Industrial-Urban Symbiosis: Enabling Circular Hubs for Regional Waste-to-Resource Transformation

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The development of industrial-urban symbiosis is key to bridge the spheres between cities and industries. This is critical especially for cities to rapidly advance their level of circularity, to shift from a focus on recycling to include upcycling and the use of urban waste fractions as industrial feedstocks. On the other hand, industries must accelerate the change from linear practices to circular business models, adding urban waste streams as feedstocks to increase the rate of secondary raw materials in their supply chain. To this end, Industrial-Urban Symbiosis (IUS) networks need to be grown and multiplied in the form of circularity hubs, meaning networks where stakeholders collaborate to reach a zero waste future. In this context, stakeholders represent the wide range of actors involved in circular ecosystems: industries, companies, municipal and regional governments, research organisations and citizen communities.

The cross-sectorial and regional implications must also be considered. Process industries are often clustered in industrial parks to take advantage of shared or related energy, common services, infrastructure and material flows (Heck et al., 2023). There is still a significant opportunity to develop this approach further, enabling a seamless circularisation of value chains to take advantage of material flows, side stream products and secondary materials across industrial sectors and within the urban environment, triggering the development of regional hubs for circularity.

Business cases identified in regions will connect local stakeholders and drive innovation based on potential integration synergies for process industries. That is why the implementation of Industrial-Urban Symbiosis and Circularity needs to take place predominantly through regions. Some EU regions have ambitious objectives like those of P4Planet, for example “Climate neutral region” or “Zero-waste region”, and this can boost the regional development of IUS and Circularity. Nevertheless, when it comes to the provision of secondary resources, interregional value chains may need to be established as well, to overcome geographical limitations where a critical mass of materials for relevant processes must be reached for process feasibility.

In this context, the EU funded United Circles project seeks to formalise three collaborative Industrial-Urban networks as intermediate stage Circularity Hubs with IUS demonstrators and advance the three Hubs4Circularity up to an independent functioning stage. United Circles’ approach to IUS is based on six assumptions:

1) **Innovation** - focused on **integrating key technologies within IUS networks**, boosting technology **innovation SMEs to work with industries and cities in circularity hubs** to reach their goals.
2) **Regional impact** - Regional and local governments **will need to expand their remit to include achieving the Twin Transition** and **work actively to attract businesses and industries** for raising co-investment in transforming urban and industrial wastes into resources through Business-to-Territory (B2T) plans.
3) **Industry support** - Industry actors **cannot innovate and scale rapidly enough to achieve the Twin Transition alone.** They will need to collaborate more openly with win-win business models and protected technology transfers underpinned by multiple partnerships.
4) **Circular culture** – this is key **to designing solutions, innovations and IUS networks for holistic management of all waste fractions in a particular waste stream and across streams.** The goal is to build a culture of responsibility and perseverance in tackling all wastes, not only the low-hanging fruits, or just resorting to downcycling.
5) **Investment - Process industries profits** from sustained growth, and this needs to channelled to new **infrastructure**, as opposed to growing investor dividend pay-outs. **Public investments also need to be redirected** for co-investment **as a key prioritisation** of more limited public funds.

6) **Global outreach** - The Twin Transition for cities and process industries needs to include a **global outreach effort to facilitate European technology export**, and prevent an '*invented in Europe and remaining in Europe*'. It also requires linking the European Community of Practice to circularity hubs in the global south, to accelerate green IUS technology deployment and investment to countries with less available capital. This idea is in line with the spirit of the Processes4Planet Partnership that targets a 'holistic, systemic, socio-economic approach' (Processes4Planet, 2021)

The Hubs need to have a technology-oriented approach to rapidly find the optimal way of setting up waste-to-secondary raw material-to new product links. To this end the project designed a toolkit of fifteen innovative technologies (Figure 1) that will be tested at semi-industrial scale in the following sectors: Cement, Biorefining, Pulp and Paper, and the Water-Nutrient-Energy nexus.

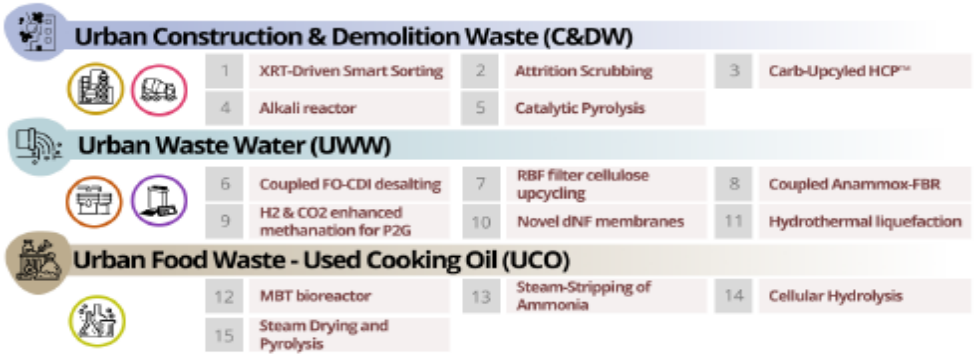

Figure 1. Overview of key technologies that will enable IUS links for the FOAK Hubs.

However, technology alone will not be enough to overcome the challenges that the Hubs will face along the way. For this reason, the concept also has a strong governance component leveraging on the idea of Hub4Circularity as the catalyst that will allow each Hub to reach critical mass in terms of IUS links, resource availability and financing. This will support the advancement of the circularity hubs concept towards an established large network of collaborating regions, each with their own sustainable and self-financed circularity hub and associated IUS network that connects sectors. Finally, the circular hubs will not come as standalone sets of technologies and governance models, as the new set of IUS links will be accompanied by a large pool of data (resource volumes, location, quality requirements, analytics, DPPs). These digital tools play a key role in supporting decision-making processes, product-material traceability and data sharing, and network development. Several pre-requisites in the selection of digital tools have already been identified:

- Services should be cloud accessible via internet so they can be universally used.
- Services should be directly available based on Software as a Service or similar approaches.
- The party developing the digital tools needs to fully own the background and have IT capabilities.

These requirements will help to overcome the challenge that the majority of developed European Industrial Symbiosis IT tools are not sustained after development (Maqbool, 2019).

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