Industrial-Urban Symbiosis Matchmaking Framework integrating Regional Scenery to support Hubs4Circularity approaches

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Circular economy is implemented at different levels through Industrial Symbiosis (IS) and in a broader way via Industrial-Urban Symbiosis (I-US), that includes the urban areas and their activities in symbiotic value chains. The Hub4Circularity (H4C) concept emerges, proposing systemic solutions, integrating multiple regional stakeholders and introducing a variety of different operational models, due to the different regional settings and regional and sector needs [1]. Previous work on identifying and facilitating IS and I-US synergies has been conducted, creating matchmaking framework using multicriteria methods, mainly focused on waste streams and stakeholders' compatibility creating valorization matches [2] or other dedicated to specific resources such as water and sludge [3]. To support H4C concept, there is a need to align I-US synergies identification and implementation with regional development strategies and relevant regional science methos. Thus, this study focuses on the integration of the regional settings, including region's characteristics, strategies, resources and waste, special needs or challenges, called as "Regional Scenery" in this study, into the matchmaking framework.

The proposed framework consists of 3 levels as below. The term region in this study is referred to Nomenclature of territorial units for statistics (NUTS) 2 [4] level.

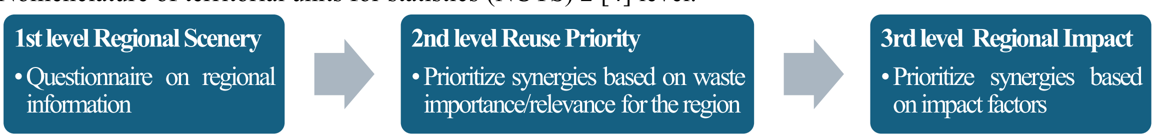

Figure 1 Proposed Matchmaking Framework Levels

Level 1 includes regional data collection via a questionnaire, including information related to:

I. Region type (coastal, non-coastal, island, predominantly rural, intermediate, predominantly urban [5])
II. Most active waste streams in the region (EWC codes [6])
III. Important infrastructures (e.g. on energy production, landfill, recycling center, WWTP)
IV. Critical resources (e.g. due to energy poverty, water scarcity, food waste)
V. Regional Strategy (Priorities on Environmental, Economic and Social Aspects)

Based on the information collected, and to be used in Level 2 and Level 3, for each region studied, Table 1 and Table 2 are produced below, depicting its Regional Scenery. Each region's waste weights (w) are formulated according to the answers of Level 1 (e.g. the streams selected in (ii) above, will have greater weights; if energy is considered critical resource in (iv) the relevant rows 23,24 of Table 1 will have a significant greater weight.). Table 1 is indicating the "magnitude", or "capacity" or "importance" of waste streams in the region, while Table 2 is indicating the impact of the synergies. An example of the implementation of these tables for some regions will be included in the full presentation.

EWC (1)	Weight (1)	EWC (2)	Weight (2)	EWC (3)	Weight (3)
1	w.1.1	9	w.1.9	17	w.1.17
2	w.1.2	10	w.1.10	18	w.1.18
3	w.1.3	11	w.1.11	19	w.1.19
4	w.1.4	12	w.1.12	20	w.1.20
5	w.1.5	13	w.1.13	21 (wastewater)	w.1.21
6	w.1.6	14	w.1.14	22 (sludge)	w.1.22
7	w.1.7	15	w.1.15	23 (electricity)	w.1.23
8	w.1.8	16	w.1.16	24 (heating)	w.1.24

Table 1 waste regional weights

Regional Factors	Factors magnitude
Energy consumption (X1)	F1
Reclaimed water (X2)	F2
Landfill reduction (X3)	F3
GHG emissions (X4)	F4
Jobs created (X5)	F5
GDP growth (X6)	F6

Table 2 regional impact factors

In **Level 2** all the different potential synergies are being identified (by matching input/output streams and services). The results are sorted based on results from Table 1, so the synergies involving value chains with greater weights come first. **Level 3** calculates a total **regional impact factor** = sum (Xi*Fi) based on Table 2 and identified synergies are also being sorted based on this factor. The Xi value will be calculated via standardized ways (LCA methods, e.g. emission factors for X4). Fi (F1-F6) is the impact factors indicating the importance of the corresponding Xi (X1-X6).

The proposed matchmaking framework could be potentially implemented and integrated in the future, using digital tools, serving two main use cases proposed below:

1. **Industry/Organization level.** User is a company representative, R&D manager, etc.

Step 1: User registers and fills in data for the region that the organization belongs to; Step 2: User fills in data for its recourses/wastes; Step 3: User is able to search for potential synergies based on its input(s)/ output(s) waste/ service(s). A list of all the "technical" feasible matches will be displayed, with a preliminary prioritization performed, based on the "magnitude" of the flows in the specific region (Table1). Step 4: User can request the calculation of the regional impact factor (Table2) and have a relevant prioritization of all the available potential synergies resulting from Step 3.

2. **Regional Level.** User is a regional representative (manager, government, association, etc.).

This case prerequires that at least some organizations of the region have already filled in data for its resources/waste/services (use case 1: Industry/Organizational level). Step 1: User registers and fills in data for the region user represents; Step 2: User is able to search for the potential synergies between companies in the region, based on specific waste types or other criteria. A list of all the "technical" feasible matches is displayed, with a first prioritization performed, based on the "magnitude" of the flows in the specific region (Table1). Step 4: User can request the calculation of the regional impact factor (Table2) and have a relevant prioritization of all the available potential synergies resulting from Step 3.

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