eu/benefits-of-copper/circular-economy/

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Criterion	Grade	Description	Assigned score and explanation
	5	Existence of a very strong local network	Association (ICA) must be considered. Considering copper slags, EUROSLAG, the European Association representing metallurgical slag producers and processors has a fundamental role in Europe.
Existence of innovative non-technological processes and initiatives	1	Previous failed experiences of establishing innovative non-technological processes and initiatives	Year 2019 was quite rich in changes and initiatives to try to better ensure the support for a responsible production and trade of copper.
	2	Absence of previous initiative	
	3	Example of a previous initiative	
	4	Example of different initiatives	
	5	Existence of numerous consolidated initiatives	
Previous industrial Symbiosis experiences in the sector	1	Previous IS experiences with very weak results	In the construction sector, recycled copper has an important role in the improvement of technological, environmental and economic aspects. Many authors published papers about copper slag utilization in building material industries in Europe.
	2	Previous IS experiences with weak results	
	3	Previous IS experiences	
	4	Previous IS experiences with good results	
	5	Previous IS experiences with very good results	
Existence of previous and current IS initiatives at European and international level, for the specific waste material stream	1	Previous failed experiences for the specific waste material stream	The German Aurubis_AG sources most of its secondary raw materials from Germany and other EU countries. Aurubis makes its customers into suppliers with its "closing the loop" approach. Some examples of these partnerships concern: *Grillo Werke AG; E.R.N. Elektro-Recycling Nord GmbH; Cablo Metall-Recycling und Handel GmbH; Deutsche Telekom AG.*
	2	Absence of previous initiative	
	3	Example of a previous initiative	
	4	Existence of numerous initiatives	
	5	Existence of numerous successful initiatives	
Specific regulation on waste management	1	Existence of a specific regulation, hindering the utilization of the specific waste stream	At European level, it is important to mention the Circular Economy package, in particular Directive 2008/98/EC (WFD-Waste Framework Directive), changed in
	2	Absence of specific and clear regulations	

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Criterion	Grade	Description	Assigned score and explanation
	3	Existence of a specific regulation, not already implemented	some points with Directive 2018/851/EC. Considering Germany, at national level, waste management finds its legal framework in the German Waste Management Act (KrWG). The regulations regarding the presence of lead inside copper products are also very important for the recycling sector.
	4	Existence of a specific regulation, already implemented	
	5	Existence of a specific regulation, promoting the utilization of the specific waste stream	
Existence of technological processes able to transform waste into secondary raw materials	1	Previous failed experience in developing technological processes	The Fraunhofer Institute has developed a dynamic model of global copper stocks and flows which allows a detailed analysis of recycling efficiencies, copper stocks in use, dissipated and landfilled copper. Focusing on recycle of copper, one of the processes is recovery of metal values from copper slag and reuse of residual secondary slag.
	2	Absence of technological processes	
	3	Existence of one viable technological processes	
	4	Existence of different viable technological processes	
	5	Existence of different consolidated viable technological processes	
Technical and non-technical barriers affecting IS opportunity already identified	1	No information related to technical and non-technical barriers	Based on the results of the project "Regulatory barriers for the Circular Economy" concluded in 2016, there are many barriers identified for copper recycling and potential industrial symbiosis.
	2	Some barriers already identified	
	3	Some barriers already identified and some solutions proposed	
	4	Few barriers already identified	
	5	No significant barriers	
Availability of studies related to the environmental, H&S and economic impacts of the IS opportunity	1	No available studies	A simulation model used by the Fraunhofer Institute for Systems and Innovation Research (ISI) found that slightly more than 50% of copper demand in Europe is covered by recycling new and old scrap. The recycling of copper requires up to 85% less energy than primary production and it is linked to positive effects from the environmental, H&S and economic point of view.
	2	Availability of studies demonstrating several criticalities	
	3	Availability of studies demonstrating some critical issues	
	4	Availability of studies demonstrating good performances	
	5	Availability of studies demonstrating huge benefits from ecological and economical perspective	
Availability of studies related to social acceptance of this secondary raw material	1	No available studies	There are not specific studies related to social acceptance of this secondary raw material.
	2	Availability of studies demonstrating very low acceptance	

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Criterion	Grade	Description	Assigned score and explanation
	3	Availability of studies demonstrating low acceptance	
	4	Availability of studies demonstrating high acceptance	
	5	Availability of studies demonstrating very high acceptance	

4.4 Fly Ashes - Focus on some European countries

Existence of already established networks (industries, IS consultancy organizations, research, civil society, organizations, public authorities and policy makers) - FLY ASHES - Focus on some European countries

According to The Fly Ash Resource Center, the European Association for Use of By-Products of Coal-Fired Power Stations (ECOBA) is the European representative organization with regards to coal combustion products (CCPs). ECOBA members represent over 86 % of the CCP production in the EU 28 countries. The mission of ECOBA is to encourage the development of technology for the use of all by-products from coal-fired power stations, to promote the mutual interests of its members (in particular within the framework of the European organizations), to establish and develop necessary legal/regulatory measures for recognition, acceptance and promotion of this kind of by-products and to ensure the exchange of information and documentation among the various national and international bodies.

Eurocoalash consists of a series of European conferences to highlight the use the CCPs as valuable raw and construction materials in the European construction industry. The conference will be organized every two years in an European country to meet the different situation in CCP and market situation.

Furthermore, in the UK, the UK Quality Ash Association (UKQAA) represents a wide range of organizations involved in the production, supply and use of coal and biomass ash.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Existence of innovative non-technological processes and initiatives - FLY ASHES - Focus on some European countries

As shown above, Eurocoal-ash is an international conference concerned with the use of Coal Combustion Products (CCPs) in the construction industry in Europe. The conference takes place every two years, moving between different countries bringing together participants from industry, research and academic backgrounds. During the conference, the current status is analyzed and any future management and technological prospects are illustrated.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Previous industrial Symbiosis experiences in the sector - FLY ASHES - Focus on some European countries

With almost 70% of the total, fly ashes is the most important CCP. An abundant part of fly ashes is used in the construction industry and in the underground mining. The following figure illustrates the percentage partition of fly ashes in the construction sector in 2016**.**

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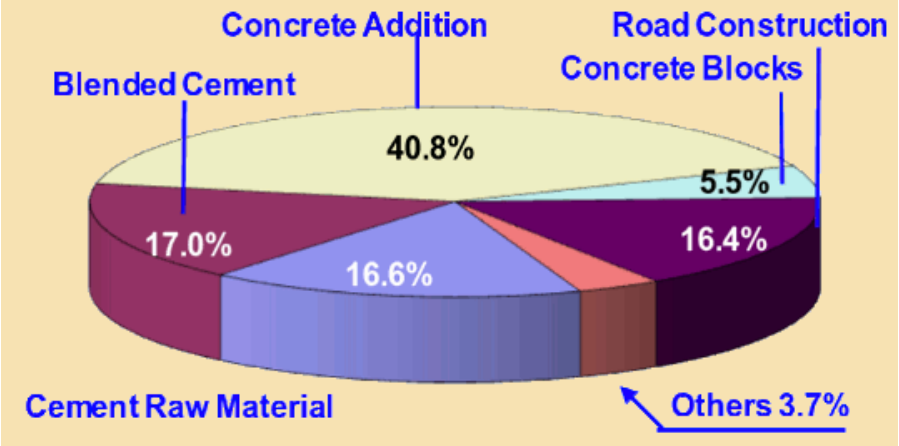

Figure 30: Percentage partition of fly ashes in the construction sector in 2016

According to the European Association for Use of By-Products of Coal-Fired Power Stations (ECOBA), there are many fly ash applications in the construction sector in Europe:

Germany: Castor and Pollux towers in Frankfurt, the cooling tower of the new 950 MW power station at Niedraußem, sand-lime bricks in house construction;

Spain: Picasso Tower;

The Netherlands: Theater in Deg Haag, the windscreen situated along-side the Caland Canal near Rotterdam;

Denmark: East Bridge to connect Copenhagen with the mainland of central Europe***;***

England: fly ash in road base in Staffordshire;

France: fly ash in road base (RN 47 at Lens La-Basse);

Belgium: five concrete storage towers in Genk-Langerlo to store fly ash;

Greece*:* Planatovryssi dam.

Other examples are in the UK. According to the UKQAA, there are many examples about the use of fly ashes from the East Midlands Airport paving the Pride Park in Derby City.

One example of Industrial Symbiosis is in Denmark (Kalundborg). A total reduction of 135,000 tons/y of fly ashes from the Denmark's largest power plant, owned by *Asnæsværket*, is achieved through fly ashes sale to cement manufacturers, as illustrated in the following scheme.

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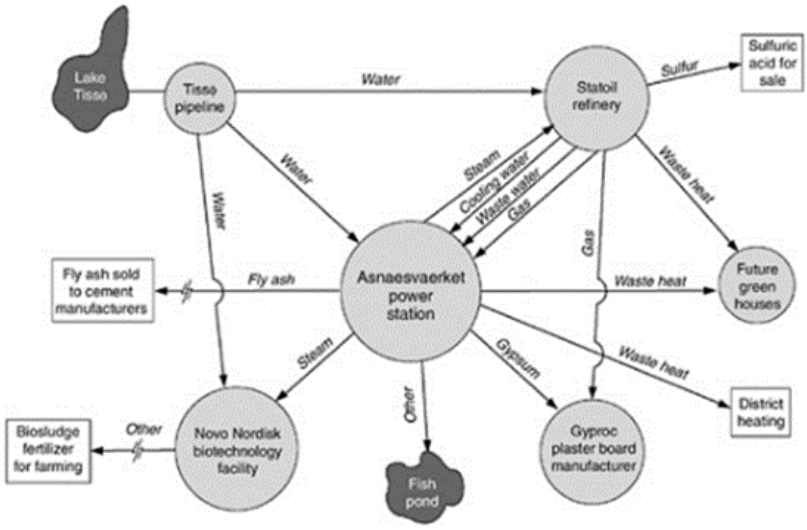

Figure 31: A Danish example of Industrial Symbiosis

Furthermore, Ecotrade (Genoa, Italy) is part of a cement-oriented network, whose purpose is to exploit synergies between companies in the environmental and sustainable industry to enable the recovery of various industrial processing by-products, including fly ashes. Another partner of this network, considering fly ashes processing, is Buzzi Unicem, the second largest manufacturer in Italy and Germany, specialized in the production of cement, premixed concrete and natural aggregates.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Existence of previous and current IS initiatives at European and international level, for the specific waste material stream - FLY ASHES - Focus on some European countries

CCPs are utilized in a wide range of applications in the building and construction industry (additive in concrete manufacture, cement replacement material, aggregate or binder in road construction) as illustrated above. They can also be utilized as mineral fillers and as fertilizers.

Assigned score for this criteria is **3** (see Evaluation Matrix table at the end of this section).

Specific regulation on waste management - FLY ASHES - Focus on some European countries

At European level, it is important to mention the Circular Economy package, in particular Directive 2008/98/EC (Waste Framework Directive), changed in some points with Directive 2018/851/EC, and the EU Action Plan, including the EU trade strategy for raw materials in line with the priorities set out in its 2008 and 2011 Communications on raw materials.

The following technical standards have to be considered:

- UNI EN 450-1 for the production of concrete, including structural concrete cast in situ or prefabricated, in accordance with UNI EN 206-1. The fly ash according to this document can also be used in injection mortars and mortars;
- UNI EN 206-1 that specifies the requirements for the component materials of concrete, the properties of fresh and hardened concrete and their verification, the limitations for the composition of concrete, the specification of concrete, delivery of fresh concrete, procedures for production control, compliance criteria and conformity assessment;
- UNI EN 12457- 2 that specifies a proof of conformity which provides information on the leaching of granular waste and sludge under the specified test conditions.

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

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Existence of technological processes able to transform waste into secondary raw materials - FLY ASHES - Focus on some European countries

The following scheme represents the post production processing of fly ash (FA), aimed at its use (i.e.: in concrete). The short analysis that will follow the scheme stops at obtaining fly ash as second raw material.

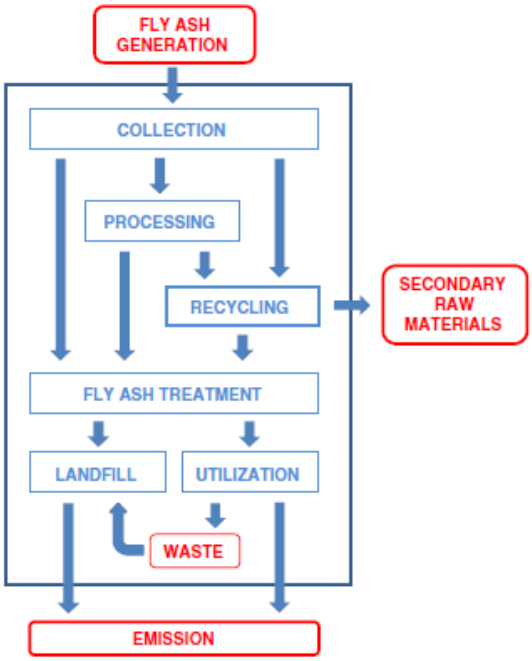

Figure 32: Flow of processes characteristic of fly ash post production

The composition of FA is very variable, depending on its origins, and pollutants can be very different. It is fundamental to exploit the chemical or physical potentials of FA constituents, in order to render them second-life functional.

Municipal solid waste incineration FAs are the most problematic ashes due to the high content of possible dangerous substances. The composition of municipal solid waste varies over time and from country to country, due to the differences in lifestyle and waste recycling process seasons.

Heavy metals (Zn and Pb) are generally found in the largest amounts. The main techniques for heavy metal entrapment are here illustrated:

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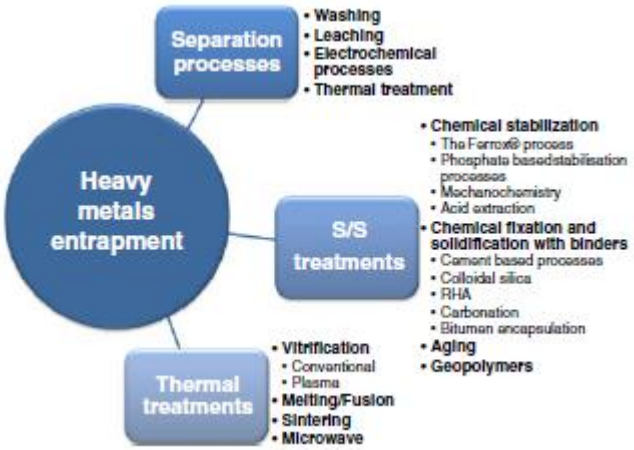

Figure 33: Main techniques for heavy metal entrapment

Besides a high content of inorganic compounds, incineration residues also contain abundant carbon-based compounds resulting from incomplete combustion of organic matter. Ashes often contain persistent hazardous organic pollutants (POP), such as polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyl's (PCB), methyl sulphates, polychlorinated dibenzo dioxins (PCDD) and furans (PCDF). The main techniques for organic pollutant abatement are shown below:

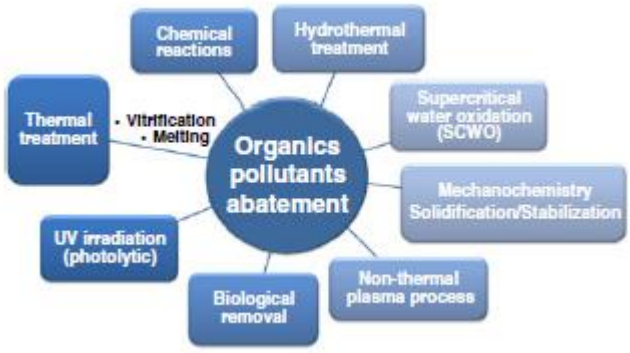

Figure 34: Main techniques for organic pollutant abatement

After the inertisation treatments, several possible uses of FA, based on its properties, can be exploited.

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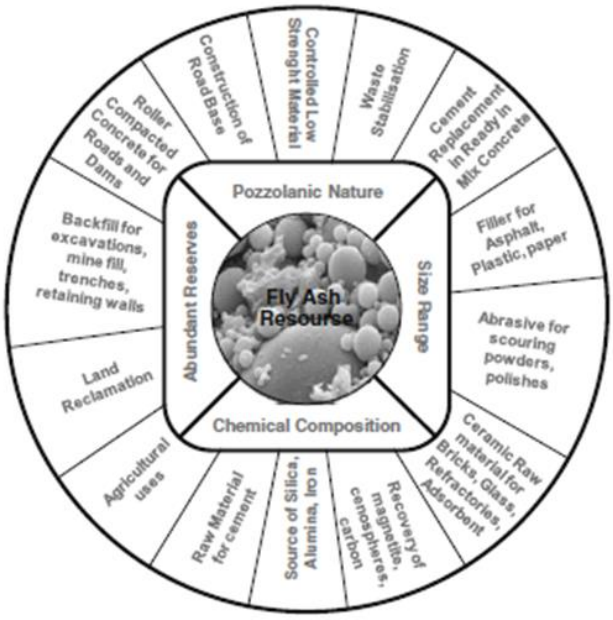

Figure 35: Possible uses of Fly Ashes

Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Technical and non-technical barriers affecting IS opportunity already identified - FLY ASHES - Focus on some European countries

Fly ash (FA) is a by-product of power and incineration plants operated either on coal and biomass, or on municipal solid waste (MSW). FA can be divided into coal fly ash, obtained from power plant burning coal, flue gas desulphurization FA, that is, the by-product generated by the air pollution control equipment in coal-fired power plants to reduce the release of SO_2, biomass FA produced in the plants for thermal conversion of biomass and municipal solid waste (MSW) incineration FA. Limitation regarding the use of municipal solid waste (MSW) fly ashes is especially due to their elevated chloride concentration.

A possible synergy is to use the fly ash as an input in cement production. This would reduce the amount of waste landfilled and avoid the environmental problems associated with conventional clinker production. However, fly ash contains heavy metals and this kind of synergy is not currently possible due to regulations. In order to use fly ash in cement production the legislation needs to change. The change could lead to economic and environmental effects, both for the cement factory and the CHP plant.

There is no fair possibility of fly ashes use by law in the various European countries. For example, in the Netherlands the status of by-product is coupled with specified applications. There are various limitations in the use in agriculture, due to its potential content of toxic elements, in particular from MSW.

Assigned score for this criteria is **2** (see Evaluation Matrix table at the end of this section).

Availability of studies related to the environmental, H&S and economic impacts of the IS opportunity - FLY ASHES - Focus on some European countries

LCA studies unveil that recycling fly ashes generally provides environmental sustainability. In particular, recycling and reuse of fly ash (FA) have a number of environmental benefits, including reduced landfilling disposal, reduced utilization of virgin resources and reduced amounts of greenhouse gas emissions (Zacco, 2014).

Due to their good adsorbent properties, FA (and in particular those from coal and rice husk) may be used as precursor for activated carbons. Thanks to its good adsorption capacities, activated carbons produced by carbonising organic materials is the most widely used adsorbent. However, the high cost of the activation process limits its employment.

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Assigned score for this criteria is **4** (see Evaluation Matrix table at the end of this section).

Availability of studies related to social acceptance of this secondary raw material - FLY ASHES - Focus on some European countries

There are not specific studies related to social acceptance of fly ashes. Fly ashes have some unique properties most useful to a wide range of industries, such as construction and building. For example, when fly ash is added to concrete, it reacts with calcium hydroxide and forms stable hydrates of calcium silicate and calcium aluminate. The resulting concrete is not only stronger and more durable, but also less permeable. This makes concrete more resistant to chemical attack.

Assigned score for this criteria is **1** (see Evaluation Matrix table at the end of this section).

Table 14: Evaluation matrix for replicability potential in different sectors – Fly ashes – Focus on some European countries

Criterion	Grade	Description	Assigned score and explanation
Existence of already established networks (industries, IS consultancy organizations, research, civil society, organizations, public authorities and policy makers)	1	Previous failed experiences of establishing a network	According to The Fly Ash Resource Center, the European Association for Use of By-Products of Coal-Fired Power Stations (ECOBA) is the European representative organization with regards to coal combustion products (CCPs). Furthermore, in the UK, the UK Quality Ash Association (UKQAA) represents a wide range of organizations involved in the production, supply and use of coal and biomass ash.
	2	Absence of a network	
	3	Existence of a network	
	4	Existence of different networks	
	5	Existence of a very strong local network	
Existence of innovative non-technological processes and initiatives	1	Previous failed experiences of establishing innovative non-technological processes and initiatives	Eurocoalash is an international conference concerned with the use of Coal Combustion Products (CCPs) in the construction industry in Europe. The conference takes place every two years.
	2	Absence of previous initiative	
	3	Example of a previous initiative	
	4	Example of different initiatives	
	5	Existence of numerous consolidated initiatives	
Previous industrial Symbiosis experiences in the sector	1	Previous IS experiences with very weak results	According to the European Association for Use of By-Products of Coal-Fired Power Stations (ECOBA), there are many fly ash applications in the construction sector in Europe.
	2	Previous IS experiences with weak results	
	3	Previous IS experiences	
	4	Previous IS experiences with good results	
	5	Previous IS experiences with very good results	

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Criterion	Grade	Description	Assigned score and explanation
Existence of previous and current IS initiatives at European and international level, for the specific waste material stream	1	Previous failed experiences for the specific waste material stream	CCPs are utilized in a wide range of applications in the building and construction industry. They can also be utilized as mineral fillers and as fertilizers.
	2	Absence of previous initiative	
	3	Example of a previous initiative	
	4	Existence of numerous initiatives	
	5	Existence of numerous successful initiatives	
Specific regulation on waste management	1	Existence of a specific regulation, hindering the utilization of the specific waste stream	At European level, it is important to mention the Circular Economy package. Some Technical standards are also important to consider.
	2	Absence of specific and clear regulations	
	3	Existence of a specific regulation, not already implemented	
	4	Existence of a specific regulation, already implemented	
	5	Existence of a specific regulation, promoting the utilization of the specific waste stream	
Existence of technological processes able to transform waste into secondary raw materials	1	Previous failed experience in developing technological processes	The composition of fly ash (FA) is very variable, depending on its origins, and pollutants can be very different. It is fundamental to exploit the chemical or physical potentials of FA constituents, in order to render them second-life functional.
	2	Absence of technological processes	
	3	Existence of one viable technological processes	
	4	Existence of different viable technological processes	
	5	Existence of different consolidated viable technological processes	
Technical and non-technical barriers affecting IS opportunity already identified	1	No information related to technical and non-technical barriers	Fly ash (FA) is a by-product of power and incineration plants operated either on coal and biomass, or on municipal solid waste (MSW). Limitation regarding the use of MSW fly ashes derive especially from their elevated chloride concentration. There is no fair possibility of fly ashes use by law in the various European countries. There are various limitations in the use in agriculture.
	2	Some barriers already identified	
	3	Some barriers already identified and some solutions proposed	
	4	Few barriers already identified	
	5	No significant barriers	
	1	No available studies	

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Criterion	Grade	Description	Assigned score and explanation
Availability of studies related to the environmental, H&S and economic impacts of the IS opportunity	2	Availability of studies demonstrating several criticalities	LCA studies unveil that recycling ashes generally provides environmental sustainability. Due to their good adsorbent properties, fly ash (in particular those from coal and rice husk) may be used as precursor for activated carbons. However, the high cost of the activation process limits its employment
	3	Availability of studies demonstrating some critical issues	
	4	Availability of studies demonstrating good performances	
	5	Availability of studies demonstrating huge benefits from ecological and economical perspective	
Availability of studies related to social acceptance of this secondary raw material	1	No available studies	There are not specific studies related to social acceptance of fly ashes.
	2	Availability of studies demonstrating very low acceptance	
	3	Availability of studies demonstrating low acceptance	
	4	Availability of studies demonstrating high acceptance	
	5	Availability of studies demonstrating very high acceptance	

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5 CONCLUSIONS

Within D7.2, "Report on Industrial Segmentation, Criteria and correlation to the FISSAC first application", the replicability concept was investigated in order to set up a methodology for industrial segmentation and for the evaluation of replicability potential, through a list of tailored criteria to guide the assessment of different opportunities. Within D7.5, "Project Validation, SWOT and Concept replicability", the criteria defined in D7.2 were applied in order to assess the replicability potential in different products/sectors and countries.
As regards the replicability potential of FISSAC Model in different countries, it is worth mentioning that responsible of Living Lab have been asked to compile the Evaluation Matrix with the criteria for their country, to assign a score to each criterion and gave an explanation about the assigned score to provide some insight. Of course, this assessment can't be exhaustive, but can provide a first overview at country level. Generally, the information gathered for assigning the score in the Evaluation matrix was based on:

- recent policy documents and measures to stimulate the transition to a circular economy;
- discussions during the Living Labs on expectations and relevant features of an ICT platform for Industrial Symbiosis;
- outcome of the calls to promote innovative and circular projects;
- EU surveys.

As regards the replicability potential of FISSAC Model for different products, the following were considered:

- Construction and demolition waste of WOOD and PLASTIC – Sweden
- GYPSUM – Sweden
- COPPER SLAG - Europe with some focus on Germany
- FLY ASHES - Europe with some focus on several European countries

In particular, as concerns Construction and demolition waste of wood and plastic, and gypsum, Sweden was assumed as reference country and a valuable contribution was given by RISE and HIFAB.

Generally, the scores assigned in the Evaluation Matrix have shown a good replicability potential of the FISSAC model, both for the different countries and for the different products.

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