SymbioBeer

Industrial Symbiosis

Guide for Policy Making

2021

Authorship & Acknowledgements

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Executive Summary

Ireland has so far aimed to decrease landfill rates, achieve higher recycling rates, as well as higher sensitization to eco-designs (through producers' responsibility initiatives) established by EU. While the adoption by Ireland of a life-cycle approach reflected in practice and in the establishment of individual and collective waste stream management systems leads to promotion of recycling and eco-design (EEA, 2016), its impact on industrial symbiosis implementation and incentivisation of synergistic transactions remains neutral (as it neither constitutes an obstacle nor driver).

Industrial symbiosis is a key strategy in delivering circular economy, and it has proven effective in delivering several 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: "… *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, p. 7).Even though there are no substantive policy and regulatory barriers to industrial symbiosis implementation in Ireland, there are still regulatory obligations required for the facilitation of industrial synergies among companies and sectors. Navigating through these regulatory obligations for facilitation of industrial symbiosis transactions require adequate understanding of industrial symbiosis implementation approaches, as well associated policies, regulations and standards.

Consequently, this guide sets out to demystify industrial symbiosis for policy making by (i) defining industrial symbiosis, as well as its origins and benefits (especially in the wider context of the circular economy); and (ii) providing an overview of industrial symbiosis approaches and examples in Ireland, as well as related EU and national policies, regulations and standards.

Lastly, this guide also (iii) provides policy making insights for supporting greater implementation and scaling of industrial symbiosis in Ireland's food sector. In particular we illustrate the role that local government and regional development actors could play related to develop or deploy instruments and/or tools tailored towards supporting synergies ranging from (i) financial instruments; to (ii) demystifying licensing, standards and regulatory procedures/ compliance schemes; to (iii) educational supports (to facilitate change of mindset); to (iv) and provision of public data reporting tools (for data collection and analysis) and information sharing/dissemination channels.

.Acronyms & Glossary

BE	Bio-Economy
C&DW	Construction and Demolition Waste
CE	Circular Economy
CEN	European Committee for Standardisation
CWA	CEN Workshop Agreement
EC	European Commission
EMF	Ellen MacArthur Foundation
EPA	Environmental Protection Agency
EU	European Union
FISSAC	Fostering Industrial Symbiosis for a Sustainable Resource Intensive Industry across the Extended Construction Value Chain
IE	Industrial Ecology
IS	Industrial Symbiosis
NWPP	National Waste Prevention Plan
GDP	Gross Domestic Product
BRC	British Retail Consortium
FBO	Feed Business Operators
RWMP	Regional Waste Management Plan
SCALER	SCALing European Resources with industrial symbiosis
HACCP	Hazard Analysis and Critical Control Point
SME	Small and Medium Enterprise
GHG	Greenhouse Gas
UK	United Kingdom
WEEE	Waste Electrical Electronic Equipment
WFD	Waste Framework Directive

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Introduction

Since industrial revolution, the development of global economies has followed a linear economy model, where “linear” refers to the cradle-to-grave flow of natural resources (also described as “take-make-waste”).

The European Union's economy is currently losing a significant amount of potential secondary raw materials present in waste streams, as well as other associated opportunities. Within this context, concepts like “Bioeconomy” “Circular Economy”, “Circular Bioeconomy” and “industrial symbiosis” have increasingly gained relevance. These concepts promote potential solutions to issues ranging from climate change to pollution, as well as economic and regional development.

The Government of Ireland’s recent commitment to the new Waste Action Plan for a Circular Economy (WAPCE) (which aims to reduce food waste by 50% by 2030) will require innovation across every step along the food chain (DECC, 2020).

Since food waste occurs at all stages of the food supply chain (Schanesa, 2018), reducing food waste throughout the value chain will be an effective strategy, especially for harnessing societal benefits, such as decreasing greenhouse gas emissions (8-10%), and reducing household and business bills (EPA, 2019).

Giving the rise in material consumption rate within the Irish economy (Figure 1 & 2), valorising waste and scaling circular economy strategies via industrial symbiosis can create conditions for import substitution and presents an important opportunity for Ireland to grow both environmentally and economically.

Industrial symbiosis is not entirely new to Ireland. SMILE (Saving Money through Industry Links and Exchanges), Ireland’s Industrial Symbiosis Programme funded by the EPA between 2010 and 2018 provided an online platform, where businesses could request or offer reusable materials, by-products or surplus stock as a raw material for another business.

Given that the Irish economy needs an estimated 100 million tonnes of materials annually (EPA, 2019) huge opportunities still exist for material reuse improvement, as Ireland still lags behind other EU countries in terms of circularity rate (third lowest in the EU) (Eurostat, 2016).

Also, the fact that only a 5% material improvement across the Irish economy is worth c. €2.32bn p.a. (Coakley et al, 2013) highlights that industrial symbiosis is a valid strategy and contributor to the delivery of a circular economy in Ireland.

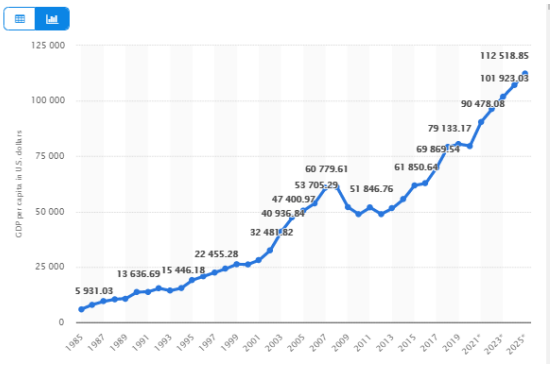

Figure 1 Domestic consumption of materials per inhabitant, in Ireland (Statista, 2021)

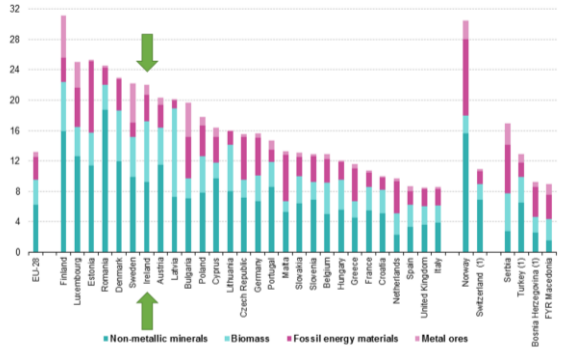

Figure 2 Domestic material consumption by main material category (Eurostat, 2017)

1. Relationship between material consumption, GDP and EU waste management sector

A strong relationship exists between the GDP of an economy (i.e. financial or economic capital growth/development) and material consumption (Niza, 2006).

Historically, for every 1% increase in GDP, material usage rises on the average by 0.4%. Previously, rise in material use and GDP has essentially been linearly associated with increased levels of environmental pressures generated by the global economic system e.g. higher carbon emission levels, increased biodiversity loss, faster resource depletion rates, more intense water and soil pollution levels, etc (Gokmenoglua et al, 2015).

Going forward, a reversal of these trends is needed to preserve and sustain the planet's capacity to support life's continuity and for achieving the set UN sustainable development goals. A delicate balance needs to be established between environmental pressures (e.g. carbon emission levels, water pollution rates etc.) and GDP growth.

Waste management strategies tailored towards carbon emission reduction or avoidance of pollution should provide new green jobs and support economic growth without harming the environment.

In line with this narrative, the EU launched Horizon 2020 (the largest ever EU Research and Innovation programme) in 2014. Within the programme, waste management was considered "strategic", because it is the second largest contributor to employment and GDP growth in the environment sector (Eurostat, 2017).

In the same vein, the *'waste management hierarchy'* (Figure 3) was adopted by the EU to set out an order for prioritization in shaping waste policies and managing waste in practice.

Figure 3 Waste Hierarchy (Defra, n.d.)

Recent EU policies and legislations (e.g. EU Green Deal, Farm to Fork Strategy, EU Circular Economy Package etc.) have also been in harmony with these objectives, setting and positioning their different targets as key drivers for the improvement of waste management systems, limiting or elimination of landfilling as a waste management procedure, stimulation of technological innovations, boosting of employment from the development of environmental-friendly goods, and creating of incentives for change of consumer behaviour (EC, 2014), (EC, 2015).

2. What is Industrial Symbiosis

2.1 The Origin of industrial symbiosis

Industrial ecology assesses sustainability at three scales (facility/firm, inter-firm, global/regional). Industrial Symbiosis (IS) is a branch of industrial ecology that assesses sustainability at inter-firm level, and creates synergies for optimizing flows of material, energy and capital between actors involved(Geyer, 2004).

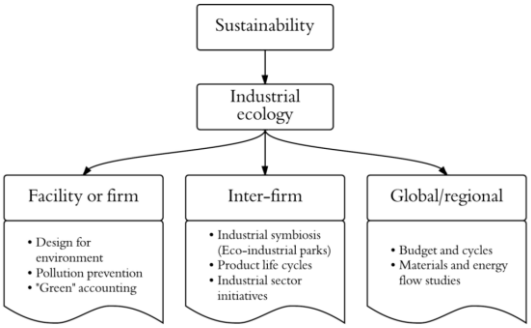

Figure 4 Industrial ecology operates on three levels (Chertow, 2000, p. 315)

Although the paradigm is much older (Renner, 1947) the term industrial symbiosis became more popular because of the Danish municipality of Kalundborg, which is the first widely recognized example of an industrial symbiosis. Even though the network has been in existence since the early 1970's, it was first recognized for its environmental efficiency in the late 80's (Chertow, 2000).

However, Kalundborg is not only recognised for its industrial symbiosis network, but also as an example of how policies and regulations may serve both as drivers and barriers in industrial symbiosis contexts (CECP, 2007), (Mirata, 2004), (SCALER, 2018).

Chertow (2000) argues that a key driver underpinning Kalundborg's formation as an industrial symbiosis was responding to a common problem of water scarcity. The municipality recognised the need to factor in wastewater treatment costs within the production cycles/models of companies in Kalundborg (since water had become a scarce resource). A policy change in this

direction led to subsequent extra business charge for water. This encouraged Kalundborg's businesses and organisations to re-evaluate their business-as-usual practices. Many businesses and organizations in Kalundborg discovered more innovative production methods, established new business ideas founded on symbiotic relationships, as well as devise more economical and environmental-friendly solutions (IWA, n.d.). Today, the Kalundborg lighthouse example is an inspiration for shaping economic or regulatory instruments in organisations, regions and other jurisdictions.

2.2 The definition of industrial symbiosis

In 2018, an industry-led consortium defined industrial symbiosis for the EU as: "…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, p. 7)

2.3 The benefits of industrial symbiosis

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 CO_2-equivalent avoided (Laybourn, 2009)

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 also delivers economic, environmental and social benefits, while also supporting transition efforts towards a more circular global economy (Laybourn, 2009).

3. Industrial symbiosis approaches and examples

The implementation and scaling of industrial symbiosis to date tends to be either **top-down** or **bottom-up** in **approach** or combination of the two.

Top-down approaches are characterised by a deliberate government-backed, central plan or strategic vision or initiatives for creation of new socio-economic opportunities and/or remediation of environmental impacts.

In contrast, bottom-up approaches are a result of direct interaction among industrial actors (no external coordination), and generally motivated by business concerns (market demands or need for innovation) arising from pending legislations and standards, impending raw material shortage risks and narrowing economic gains (due to high waste management cost or rising virgin material prices).

3.1 Top-down and bottom-up approaches for industrial symbiosis adoption

Centrally imposed plans, policies and regulations (e.g. taxation) or strategic visions may serve both as drivers and barriers for industrial symbiosis transitions (CECP, 2007), (Mirata, 2004), (SCALER, 2018). They can also influence industrial symbiosis from an organizational point of view (ENEA, n.d.).

Supporting policies or initiatives for industrial symbiosis can be intentionally facilitated for creation of new businesses and value chains, regeneration of abandoned sites and facilitation of purpose-built developments.

Top-down industrial symbiosis approaches are often adopted by policy makers to increase the productivity of existing resources, reduce carbon emissions, and attracts new investment and green business growth (CEN, 2018).

Planning top-down industrial symbiosis transactions and its development often involves government agencies to facilitate territorial planning (designed and managed based on the principles of ecology and industrial symbiosis, as well as granting of subsidies (Chertow, 2007).

In contrast, bottom-up approaches (e.g. the Kalundborg case described earlier) are organically driven by the decisions taken by private actors for economic and environmental benefits, without direct government intervention or explicit incentivisation.

Every transaction in a bottom-up industrial symbiosis engagement must be feasible from a market point of view. In other words, it must be meeting a market demand or to creating an innovative product (CEN, 2018), (ENEA, n.d.). Bottom-up approaches are often driven by the desire to make raw materials more readily available or cheaper for actors; to increase the profitability of actor's products/operations or to jointly avoid certain regulations commonly affecting the companies or sectors involved.

3.2 Examples of industrial symbiosis in Ireland

Ireland's examples of industrial symbiosis projectstend to be more top-down in nature, i.e. they were funded by European and national grants or facilitated by central policies, programs and initiatives.

This section highlights some current EU and nationally funded top-down industrial symbiosis projects in Ireland. We also highlight a well-known case study of a bottom-up industrial symbiosis project in Ireland (Ecocem).

3.2.1 Top-down industrial symbiosis projects

Top-down industrial symbiosis projects in Ireland are of two types:

1) EU funded projects: tend to aim at

testing new technologies for extraction and transformation of valuable secondary raw materials into new products/ingredients; while

2) Nationally funded projects: tend to aim at piloting and delivering innovative valorisation and resource efficiency pathways.

EU funded projects

The EU-funded **AgriChemWhey** project is building a first-of-a-kind bio-refinery, capable of transforming excess whey permeate and difficult-to-dispose by-products of milk processing into lactic acid. This lactic acid can in turn be used to make biodegradable plastics, bio-based fertiliser and other minerals (AgriChemWhey, 2020).

The **RemovAl** project is targeting optimizing and scaling-up developed processing technologies for extracting industrial residues from the aluminium and other metallurgical sectors, and valorising them for use in the construction, non-ferrous metal and cement sectors. Auginish Alumina is the Irish industry partner and pilot site (RemovAl, 2018).

BioWILL will deliver a biorefinery model using willow, by producing high value salicylates from willow bark for medical applications. The bark residue and bark-free willow pulp will be converted into safe food quality packaging material to replace fossil derived plastics (BioWILL, 2019).

National funded projects

SMILE (Saving Money through Industry Links and Exchanges) Resource Exchange- Ireland's National Industrial Symbiosis Programme was established in 2010 and ran until 2018. It was funded by the EPA National Waste Prevention Programme. SMILE provided an online platform where businesses could connect and identify synergies through requests, or offer reusable materials, by-products or surplus stock as a raw material for another business (LEO, n.d.)

The **Tallaght District Heating Scheme** project aims to reduce GHG emissions associated with the use of fossil fuels for heating in Tallaght, South Dublin by valorising waste heat (from ICT data centres), which currently do not generate any revenue (Codema, 2018).

The EPA funded **NEWTRIENTS** project aims to deliver innovation and efficiency through value added wastewater resource recovery from the dairy processing industries. This can lead to a paradigm shift from conventional wastewater treatment in the dairy processing industry to closed loop reuse of valuable components present in the effluent (UCC, 2017).

The focus of the research project "**How to achieve a carbon neutral distillery**" between UCC and Irish Distillers Ltd is to identify alternative uses of by-products generated during the distillation process. The potential to convert these by-products

into renewable energy (via production of biogas through anaerobic digestion process) is also being explored (UCC, 2019).

SymbioBeer is an EPA Green Enterprise funded project between St. Mel's Independent Brewing Company (a micro-enterprise) and Panelto Foods (an industrial bakery) facilitated by Irish Manufacturing Research (IMR). The project which ran from 2020-2021 created an industrial symbiosis demonstration pilot between two food related sectors (bakery and brewery sectors) in the industrial area of Longford. *(This guide is an output of this demonstrator)*

3.2.2 Bottom-up industrial symbiosis projects

Ecocem's ground granulated blast furnace slag (GGBS) is a low carbon binder feasible for replacing conventional cement in concrete manufacturing. It is manufactured from the granulated blast furnace slag, a production residue from cast iron manufacturing process. The use of GGBS will reduce CO_2 emissions associated with the production and use of cement by the construction industry, and cut down the extraction of materials associated with conventional cement production (EcoCem, 2021).

4. Key Policies, regulations and standards

An overview of Irish policies, regulations and food standards that are relevant for transforming production residues into secondary raw materials are presented as follows.

4.1 Key Policies

Aligned with the findings from Connolly et al. (2017) and Lyons et al. (2017), Irish policies related to resource reuse opportunities (and summarised in Table 1) do not represent a substantive barrier to industrial symbiosis adoption. Policies and regulatory framework are rather requirements for product, environmental and health protection, and help ascertain the integrity, legality and traceability of resources involved in the industrial symbiosis transaction.

Table 1 Irish policies

Table 1: Irish policies on resource use opportunities
The National Waste Prevention Programme: It is operated by EPA, it has been in place since 2004
A Resource Opportunity-Waste Management Policy in Ireland (DECLG, 2012): It provides a roadmap for waste and resource planning, encouraging and promoting reuse of unwanted goods.
The Regional Waste Management Plans (RWMPs) 2015–2021: It emphasizes prevention, reuse and preparing for reuse, focusing on both the circular economy and the waste hierarchy as central.
National Climate Action Plan (2019): It outlines the current state of play across key sectors, and it supports industrial symbiosis.

Table 1: Irish policies on resource use opportunities
Waste Action Plan for a Circular Economy (2020): It introduces ambitious new targets to tackle waste and move towards a circular economy. It also supports industrial symbiosis.
Whole of Government Circular Economy Strategy – currently open for public consultation
Origin Green: The Bord Bia Origin Green Programme encourages all food and drink producers in Ireland to take part in the verified sustainability programme. As part of this support, companies are encouraged to take part in resource efficiency and environmental management programmes under the Enterprise Ireland Lean and Green initiatives.

4.2 Key Regulations

Key regulations associated with secondary raw material use and industrial symbiosis in Ireland can be found in Table 2.

Table 2 Key waste regulations

Waste regulations
The EU Waste framework Directive (2008/98/EC-Regulations) transposed into Irish Law as S.I. No. 126 of 2011: It lays out basic waste management principles for three items: by-products, hazardous wastes and end-of-waste criteria. Two of these three items are however related to resource reuse and industrial symbiosis (namely Article 27 on by-products and waste determination, and Article 28 on end-of-waste criteria).
Landfill Directive (1999/31/EC): Legislation surrounding mineral construction and demolition (C&D) waste in the EU is largely shaped by the Waste Framework Directive. Three relevant articles (2, 6, 11) underline how important it is: 1) to reuse excavation material from construction activities, 2) to turn C&D waste into a resource for new applications, and 3) to have a minimum target of 70% of weight for reusing, recycling and recovering all non-hazardous C&D waste.
Packaging and Packaging Waste Directive (1994/62/EC): The legislation applies to virtually all organisations in the commercial sector as

Waste regulations
these bodies will supply goods to others that are contained in packaging, and including packaging designed to be consumed at the point of sale, such as bottles, etc. All of these producers are under a legal obligation to ensure that the seven main types of packaging waste are segregated when they arise on their premises: aluminium, fibreboard, glass, paper, plastic sheeting, steel and wood.
Food Waste (SI 508 of 2009): It embraces food waste arising from large and small supermarkets, from pubs, hotels, cafés and hot food outlets. All operators of obligated premises are required by law to segregate any food waste generated, keeping it separate from contamination by other waste. It then must be separately collected or delivered directly by the producer to a composting or other similar plant.
Sewage Sludge - EU Directive 86/278- Waste Management (Use of Sewage Sludge in Agriculture) Regulations 1998: Regulations on sewage sludge covers processing residue arising from sewage treatment, plus sludge collected from septic tank maintenance. Use of sewage sludge as an agricultural fertiliser falls under the amended regulation on sewage sludge.

4.3 Key food standards

Relevant food standards, associated with the context of industrial symbiosis and with the quality of resource usable; in food and food related sectors; are listed below.

Table 3 Key Food standards

Food standards
The (British Retail Consortium) BRC Standard for Food Safety: The BRC Global Standard for Food Safety was established in 1998 to ensure that traded products are produced according to well-defined quality standards and in compliance with minimum requirements. It can be compared to a specification that binds qualified suppliers to the distribution company. It is one of the food safety standards recognized by the Global Food Safety Initiative (GFSI).
Feed Materials Assurance Scheme (FEMAS): FEMAS aims to protect human and animal health by ensuring safe practices throughout the feed chain for food producing animals based on HACCP principles. It verifies that the industry is meeting its obligations under the appropriate feed safety related legislation and codes of practice, in maintaining safety in the feed and food chain.

5. Concluding insights

In conclusion, we present policy making insights for the implementation and scaling up of industrial symbiosis in Ireland. Currently Ireland has so far aimed to decrease landfill rates and to achieve recycling rates established by the EU. It has also made efforts to create a higher sensitization of eco-design criteria through producer's responsibility schemes (EEA, 2016). The life cycle approach underpinning the implementation of these initiatives neither constitutes an obstacle nor a driver for the adoption, implementation and scaling of industrial symbiosis in Ireland. That said, within this policy and regulatory context, local authorities and regional development actors can play a central role in encouraging and supporting industrial symbiosis collaboration between companies by designing supportive strategic plans and policies.

5.1 Insights for policy-making

Insights garnered during the stakeholder engagement activities during the SymbioBeer project, i.e. stakeholder dissemination and interaction workshop facilitated by IMR involving representatives of local authorities and regional economic development agencies (from Longford, Donegal, Derry and Strabane), as well as industry representatives from the food and beverage sectors (from Heineken, Diageo, Avoca Seafoods, Goodness Grain Bakery, Lough Ree Distillery, Biasol, Aryzta, Frylite, Adnams, Puratos, St.Mels and Panelto) are reported in this section.

Local government and regional development actors have the potential to develop/deploy instruments and/or tools tailored towards supporting synergies within the context of facilitated industrial symbiosis transitions.

Such tailored instruments and/or tools can include:

(i) financial instruments;

(ii) demystifying licensing, standards and regulatory procedures / compliance schemes;

(iii) educational support (to facilitate change of mindset);

(iv) and provision of public data reporting tools (for data collection and analysis) and information sharing/dissemination channels.

The role of policy making stakeholders (i.e. local authorities and regional development agencies) in devising and implementing the instruments and tools are further explained below.

Financial instruments

Policy making stakeholders (e.g. local authorities and regional development agencies) and regulatory bodies (e.g. EPA) can collaborate with company representative/associations (e.g. chamber of commerce, sectoral associations etc.) to facilitate industrial symbiosis adoption

by devising financial instruments tailored towards:

•reducing companies' high set up costs,

•lowering high risks associated with new investments,

•and supporting the creation of new players to fill existing market gaps (e.g. start-ups, new partnerships etc.) for implementation and scaling up of industrial symbiosis activities.

•Other financial instruments (e.g. taxation) could be used as a driver for facilitating the use of companies' residues for higher value applications, for example higher taxes for companies who choose lower step/value applications as listed in the EPA Food Waste Hierarchy (i.e. landfill disposal, anaerobic digestion, composting).

•Policy making stakeholders and regulatory bodies can also encourage industrial symbiosis by favouring it as a selection criterion in green public procurements for stocking their food canteens, as well as office stores, warehouses, and refrigerators.

Educational support

Policy making stakeholders and regulatory bodies can facilitate industrial symbiosis transition by educating industry managers and practitioners, local authorities, and regional development representatives on the need to re-evaluate and change their mindset.

There is need for community engagements tailored towards sensitization to the end-of-the-cliff effects of currently dominant linear economy model on the one hand; and reinforcement on the need for application of resource efficiency principles (internally within, as well as among companies and sectors) within the context of transition to more a circular economy on the other hand. Drawing more attention to success stories, case studies, EU best practices (see by way of example https://circuleire.ie/circular-economy-knowledge-library/) can contribute to improving knowledge about local involvement in industrial symbiosis activities, paving the way for successful partnerships.

Licensing, standards and regulatory procedures/compliance schemes

Licensing, standards and regulatory procedure/compliance schemes are important requirements for facilitation of industrial symbiosis within food and beverage sectors. Ensuring integrity, legality, traceability and alignment with regulations on the quality of raw material inputs and final products (for human and animal food production chains, and retailers) are important to guarantee the safety and protection of human and animal health.

Due to the time investment required meeting licensing, standard and regulatory procedure obligations for use of production residues as secondary raw materials accelerating the uptake of industrial symbiosis may require dialogue between policy making stakeholders and regulatory bodies (e.g. EPA), food standards bodies and company representatives in relation to:

(1) demystifying the inter-related licensing, standards and regulatory procedures/compliance schemes which are needed for industrial symbiosis adoption in Ireland;

(2) recognition and alignment of licensing, standards and regulatory procedures/compliance schemes as one of the steps in the process to meet traceability requirements and protocol,

(3) recognition of licensing, standards and regulatory procedures/compliance schemes as one of the sources for collection of data and work together for facilitating close proximity collaborations (by collecting company locations, reporting quantity and quality of potential residuals/material substitutes available).

Development of public data reporting tools and information sharing/dissemination channels

In Ireland, residues from the food and beverage sector tend to end up in lower value applications (e.g. animal feed, anaerobic digestion, composting and landfill disposal) due to lack of visibility of the flow of supply of and demand for residues available. This hinders the possibility of industrial symbiosis adoption as the security of supply of production residues to meet material substitution demands are not guaranteed.

Facilitating the visibility of data on production residues and tracking their relative availability in regions through public channels (as it is already done with waste statistics) is an avenue policy making stakeholders, authorities, regulatory bodies and company representatives can explore to facilitate scaling up of industrial symbiosis transactions. Publicly available (online) data reporting tools (for data collection and analysis) and information sharing channels (for dissemination of information among potential industrial symbiosis partners) can increase the visibility of supply of and demand for residues.

One best practice example to consider is the ACT'IF tool, developed by the French Chamber of Commerce and Industry (CCI) of Haute-Garonne in 2008 (and replicated across all 22 French regions). It has helped facilitates secondary raw material markets through: (a) identification and quantification of secondary raw materials, (b) analysis of regional waste streams and (c) provided facilitation support. To date 3,700 companies have referenced 17,000 resource streams with > 65,000 tonnes of waste valorised and delivering €545,960 in cost savings (ACT'IF, n.d.).

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