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Industrial Symbiosis 2020

Summary of CIRCULÉIRE's Thematic Working Group Industrial Symbiosis Synthesis Report

Elaborated by International Synergies Limited

IRISH MANUFACTURING RESEARCH

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Climate-KIC is supported by the EIT, a body of the European Union

Authorship

This *Industrial Symbiosis 2020* Synthesis report provides detailed insights into the Irish Industrial Symbiosis landscape. Please refer to the *Industrial Symbiosis 2020 Summary Report* for an overview of key findings from the *Industrial Symbiosis 2020 Synthesis Report*.

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Acknowledgements

Irish Manufacturing Research and International Synergies Limited would like to thank the following actors without which neither the *Industrial Symbiosis 2020 Summary Report* nor the *Industrial Symbiosis 2020 Synthesis Report* would have been possible:

- ***Expert Panel Members***
- ***Anonymous Expert Peer Reviewer***
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About CIRCULÉIRE

CIRCULÉIRE, the National Platform for Circular Manufacturing seeks to accelerate Ireland's transition towards a net-zero carbon circular economy.

A key objective of the programme is to demystify, de-risk and deliver circular business model innovation for Irish industry.

An Industrial Symbiosis Thematic Working Group was established with expert panel representing industry and research in Ireland. The two objectives of the working group were:

- to produce a state-of-the-art review to understand best practice (practice and policy) from further afield to inform how to address gaps / barriers in Ireland, and
- to develop recommendations for circular innovation projects (that are systems innovations) with potential to be funded by CIRCULÉIRE's Innovation Fund and rolled out across Ireland.

Want to learn more about CIRCULÉIRE? Look at www.circuleire.ie **or contact** circuleire@imr.ie

About ISL

International Synergies Limited (ISL) is world-leading expert in industrial symbiosis implementation.

ISL facilitated the Industrial Symbiosis Thematic Working Group comprising of eight industry panel members and fourteen non-industry panel members.

Want to learn more about ISL? Look at https://www.international-synergies.com/ **or contact** info@international-synergies.com

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Executive Summary

Industrial symbiosis has proven effective in delivering economic, environmental and social benefits, as well as supporting transition to a more circular economy around the world. An industry-led consortium defined industrial symbiosis for the EU as follows: ***"Industrial symbiosis is the use by one company or sector of underutilised resources broadly defined (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials) from another, with the result of keeping resources in productive use for longer."*** (CEN 2018).

To accelerate the uptake of industrial symbiosis in Ireland, this report introduces the concept of industrial symbiosis and various approaches to its delivery. Examples of industrial symbiosis best practices (implementation and policy) are presented to inform how to address gaps and barriers (real or perceived) in Ireland.

The cross-cutting nature of industrial symbiosis, in terms of working across sectors, providing multiple benefits and contributing to many policy aims and objectives makes a coordinated approach between government, industry and solution providers such as research organisations highly important.

A review of conditions in Ireland reveals no specific hindrances to more widespread adoption of an industrial symbiosis approach.

Ireland can scale implementation of industrial symbiosis via adoption of the EU recommended facilitated approach that has proven effective in helping to remove barriers including market failures. Such an approach would invariably identify demand-led research needs to advance industrial symbiosis both over short-and long-term horizons.

Potential industrial symbiosis innovation projects identified through a facilitated ideation process are presented in this report. **In addition, four resource flows (cement, sludge, whey and solvents) that have a high industrial symbiosis pedigree across the world and involve cross-sector interaction and business opportunity creation are explored herein**.

The recommendations put forward to promote the uptake of industrial symbiosis in Ireland fall into four themes, namely: technologies, end of waste, networks and data.

The principal recommendation is for a facilitated industrial symbiosis programme with clear roles and responsibilities, namely: a government owner or sponsor, a national coordinating body for delivery and an innovation/research partner. The key advantage of such an approach is that a national coordinator can bring ALL the threads of industrial symbiosis together, including key relationships with funders and regulators for optimal engagement and impact.

Contents

1.0 Industrial symbiosis & related concepts

Key Messages:

- Industrial symbiosis delivers resource efficiency and carbon savings with an excellent value-for-money, and can contribute to the realization of all sustainable development goals.
- There are four major implementation approaches for industrial symbiosis namely self-organized, facilitated, ICT-supported and strategic or planned approaches.
- The core elements of industrial symbiosis identified as required across all four approaches include: (i) underutilized resources are returned to productive use; (ii) information about opportunities is required to advance synergies; (iii) Business conditions (market or policy/regulation based) incentivize industrial symbiosis.
- Optional dimensions that may occur in some synergies and not in others include: (i) collaboration through networks; (ii) innovation; and (iii) shared services.
- This report showcases four industrial symbiosis examples-NISP® Canada, Western Cape Industrial Symbiosis Programme (WISP), national policy example from Turkey, and the eco-industrial park (EIP) model from the Republic of Korea (abandoned in favour of a regional network model).

1.1 Industrial symbiosis and climate mitigation

Various definitions for industrial symbiosis (IS) have been offered by academics, as reviewed by Lombardi and Laybourn (2012), and others including various departments of the European Commission. The CEN Workshop for Industrial Symbiosis (CEN, 2018) however reached an industry-led consensus on key definitions, core elements and implementation approaches to industrial symbiosis. According to CEN Workshop Agreement for Industrial symbiosis (CEN, 2018): ***"Industrial symbiosis is the use by one company or sector of underutilised resources broadly defined (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials) from another, with the result of keeping resources in productive use for longer."***

The European Commission's 2011 Roadmap for a Resource Efficient Europe recommends IS as a priority for all member states to exploit resource efficiency gains. This recommendation was translated into policy in 2018 (DG ENV, 2018). European firms of all sizes are actively pursuing resource and energy efficiency (Eurobarometer, 2012). This has become increasingly important as the European industrial sector shrinks, and as energy costs and raw material demand increase (DG ENT, 2013; Dobbs et al, 2011).

There is a growing market for IS across Europe, supported by the high-level European Resource Efficiency Platform (EREP, 2014) recommendation that EU Member States should foster IS by promoting a pan-European network of IS initiatives. A report by Ellen MacArthur Foundation based on McKinsey & Co analysis estimates an annual net material cost savings opportunity of up to €487 Billion for a subset of EU manufacturing sectors (EMF, 2010). Industrial symbiosis has been shown to deliver resource efficiency with an excellent value-for-money e.g. a return of less than €1 per tonne of CO2-equivalent avoided (Laybourn & Morrissey 2009). Industrial symbiosis delivers environmental, economic and social benefits (see Table 1).

Table 1: Industrial symbiosis benefits delivered (Laybourn & Morrissey 2009; Sommer 2020)

Environmental	Economic	Social
• Decarbonisation • Landfill diversion • Water savings • Virgin material savings • Energy reduction • Reduction in pollution • Reduction in waste, including hazardous waste	• Increased sales & reduced costs • Profits leading to tax revenues • Increased competitiveness • Demand-led innovation • Private investment	• Job creation and safeguarding • Cascading of best practice • Cleaner environment • Education and skills • SME engagement

1.2 Industrial symbiosis, circular economy & the SDGs

Any relationship of industrial symbiosis to other concepts is anchored in the classic definition of sustainable development, Brundtland (1987) "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.". This aspiration has obvious implications for resource and energy use which are

reflected in the definitions of circular economy and industrial ecology. The many definitions of the circular economy (none of which are definitive) all purport to highlight the attributes that a circular economy should have to contribute towards sustainable development.

A popular definition of circular economy from the Ellen Macarthur Foundation includes in its three principles to "keep products and materials in use," a core concept reflected in the CEN Working Agreement (CWA) definition of industrial symbiosis. The European Commission further defines a circular economy as one where resources are kept in productive use for longer, as per the CWA definition of industrial symbiosis: **"… the value of products and materials is maintained for as long as possible. Waste and resource use are minimised, and when a product reaches the end of its life, it is used again to create further value. This can bring major economic benefits, contributing to innovation, growth and job creation." (EC, 2020).**

Industrial symbiosis has been identified at the highest level as being able to contribute to the SDGs. For example, at the G7 Alliance for Resource Efficiency 2015 first workshop on industrial symbiosis UNEP identified that IS has a significant contribution to the following SDGs:

- Decent Work & Economic Growth (8)
- Industry Innovation & Infrastructure (9)
- Sustainable Cities (11)
- Responsible Consumption and Production (12)
- Climate Action (13)
- Partnerships (17)

However, the UNEP International Resource Panel Co-Chair and former EU Environment Commissioner Dr. Janez Potočnik argued in 2019 that resource efficiency (industrial symbiosis being a key part 'a la' G7 Alliance for Resource Efficiency) contributes to all SDGs.

1.3 Industrial Symbiosis Implementation Approaches

The industry-led consensus document (CEN, 2018) described four implementation approaches to industrial symbiosis. These four approaches include self-organized, facilitated, ICT-supported and strategic or planned approaches.

Self-organised: a bottom-up approach resulting from direct interaction among industrial actors, without any external coordination. It is generally motivated by business concerns arising from context, including resource risk, pending legislation and economic gains.

Facilitated: where a third-party intermediary coordinates the activity by working with organizations to identify opportunities and bring them to fruition. Industrial symbiosis practitioners play the critical role of facilitating and coordinating the contributions of the various stakeholders. By engaging with organizations from all sectors, the practitioner enables the flow of information across sectoral boundaries. The practitioners also often provide the needed support to overcome technical or regulatory barriers associated with synergies.

ICT-supported: Part of the challenge of industrial symbiosis in practice is that most opportunities for a given organisation lie outside one's own sector. Decision-makers in industry today will have experience deriving primarily from a single industry; going outside one's own sector, and traditional supply chain, requires support. This market failure of information in relation to resource efficiency can be addressed through mechanisms that improve information flow between actors.

Strategic or planned: a top-down approach where networks are formed following a central plan or strategic vision that includes attracting new businesses to regeneration sites or purpose-built developments.

Noteworthy however is the fact that these four approaches to industrial symbiosis delivery are not mutually exclusive. This is demonstrated in the well-known industrial symbiosis network in Kalundborg, Denmark. The Kalundborg IS Network was self-organised until 1989 (achieving 10 synergistic relationships in that time-Schwarz & Steininger, 1997), after which a coordinating organization (the Symbiosis Institute) was launched to accelerate its delivery of successful synergies.

The National Industrial Symbiosis Programme (NISP®) in England, famous for its facilitated approach, started without ICT support in its early days and then developed a bespoke ICT support tool SYNERGie®. ICT-enabled approaches such as SMILE in Ireland may or may not include facilitation. Strategic/planned approaches may involve facilitators and/or ICT support.

1.4 Core elements of Industrial Symbiosis

The core elements of industrial symbiosis identified as required across all four approaches by CEN, 2018 are as follows:

• Returning underutilised resources (often called waste) to productive use: Transactions (synergies) involving material, energy and water tend to be at the core of industrial symbiosis, but non-material

resources such as expertise, capacity and logistics can be equally valuable.

• **Information about opportunities** (e.g., data on other organisations' resources or new technologies) is required to be able to advance a synergy.

• **Business conditions incentivize industrial symbiosis.** This may be through market conditions (cost reduction, risk reduction, improved competitiveness) or through policies and regulations that specify definitions (for example, waste versus by-product) and responsibilities."

Optional dimensions that may occur in some synergies and not in others according to CEN, 2018 include:

• **Collaboration through networks**: A diverse network of organisations of all sectors and sizes contributes to success, as most opportunities lie outside one's own sector. Sectors including Government, third sector, research and the community each can contribute to industrial symbiosis, bringing new ideas and stimulating further activity. A formal network is not required for an actor to pursue industrial symbiosis (e.g., in the self-organised approach).

• **Innovation**: Often an industrial symbiosis opportunity entails innovative diversification of the business-as-usual supply chain.

• **Shared services**: Sharing may reduce the environmental impact of the services in line with the goal of industrial symbiosis. However, if those services are not derived from previously underutilised resources then it may not be aligned with the core elements of industrial symbiosis.

1.5 Industrial symbiosis examples

In reality, different examples of industrial symbiosis combine different implementation approaches. This report showcases two successful facilitated regional programmes using the UK developed National Industrial Symbiosis Programme (NISP®) model (NISP® Canada and Western Cape Industrial Symbiosis Programme – WISP), one national policy example from Turkey, and finally the eco-industrial park (EIP) model from the Republic of Korea which has been abandoned in favour of a regional industrial symbiosis network model. Noteworthy however is departure from stereotypes and the rapid movement of nations like Israel over the last three years from having no industrial symbiosis policy or implementation to a national policy and national facilitated implementation.

The NISP® model particularly has been adapted and adopted in over 20 countries on six continents, including in Europe: Belgium, Denmark, Finland, France, Germany, Hungary, Italy, Netherlands, Poland, Romania and Spain. Facilitated networks have been developed in Europe often as part of projects supported by EU funds (e.g. LIFE+, European Regional Development Funds, Horizon 2020 etc.). Facilitators may come from the private sector (as with NISP® England), the public sector (e.g., Manresa, Spain), the third sector (e.g., GreenCape, South Africa) or academia (Rotterdam, Netherlands). Their activities can be directed to achieve specific targets: for example, if success is determined by achieving substantial landfill diversion, then target sectors are likely to include construction, cement, and foundries as part offor the large volumes of materials mobilised. If instead the key metric is innovation, the coordination focuses on attracting entrepreneurs and innovators.

- **WISP: from ICT to facilitated programme**

The Western Cape Industrial Symbiosis Programme (WISP) is a multiple award-winning free facilitation service to businesses, which is funded by the City of Cape Town. WISP facilitators provide businesses with dedicated time and technical expertise, connecting companies with unused or residual resources such as materials, energy, water, assets, logistics and expertise. WISP's aim for their business 'members' is to:

- Cut costs and increase profit
- Improve their business processes
- Create new revenue streams
- Learn from WISP team and each other
- Operate more sustainably

Prior to WISP, the Integrated Waste Exchange was established by the City of Cape Town in May 2000; on 11 September 2014 (i.e. after more than 14 years), it had 100 resources listed. In contrast, the facilitated WISP identified and captured detailed information on 465 resources in less than one year – making expert-supported IS more than fifty times more effective at capturing resources.

WISP works with companies of all sizes and from different industries: for example, successful synergies have been facilitated in the food, textile and manufacturing industries. Membership is free regardless of sector, size or turnover. WISP was a runner up in the Circulars Awards 2018.

- **NISP® Canada: Facilitated programme with ICT support**

Based on regional programmes in Alberta and British Columbia, NISP Canada has during its pilot phase achieved $6.3M in direct economic impact to participating businesses. 23,800 tonnes of CO_2e emissions avoided, equivalent to more than 5,000

passenger vehicles driven for one year; and 253,800 tonnes of waste diverted from landfill. NISP® Canada is principally funded by the Western Diversification Programme to help diversify the economy of western Canada. The example illustrates both how the motivation for the initiation of industrial symbiosis can be different and how the investors/funders of programmes can influence the direction/focus of a programme towards specific objectives. FISS in Finland for example was set up for the purpose of increasing innovation post the collapse of Nokia.

- **Turkey: National policy and roadmap**

This example from Turkey illustrates how industrial symbiosis has been implemented in a range of policies from regional to national. However, it also illustrates that policy statements are not sufficient to guarantee action. So, in the Irish context, even though supportive policies would be welcome, there is no guarantee that implementation would follow.

Rapid industrialisation and urbanisation in Turkey over the last thirty years has led to challenges with waste elimination and the need to transform to a more resource efficient and greener industrial structure. In the 10th Development Plan of Turkey, environmental protection and sustainable use of resources are among the priority goals. In this regard, industrial symbiosis is defined as a strategic tool to achieve these goals in many national policy documents. Industrial symbiosis is also defined as a tool for reaching eco-efficiency and regional competitiveness objectives in regional policy documents. 19 out of 26 regional development plans and policy documents throughout Turkey define industrial symbiosis as a tool for reaching the above-mentioned objectives. Moreover, Turkey announced industrial symbiosis will be used to mitigate its GHG emissions in its Intended Nationally Determined Contributions within the context of United Nations Framework Convention on Climate Change Conference of the Parties (COP21) held in Paris in December 2015. In addition, industrial symbiosis is included within many national policy documents such as the Priority Transformation Programme for Enhancing Productivity in Manufacturing, SME Strategy and Action Plan (2015-2018), National Efficiency Strategy and Action Plan (2015-2018) and the National Cleaner Production/Eco-efficiency Strategy (2014-2017).

As a response to the above policy initiatives, the Turkish Ministry of Industry and Technology commissioned a Roadmap for Implementation to recommend a governance and delivery structure (Figure 1).

- **Republic of Korea: from eco-Industrial Parks (EIP) to regional activity**

The Korean government established a three-stage, 15-year EIP program to enhance industrial performance and competitiveness. During the first five years of pilot experimentation, between 2005 and 2010, 47 IS projects were implemented at five pilot sites by examining technical, economic, legal/regulatory, and social factors to expose important drivers for further IS development in Korea and elsewhere (Park et al., 2016). From its beginning, the program focused on establishing appropriate legal and regulatory systems to support and promote EIP projects. To support the program, the Transition to Environment-friendly Industrial Structure Act was amended in 2006, empowering the regional EIP centres to compile statistics from central and local government bodies, and to collect industry data through facility visits and surveys (Park et al., 2016). In December 2016, the Korean Government ceased funding EIPs under the coordinating body of KICOX and reintroduced funding in 2019 for regional industrial symbiosis networks. This strategic redirection recognised the limitations of the eco-industrial park model, especially with regards to innovation and sustainability of funding large projects with long payback periods.

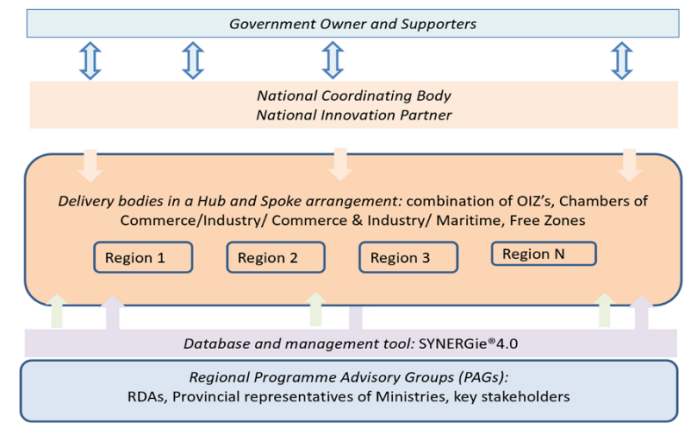

Figure 1: Proposed roadmap structure for Implementation of national industrial symbiosis activity in Turkey

2.0 Evolution of Industrial Symbiosis Policy in Europe and Ireland

Key Messages:

- No major policy constraints to industrial symbiosis in Europe and Ireland.
- Key enablers and barriers to industrial symbiosis include awareness, regulations, investments, data, skills and infrastructure.

2.1 Overview of European and Irish industrial symbiosis policy

Facilitated industrial symbiosis in and outside the EU has proven to be a resilient approach to multiple challenges of policy, and regulation, and to background conditions of policy, sectors, diversity etc. Policies related to industrial symbiosis within the EU may have evolved from a wide variety of agendas ranging from Environment (waste), to Enterprise (competitiveness), to Research and Innovation. We reviewed IS related policies within the EU and Ireland in this section.

European policies related to industrial symbiosis

Industrial symbiosis has been incorporated into European policy and reports since 2009, starting with Its inclusion in the European Waste Framework Directive (WFD) as an example of best practice. It is worth noting how quickly (within 10 years) mentions of industrial symbiosis have gone beyond waste as many Directorate-General(s) (DGs) within the European Commission have identified IS as relevant to their respective agendas, from DG Regions (focusing on economic development) to DG Enterprise (for Entrepreneurship), DG Environment (focusing on resource efficiency) and DG Energy (for strategic planning). Some recent and relevant documents addressing key policies and reports are:

The DG GROW commissioned report "Cooperation Fostering Industrial Symbiosis (Domenech et al, 2018)" put forward the following key findings:

•Cost reduction of €73 billion estimated across EU from IS

•Public sector-supported facilitated industrial symbiosis is the best model to address market failures

•No evidence of operative fully commercial facilitation (of industrial symbiosis) in Europe

•Success of industrial symbiosis initiatives is largely dependent on the policy environment

The WFD Amendment (DG ENV, 2018) specifically states:

•"Waste management in the [EU] should be improved and transformed into sustainable material management … promoting the principles of the circular economy … in a way that preserves resources and closes loops"

•"In order to promote sustainable use of resources and industrial symbiosis, Member States should take appropriate measures to facilitate the recognition as a by-product of a substance or an object resulting from a production process whose primary aim of which is not the production of that substance … the Commission should be empowered to adopt implementing acts in order to establishing detailed criteria … prioritising replicable practices of industrial symbiosis practices. "

The 2020 Circular Economy Action Plan includes the commitment to: "facilitating industrial symbiosis by developing an industry-led reporting and certification system, and thereby enabling its implementation."

This commitment has been actioned via **a DG GROW-commissioned project to establish a Europe-wide industrial symbiosis network** (working title CircLean) to be fully operational in 2022. Further information on CircLean and the relationship of industrial symbiosis to the European Green Deal can be found here: CircLean

Irish policies and regulations related to industrial symbiosis

The potential impacts from market drivers and changes in the market will shape the business case for any industrial symbiosis transaction. Policy and regulation however play an important role in determining the market context for industrial symbiosis namely the cost of waste, the cost of other markets such as carbon, raw materials supply (i.e. security and volatility) and so on. It therefore needs

to be properly understood in the light of industrial symbiosis implementation.

References by Connolly et al., 2017 and Lyons et al. 2017 for the EPA specifically address Irish policies related to resource reuse opportunities. The key policies identified in the documents reviewed are presented here; none has been identified as presenting a substantive barrier to IS in Ireland.

The Waste Framework Directive 2008/98/EC1 [WFD, EC (2008)] have been transposed into Irish legislation in 2011 (S.I. No. 126 of 2011). The Irish EPA reports that "Article 27 of the European Communities (Waste Directive) Regulations, 2011, allows an "economic operator" to decide, under certain circumstances, that a material is a by-product and not a waste. Article 27 was introduced into Irish law to implement article 5 of the 2008 Waste Framework Directive (2008/98/EU). However, lack of clarity in Article 27 for by-products or wastes is identified as a significant barrier (Lyons et al. 2017) requiring substantial time and effort to make Article 27 determinations for wastes and by-products. No substantive differences with other European Union Member States are identified: thus, Ireland is in a position to implement industrial symbiosis comparable with other EU Member States where IS is more prevalent.

The National Waste Prevention Programme (NWPP), operated by the Environmental Protection Agency (EPA), has been in place since 2004. The 2012 A Resource Opportunity: Waste Management Policy in Ireland (DECLG, 2012) provides a roadmap for waste and resource planning in Ireland, encouraging and promoting reuse opportunities through the NWPP, and building on examples of reuse sites such as SMILE (2011-2018) and FreeTrade Ireland, which facilitate the reuse of unwanted goods between businesses and members of the public.

The Regional Waste Management Plans (RWMPs) 2015–2021 emphasize prevention, reuse and preparing for reuse, focusing on both the circular economy and the waste hierarchy as central.

Ireland's National Climate Action Plan (2019) and the Waste Action Plan for a Circular Economy (2020) are both supportive to the implementation of IS. The Climate Action Plan outlines the current state of play across key sectors including Electricity, Transport, Built Environment, Industry and Agriculture and charts a course towards ambitious decarbonisation targets. The Waste Action Plan for a Circular Economy will introduce ambitious new targets to tackle waste and move towards a circular economy. The plan includes a ban on certain single use plastics from July 2021, the application of green criteria and circular economy principles in all public procurement, a waste recovery levy to encourage recycling, and ensuring all packaging is reusable or recyclable by 2030.

2.2 Key enablers and barriers of industrial symbiosis

Barriers to IS are identified in the literature at multiple levels. Some are non-technical in nature. Enablers are identified as the components that support IS projects. A given factor could be an enabler on one side, but a barrier on the other. For example a coordinating body is an enabler, but lack of a coordinating body is a barrier (depending on the context). Industrial symbiosis is enabled by a broad range of social elements, political instruments and economic drivers, ranging from Environment (waste), to Enterprise (competitiveness), to Research and Innovation.

Table 2 details the barriers consistently identified across four key publications namely Connolly et al. 2017 (RPS for EPA); Vladimirova et al 2017 (for Horizon 2020 project SCALER); Lombardi, 2018 (EPEE for Horizon 2020 project SHAREBOX) and Sommer, 2020 (for DG Research & Innovation). Highlighted in green below are the barriers identified by all of four reviewed reports suggesting that they are commonplace. Less frequently documented barriers are mostly context specific. In discussing barriers and enablers, it is worth making the point that constraints often identified by academic literature (e.g. trust, equity, confidentiality, need for new forms of contract) are not validated by industry-led work.

2.3 Current landscape and gaps in practice and policy in Ireland

The SMILE (Saving Money through Industry Links and Exchanges) reuse website was funded by the EPA 2011-2018. The SMILE programme started off as a platform for connecting companies for exchanging excess resources. Without technical assistance to implement IS synergies in the early stages, not many IS projects were being completed. With time, SMILE learned from other European networks and hired consultants to facilitate the identification of new companies and contacted the companies periodically to discuss the synergies. Subsequently, the website services of the sharing platform have been maintained in their simplified version. (Domenech et al, 2018).

Table 2: Barriers and enablers listed by four key publications (Connolly et al. 2017, Vladimirova et al. 2017, Lombardi 2018, Sommer 2020)

Barriers and enablers	Description
Awareness	Lack of awareness and understanding; Lack of visibility of opportunities
Regulations	Clarity, stability, consistency and a long-term perspective on regulations re: waste as a raw material; harmonisation of regulations
Investments	New technologies, new infrastructure (pipelines, grids), the operation itself and time needed.
Data	Antitrust, legal and IP-protection rules pertaining specifically to the exchange of data (technical, commercial)
Skills	Relevant skills and successful business models (lack of)
Infrastructure	For transport and logistics gas, electricity and energy

A qualitative study delivered by Lyons et al. 2017 for the EPA had as its objective to identify if industrial symbiosis (IS) type transactions were occurring in the Republic of Ireland. Even without a centralised or managed industrial symbiosis activity in Ireland, numerous IS transactions were identified as active in Ireland through semi-structured interviews with a selection of 6 companies identified through internet searches and network referrals (Lyons et al 2017).

According to Lyons et al., 2017, existing IS transactions in Ireland from a sample of 6 companies are as follows:

•Aluminium oxide some of which is re-melted with the remainder made into new products,

•Off use lime (lime rejected for a specific purpose),

•Off size wood pallets,

•Clean plastics,

•Paper and cardboard,

•Off cut animal products for new markets (e.g., feet)

•Magnesium oxide (by reducing excess water from 50% to 20%)

•Non-traditional uses of animal by-products (land spreading and anaerobic digestion)

•Refuse Derived Fuel (Cat.1 animal wastes, smaller plastics that cannot be recycled, etc)

•Metal shavings to local scrap yard

•General office waste (essentially municipal waste recycling)

Also, existing internal energy cascades (i.e. to the company but not necessarily the same plant) include:

•Animal waste products directed to an anaerobic digester to produce electricity that is sold to the local grid

•Recovering and redirecting heat from refrigeration processes to further run the refrigeration processes

•Recovering heat to generate hot water to wash/melt animal fat

•Exhaust gasses in the lime kiln to preheat the limestone coming into the kiln.

•Internal energy cascading, using excess heat from one process to heat another process

•Reed beds to process waste waters and reuse clean water for various washing purposes."

Lyons et al. 2017 also reported that economic incentives are the most significant factor for IS in Ireland. Others include cost reduction, the minimization of by-product/waste production via more efficient internal methods of production and finding new markets for by-products and wastes. Environmental compliance is identified as a major driver, particularly for international organisations and those with corporate mandates to reduce waste.

3.0 Potential Industrial Symbiosis Innovation Opportunities

Key Messages:

- The state-of-the-art review and stakeholder ideation workshops fed into identifying circular innovation projects to deliver carbon reduction.
- Four resource flows (cement, sludge, whey and solvents) that meet the criteria for development as carbon reduction projects were examined along six critical dimensions namely (i) nature of industrial symbiosis; (ii) scale of circular economy activity and expected scale of opportunities and potential impact (if successful); (iii) key actors required; (iv) estimated scale of investment, and transformation potential (scalability and replicability); (v) systems innovation required; and (vi) key enablers and key barriers.

3.1 Ideation methodology and overview

Stakeholder ideation workshop sessions which brought together eight industry panel members and fourteen non-industry panel members were facilitated by International Synergies Limited **to develop innovation ideas tailored to Irish context** i.e. recommendations for potential circular innovation projects.

Methodology description

Through ideation, or brainstorming, participants were directed to solve problems through "How Might We…?" questions (HMW questions) that frame the challenge to generate the broadest range of possibilities. To encourage cross-fertilisation of ideas, participants were asked to build on each other's ideas through a 'Yes and…' exercise in each session.

The objective of Session 1 was to generate "How Might We…" questions leading to innovation projects:

- Circular innovation projects addressing the drawbacks identified in the State-of-the-art review: Awareness raising, Enabling Policy, Facilitation and Business landscape;
- Carbon reduction projects via specific resources: Metals, Plastics (High density and others), Wood, Waste heat/steam and Glass.

The results identified in Session 1 were grouped into themes, and the themes prioritised based on the facilitator's (i.e. International Synergies Limited-ISL) assessment of their potential to yield relevant project ideas. The priority themes were taken forward into Session 2 for development.

The objective of Session 2 was to brainstorm HMW **solutions** to the priority themes taken forward from Session 1: Business, Data & Information, and Technology.

The themes taken forward from session 1 included:

- Embedding IS into Business as Usual?
- Identifying and using the data needed?
- Identifying the technologies needed to address IE needs?

The objective of the final Session 3 was to develop the top HMW **solutions** (i.e., potential projects) identified in Session 2. In Session 3, panellists were asked to apply the project ideas generated to specific sectors to justify resource-specific carbon reduction project ideas. Various ideas put forward onto sector specific boards were distilled.

3.2 Overview of ideas generated

Results from sessions are summarised by theme in the tables below with panellist contributions on the left, reference points (existing materials and activities to draw on) in the middle column and potential projects suggested on the right. Those projects taken forward in the Overall Recommendations section are highlighted in **bold red text.**

Table 3a: Awareness raising as barrier/enabler and potential projects

Theme: Awareness raising		
PANEL INPUT…	**REFERENCE POINTS**	**POTENTIAL PROJECTS**
• Relevant business case • Case studies • Standards, Certification • Language/ communication • SMART targets for public consumption	• Libraries of case studies and training materials (previous presentation and webinar slides etc.) • Literature • Industry best practice • 2021 EU CircLean label for IS	• Awareness raising campaign should be focused on the goal of moving industry to action • Cohort training to create leaders and teams for implementation in industry • Train companies to prepare for IS (map resources, identify opportunities) • Train companies to measure & report impacts from IS within business • Work with National Standards Authority of Ireland (NSAI) for accreditation of standards and certification • Review existing carbon reduction awards to include IS activities • **Speed-up efforts to identify solutions for industry-identified difficult-to-manage waste streams**

Table 3b: Mapping of resources as barrier/enabler and potential projects

Theme: Mapping of resources (company, industry/sector)		
PANEL INPUT…	**REFERENCE POINTS**	**POTENTIAL PROJECTS**
• Create national register of inputs, outputs • GEO identified resources • Identify & prioritise high value streams • Security of supply for materials relevant to IE economy • Carbon valuation for all materials	• Free workbook for companies from UNEP • Various tools from H2020 projects • Industry best practice • Trade associations • Public sources • Waste reporting • Irish Environmental Protection Agency (EPA) • European Environment Agency (EEA) • Professional bodies • Industry roadmaps • Resource risk assessments	• Companies implement mapping of own resources to identify IS potential • Industrial parks implement mapping of member company resources to identify IS potential • Quantify potential for IS impact at various levels • **Map priority resource issues that can be addressed through IS** • **Relate resource issues and IS potential to industry roadmap and sustainability drivers** • **Partner with trade associations to develop sector maps and current IS activity**

Table 3c: Map/develop technologies & solution providers as barrier/enabler and potential projects

Theme: Map/develop technologies & solution providers		
PANEL INPUT…	**REFERENCE POINTS**	**POTENTIAL PROJECTS?**
• Mapping technologies • Directory of technology, solution providers • Top 10 innovative technology companies, projects	• Best Available Techniques Reference Documents (BREF) map technologies to European Waste Catalogue (EWC) • Enterprise directory • Software	• **Directory of local solution providers and its promotion to industry** • **Identify and promote top 10 innovative technology companies with IS related solutions** • Entrepreneurial hubs for developing and testing solutions: a meeting place or base for entrepreneurs, solution providers and machineries for testing of solutions (e.g. 3D printing etc). This may be situated at one of the existing pilot testing hubs

Table 3d: Identify IS opportunities as barrier/enabler and potential projects as barrier/enabler and potential projects

Theme: Identify IS opportunities		
PANEL INPUT…	**REFERENCE POINTS**	**POTENTIAL PROJECTS**
• Derisk IS • Make connections less complicated • Build new partnerships	• Facilitation recognised as the most effective means to deliver impact • Libraries of case studies • Literature • Software • Industry best practice • Consultants • Industry and trade associations • Chambers of commerce • Local universities • Entrepreneur hubs	• **Specific technical challenges associated with material specification for innovation reuse** • **Pilot facilitated activity in an area, county or industrial park; monitor impacts; assess ROI** • **Establishment of networks for enabling of cross-sector collaboration** • Techniques to work with supply chains

Table 3e: Funds/Financing as barrier/enabler and potential projects as barrier/enabler and potential projects

Supporting theme: Funds/Financing		
PANEL INPUT…	**REFERENCE POINTS**	**POTENTIAL PROJECTS**
• How to identify funds, financing • How to align to existing calls • Responsible body in IE? (Entreprise Ireland-EI, Industrial Development Acts- IDA…)	• National Contact Points • University/ Institution landscape scanning	• Develop Irish roadmap to IS • Develop link to centralised funding bodies that foster technology innovation in industry (model Innovate UK)

Table 3f: Software as barrier/enabler and potential projects as barrier/enabler and potential projects

Supporting theme: Software		
PANEL INPUT…	**REFERENCE POINTS**	**POTENTIAL PROJECTS**
• Secondary raw materials marketplace • SMILE • Use AI to make B2B matches • Geo-locate resources	• CircLean and others	• Develop own software • License existing software • Populate software • **Drive industry adoption of software**

Table 3g: Regulations/Standards as barrier/enabler and potential projects as barrier/enabler and potential projects

Supporting themes: Regulations/Standards		
PANEL INPUT…	**REFERENCE POINTS**	**POTENTIAL PROJECTS?**
• Material passports • Recovery processes • Tech spec harmonisation	• Emilia Romagna, Italy: End-of-Waste (EoW) exceptions • UK: waste protocols	• **Develop targeted end of waste criteria, waste protocols to facilitate reuse** • Implement pilot to facilitate EoW

Table 3h: Planning as barrier/enabler and potential projects as barrier/enabler and potential projects

Supporting theme: Planning		
PANEL INPUT…	**REFERENCE POINTS**	**POTENTIAL PROJECTS?**
• County development plans • Irish Planning Authority decision making	• Existing policies in UK, Turkey, Mexico, PR	• Counties or industrial parks analyse existing resource flows for investment opportunities, relate to planning legislation

3.3 Resource-focused opportunity development

The Terms of Reference for the Stakeholder Ideation Workshop was the identification of "potential circular innovation projects (which are systems innovations) which have the potential to be funded by CIRCULÉIRE's innovation fund and rolled out across Ireland".

Few resource-focused opportunities identified in the Ideation sessions were suitable for development against the criterion for resource-specific carbon reduction projects. Drawing on International Synergies Limited's vast experience, four resource flows with high industrial symbiosis pedigree, as well as the potential for cross-sector interaction and value creation were identified and presented- **cement**, **sludge**, **whey and solvents.**

Below, the nature and scale of the industrial symbiosis activity, and the circular economy impact associated with the four identified resource flows are briefly described. ***Please refer to Section 8 of the Comprehensive Industrial Symbiosis 2020 Synthesis Report for insights into actors required for implementation, estimated scale of investment required, transformation potential (scalability & replicability), systems innovation required, as well as key enablers and barriers***.

Nature of industrial symbiosis: Industrial symbiosis activities on the 4 resource flow examined are expected to be at **national scale**.

- **Cement**

Industrial symbiosis in the cement industry is based on established alternative raw materials (ARMs) for both fuel and raw materials substitution, as well as new technologies, only some of which are being explored in Ireland. Opportunities exist in Ireland to engage more broadly in ARMs (both fuels and raw material substitution) and to develop new technologies for expanding the accepted use of ARMs.

- **Sludge**

Industrial symbiosis for sludge relies on established opportunities to extract valuable components from both municipal and industrial sludges. Opportunities exist to develop new technologies and apply existing ones in various sectors especially agri-food and beverage, building and construction, and pharmaceuticals.

- **Whey**

Ireland is home to various extraction techniques that valorise the components of whey. The opportunity for Ireland may be to adapt and extend the various technologies to extract whey for higher-value applications such that they are accessible to the micro, small and medium producers.

- **Solvents**

There are various ways to make solvent use more circular in Ireland. Solvents currently going to disposal may be suitable for recovery and/or recycling (including as substitute fuels for cement). Economics play a part in the solvents current disposal system. There is therefore need to engage opportunities within the existing economic system (via creating incentives), in order to develop new, more efficient and economically profitable technologies for recovery.

2. Scale of circular economy activity and expected scale of opportunities and impact (if successful): Scale of circular economy activity and expected scale of opportunities and impact (if successful) across the four resource flows are substantial.

- **Cement**

According to Cement Manufacturers Ireland, fuel substitution provides an opportunity for reduction of 40% of GHG emission from Irish cement production. As at 2003, Netherlands already achieved an 80% substitution of fuels in cement production. Ireland had only achieved 34% by 2016 despite a set target of 85%.

- **Sludge**

According to Eurostat, as of 2016, 137 thousand tonnes per annum (tpa) of sludges and liquid wastes from off-site waste treatment plant are going into disposal rather than productive applications in Ireland. Over 50% of wastewater sludge was being treated by anaerobic digestion in 2014 (Irish Water, ND).

- **Whey**

As of 2018, 30% of whey produced in Ireland (about 538 thousand tpa) was not economically accessible because they were produced by smaller producers (IFA, 2020).

- **Solvents**

Eurostat reports the Irish waste treatment of 14,566 tonnes of solvents in 2014, down from previous years. About half (48% in 2014) go to incineration without energy recovery (class D10, 7023 tonnes), another 30% to incineration with energy recovery (R1, 4501 tonnes) while only 15% are recovered for recycling. Payback time and associated carbon reduction estimated for a Turkish case of solvent recovery and reuse in printing was 1.77 years and 7 thousand tonnes of carbon on an investment of 39 million USD (IFC, 2018). Blended fuel from additional solvent capture in Ireland can act as substitute fuel with cement production processes.

4.0 Key findings & Recommendations

Key Messages:

- Gaps limiting mainstream uptake of industrial symbiosis in Ireland include: (i) need for public sector investment in facilitation of business-to-business reuse activities; (ii) need for facilitated industrial symbiosis as per EC recommendations; (iii) stimulation of scaling up and replication activities via raising awareness on the industrial symbiosis potential of ongoing activities; (iv) dedicated government support and greater transparency concerning waste regulations of industries interested in industrial symbiosis; and (v) the need for coordination of approach to applied research for developing solutions to industry focused problems.
- The following key recommendations will enhance the proliferation of industrial symbiosis in Ireland: (i) mapping priority resources; (ii) development of technologies addressing specific material reuse challenges; (iii) providing end of waste support for industrial symbiosis activities; (iv) establishing networks to deliver industrial symbiosis opportunities; (v) managing relevant data; and (vi) establishing national governance framework to support industrial symbiosis (comprising of a national government owner, national coordinating body and a national innovation partner).

4.1 Key findings

Key findings of this report include:

- After many years of lack of clarity, there is now a good industry-led consensus definition for industrial symbiosis (IS), which is a key enabler of the circular economy.
- Industrial symbiosis is proven effective in delivering carbon mitigation through resource efficiency.
- Of the 4 approaches to IS delivery, the most effective is a facilitated model, as per EC recommendations.
- Key barriers to address include awareness raising, and clarity in regulations.
- There are successful facilitated regional IS programmes outside of Europe across countries with quite different policy frameworks.
- As evidenced in Republic of Korea and Denmark, the trend is toward regional IS networks and away from geographically confined programmes that limit opportunity (e.g. the eco-industrial park model).
- Due to the breadth of impacts, industrial symbiosis is attractive as a policy tool across agendas including: waste, resource efficiency, climate change, economic development, innovation and entrepreneurship.
- After over a decade of inclusion in reports and policies across Directorate Generals (DGs) within the European Commission, industrial symbiosis was incorporated into law in the 2018 WFD amendment and forms a key element of the 2020 CE Action Plan.
- Irish policy and regulations are consistent with the European context (EC), presenting no particular barriers to industrial symbiosis in Ireland.
- The majority of current Irish resource reuse activities are consumer-focused rather than business-to-business (B2B), which is the space predominantly occupied by industrial symbiosis.
- Nevertheless, various industrial symbiosis transactions have been identified as currently active in Ireland.

The literature review highlights the following gaps in Ireland that are limiting mainstream uptake of industrial symbiosis:

- Public sector investment in facilitation of business-to-business reuse activities.
- Facilitated industrial symbiosis as per EC recommendations.
- Awareness raising to help industry recognise the industrial symbiosis potential of ongoing activities, in order to stimulate scaling up and replication.
- Dedicated government support and greater transparency for industry undertaking the required regulatory activities to reuse resources labelled as waste, so that companies know exactly what is permissible.
- Lyons et al., (2017) identify the need for a coordinated approach to applied research towards the development of practical solutions to the more complex problems faced by some industries (e.g. testing the durability of concrete

that replaces Portland Cement to ensure a particular life span)." Sommer (2020) further identifies the need for support to establish pilot and testing facilities for the development of technologies needed to advance industrial symbiosis.

4.2 Key recommendations

The Ideation Section lists specific project opportunities that could match CIRCULEIRE's Innovation Fund Call for Circular Economy Demonstration Projects however, these projects on their own would not propagate widespread adoption across Irish industry and consequently do not maximise the potential of industrial symbiosis.

The following recommendations *(largely based on ISL experience with input from the thematic working group panellists in Ideation sessions 1 and 2)* are of a wider scope. They respond to the themes originating from both the State-of-the-art review and the Ideation process, while building overall capacity for industrial symbiosis to generate benefits across all sectors of the economy, ultimately to the benefit of society as a whole. Viewing industrial symbiosis as a series of discrete projects requiring support and intervention diminishes the proven ability for industrial symbiosis to bring about **systemic change** that contributes to the sustainability of industry whilst also providing environmental and social benefits. ***Please refer to Section 9 of the Comprehensive Industrial Symbiosis 2020 Synthesis Report for a detailed overview of the overarching recommendations from this Thematic Working Group.***

- **Map priority resources**

Industry (sector associations, leading companies, trade associations etc) to partner with the waste industry to develop sector maps, highlighting any current IS activity, priority resource flows (determined by potential value or risk factors such as scarcity or geopolitics) as well as technical solutions to address priority resource flows – either via identifying suitable alternative raw materials to reduce dependence on limited supplies, or making a waste flow suitable for productive reuse thus avoiding disposal and associated carbon impact.

- **Develop technologies addressing specific material reuse challenges**

Following on the identification of priority resources for Irish economy, an Innovation call could be tailored to identify the top 10 innovative technology solutions utilizing these priority resource flows. This could be complemented with industry identified difficult-to-manage waste streams (potentially also arising from the mapping process described above). An identification of specific technical challenges associated with materials requiring innovative reuse will also be necessary. This can lead to market demand-led innovation. Assessment criteria for identifying technological solutions for innovative material reuse could include potential economic and environmental impacts as well as replication potential.

- **End of waste support for industrial symbiosis opportunities**

Similar to waste protocols (UK) and by-product identification (Italy), an end of waste policy support is needed in Ireland to create exemptions for industrial symbiosis. This activity would respond to the WFD 2018 amendment requirements for member states to improve waste management and "transform into **sustainable material management** … **promoting the principles of the circular economy** … in a way that preserves resources and **closes loops** and ….to adopt implementing acts and establish detailed criteria … **prioritising replicable practices of industrial symbiosis".**

The panel also suggested identifying the materials capable of reuse using a Global Trade Item Number (GTIN) which would allow other companies to replicate. This would also link to 'establishing detailed criteria" as above.

Ideally a single point of contact at the Ireland EPA would be an asset for quickly determining the regulatory possibilities regarding industrial symbiosis transactions but would also collate data that would inform future regulation e.g. identify potential for waste protocols, identify any unintended negative environmental consequences of some regulations.

- **Establish networks to deliver industrial symbiosis opportunities**

Establishing networks to enable cross sector collaboration is a recurrent theme for almost all potential industrial symbiosis opportunity. Another way of approaching network requirements would be to connect existing networks to enable cross-sector collaboration. Some such relationships may become evident in the cross-sector priority mapping as shared concerns are identified. The best way for a network to deliver industrial symbiosis impacts is through facilitation, as per the European Commission recommendations [DG GROW 2018, EREP etc.]. A potential structure could utilise a **national coordinating body** (e.g. Industry, Research + Development Group - IRDG) with the primary responsibility to oversee implementation by all delivery partners. National coordinating bodies can also act as the liaison between the **Government**

owner (if publicly funded e.g. Department of Business, Enterprise and Innovation) and the activity on the ground. The coordinating body could be supported by a **national innovation partner** (e.g. Irish Manufacturing Research) supporting industrial symbiosis delivery through technology development and technical support. The industrial symbiosis facilitators (practitioners) actively engage with companies around the country to gather information, identify and advance opportunities through to successful completion, and then report back on their impacts. IS facilitators/practitioners could be employed directly by the national coordinator or connected by subcontracting arrangements.

- **Manage relevant data**

Establish a country-wide cross-sector ICT support platform capable of the following:

- User registration process with email validation
- Capture and characterise (geo-locate) resources available for synergies.
- European Waste Catalogue (EWC) and category coding assistance.
- Manage and monitor synergies and barriers.
- Perform data analysis for active pipeline management and impact reporting.
- Enable internal and external reporting of impacts.
- Incorporate big data from public sources to enable quick entry and opportunity identification.
- Draw on a library of past successes to ease opportunity identification and replication.
- Ability to control access to information (public, semi-public, private) including impacts reporting.
- Ability to selectively share contact information.

- **Establish national governance framework to support industrial symbiosis**

As discussed in the section on establishing industrial symbiosis networks, there are three key players to deliver all the functions necessary to optimise industrial symbiosis implementation-**National Government Owner, National Coordinating Body, National Innovation Partner**. Outlined below are the suggested responsibilities of the National Government Owner & Coordinating Body – ***see Section 9 of the Comprehensive Industrial Symbiosis 2020 Synthesis Report for a detailed overview of the responsibilities of three key players.***

National Government Owner

The responsibilities of the National Government Owner of the national industrial symbiosis activity could include:

1. **Ensure a supportive policy context across government Ministries.**
2. **Invest in industrial symbiosis activities with new budget OR redirect budget from activities not likely to provide a comparable impact.**
3. **Appoint a lead national coordinating body**:.
4. **Coordinate with and influence other national programmes, activities and strategies to support industrial symbiosis activities and broad investments in it.**
5. **Collect, collate and disseminate impact data in terms of micro and macro-economic benefits together with impacts on environment, innovation, job creation and skills development.**
6. **Utilise legitimising power to drive stakeholder support for the programme**
7. **Build the national programme over time**
8. **Disseminate learnings and impacts across Government to build broad support and engagement across Ministries**
9. **Represent Ireland internationally** in this field.

National Coordinating Body

A national coordinating body for implementation would have the primary responsibility to oversee and deliver implementation by all delivery partners, while also acting as the liaison between the Government owner and the activity on the ground.

The responsibilities of a national coordinating body could include:

1. **Train facilitators/practitioners.**
2. **Maintain consistent methodologies, processes and standards across the regions.**
3. **Set, monitor and evaluate strategic targets.**
4. **Branding & communication.**
5. **National stakeholder engagement**.
6. **Database management software and licensing**.
7. **Raise funding/investment**.
8. **Policy recommendations.**

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An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

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Climate-KIC is supported by the EIT, a body of the European Union