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D 3.1: Flow maps and data based for selected urban areas

March 2019 (M10)

Responsible Partner: **TECNALIA**

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 776751

DOCUMENT DETAILS

Title:	Flow maps and data based for selected urban areas
Annexes:	2

Deliverable No.	3.1
Work Package	WP3 – Assessing the waste to resource opportunities in urban and peri-urban areas
Task	Task 3.1 -– Flow map of urban and peri-urban areas
Deliverable Type	Report
Lead Partner:	TECNALIA
Contributing Partner(s)	TECNALIA, TUDelft, ZAG, Opencontent, NIGRAD, IETU, FGP, 6MAJ.
Due date of deliverable	28 February 2019
Actual submission date	14 March 2019
Date of revision	3 June 2020

Dissemination level:		
PU	Public	x
RE	Restricted to a group specified by the consortium (including Commission Services)	
CO	Confidential, only for members of the consortium (including Commission Services)	

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DOCUMENT HISTORY

Version	Date	Partner	Author	Changes
1	23.11.2018	TECNALIA	Javier del Pozo, Ainara Garcia Pierre Menger	Document creation
2	24.01.2019	TUD	Arnout Sabbe	Revision draft, Amsterdam case study.
3	04/02/2019	FGP	Lidia Gullon Santiago Rosado	Revision draft Madrid case study
4	20.02.2019	NIGRAD, ZAG	Matej Kadič, Brina Novak, Tomislav Ploj, Mirko Šprinzer, Kim Mezga, Alenka Mauko Pranjić, Ana Mladenovič	Revision draft Maribor case study
5	21.02.2019	Open Content	Mario Conci	Trento case study
6	25.02.2019	6.MAJ	Tadej Žurman	Umag case study
7	25.02.2019	IETU	Marek Matejczyk	Katowice case study
8	13.03.2019	TECNALIA, ZAG	Ainara Garcia Pierre Menger Kim Mezga	Final version
9	31.05.2020	TECNALIA, All	Ainara Garcia Pierre Menger	Improvements of deliverable addressing reviewers' comments
10	10.06.2020	ZAG	Alenka Mauko Pranjić, Anja Ilenič	Quality check

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Keywords:
Mass Flow Modelling (MFA), Waste as resource, Data bases, Sankey Diagram, Region, Urban areas.

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EXPLANATION OF ACRONYMS & ABBREVIATIONS

Acronym	Full name
AG	Activity group
APPA	Provincial Agency for Environmental Protection
ARSO	Slovenian Environment Agency
AS-MFA	Activity-based Spatial Material Flow Analysis
CDW	Construction and demolition waste
CE	Circular Economy
CinderCEBM	CINDERELA Circular Economy Business Model
CinderOSS	CINDERELA One Stop Shop
CPA	Products by Activity
D	Deliverable
EC	European Commission
EPER	European Pollutant Emission Register
E-PRTR	European Pollutant Release and Transfer Register
ETV	Environmental Technology Verification
EWC	European List of Waste
IETU	INSTYTUT EKOLOGII TERENOW UPRZEMYSLOWIONYCH
IPPC	Integrated Pollution Prevention and Control
FGP	Fundación Gomez Pardo
FP	Framework Programme
GDSE	Geodesign Decision Support Environment
H2020	Horizon 2020 The EU Framework Programme for Research and Innovation

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Acronym	Full name
LCA	Life Cycle Assessment
LMA	Landelijk Meldpunt Afvalstoffen
M	Project month (e.g. M6 stands for month 6 of the project)
MFA	Material Flow Analysis
NACE	European classification of economic activity
NAT	National
NIGRAD	NIGRAD d.d. komunalno podjetje
NUTS	Nomenclature of territorial units for statistics
Opencontent	OPENCONTENT SOCIETA COOPERATIVA
OW	Organic waste
OTH	Other
POLOPN	POLO TECNOLOGICO DI PORDENONE SOCIETA CONSORTILE PER AZIONI
R&D	Research and Development
REG	Regional
SRM	Secondary Raw Material
TECNALIA	FUNDACION TECNALIA RESEARCH & INNOVATION
TUDelft	TECHNISCHE UNIVERSITEIT DELFT
WP	Work package
ZAG	ZAVOD ZA GRADBENISTVO SLOVENIJE

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1. OVERVIEW OF THE DELIVERABLE

1.1. Introduction

The construction sector exerts great pressure on resources. To deal with this problem, industrial ecology proposes a systemic approach to optimise material and energy flows in an endless circuit, continually drawing value from waste or residual materials.

One of the first objectives of CINDERELA is the assessment of the waste streams in urban and peri-urban areas in terms of availability and potential for delivering qualitative secondary raw materials (SRM) in relevant amounts that can be of use for manufacturing construction materials. As amounts of available waste materials differ greatly per each region (e.g. in some regions the same materials are already brought back into the economy through reuse or recycling while in others they tend to enter end-of-pipe treatment methods right away), assessment of business potential for a specific material greatly depends on the current waste flows. Therefore, assessing current transportation needs, avoided negative impacts through upcycling and stability of secondary material supply is import for the solution viability and therefore needs to be well considered by the decision makers.

The main output of the WP3 will be the framework for the SRM based urban and peri-urban construction to establish it in the CinderCEBM (WP4). To increase its replication potential, it is suggested to build the framework based on a detailed methodology with three well-differentiated phases (Figure 1) linked between all WP3 tasks.

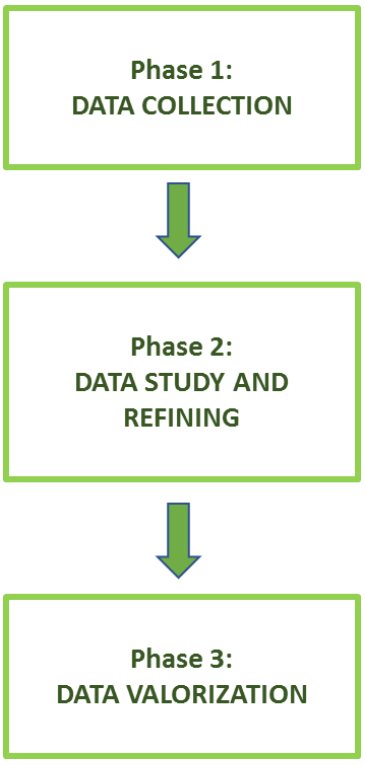

Figure 1 – Simplified WP3 Framework.

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- **Phase 1**: **Data collection** - in this phase, data on waste in specific urban and peri-urban areas are collected. The data may originate from different sources (e.g. official waste databases, interviews with stakeholders etc.). A set of minimum requirements are needed for qualitative data on wastes:
    - Waste code according to European Waste Catalogue (EWC),
    - Information on waste generator, i.e. polluter (name, address, European Classification of Economic Activity – NACE code, etc.),
    - Quantity of waste,
    - Information on waste flow (i.e. information on waste collector, waste treatment etc.) and
    - Description of waste

- **Phase 2**: **Data Study and refining** - in this phase, data are refined according to needs of specific MFA tool (GDSE tool in our case) and supporting GIS based visualizing tool for current waste flows (Task 3.1)

- **Phase 3**: **Data Valorization** - in this phase, the waste selection is further narrowed down through a set of criteria, i.e. i) quantity of waste, ii) technical properties (i.e. suitable for construction products), iii) availability (versus well established waste management routes), iv) recyclability (availability of suitable technologies for recycling) and others (Task 3.2). Also, during this phase, potential value chains for waste-to-product flows are assessed (Task 3.3). Finally, a general framework for waste based urban construction sector is set. The latter includes identifying driver and barriers for the construction's sector development.

Figure 2 shows the detailed steps in all of the three above mentioned phases.

The scope of this deliverable includes selecting the appropriate methodology for the initial analysis of waste in urban and peri-urban environment in Phase 1 and 2 of the General Framework.

The purpose of such approach is to funnel down the large quantity of waste data towards selection of materials, suitable for recycling into construction sector (Figure 3) not only in terms of technical feasibility but also financial viability and reduced environmental impacts. This is an iterative process where waste data are refined again and again in order to select the most appropriate waste flows (with the highest added value) in certain urban- and peri-urban environment for CINDERELA Circular Economy Business Model (CinderCEBM). Hence, the suggested framework shall provide a guided approach that will allow stakeholders taking decisions while considering local context specific information on waste stocks, flows and their treatment processes. In turn, this information will support the design and evaluation of new business models values and viability.

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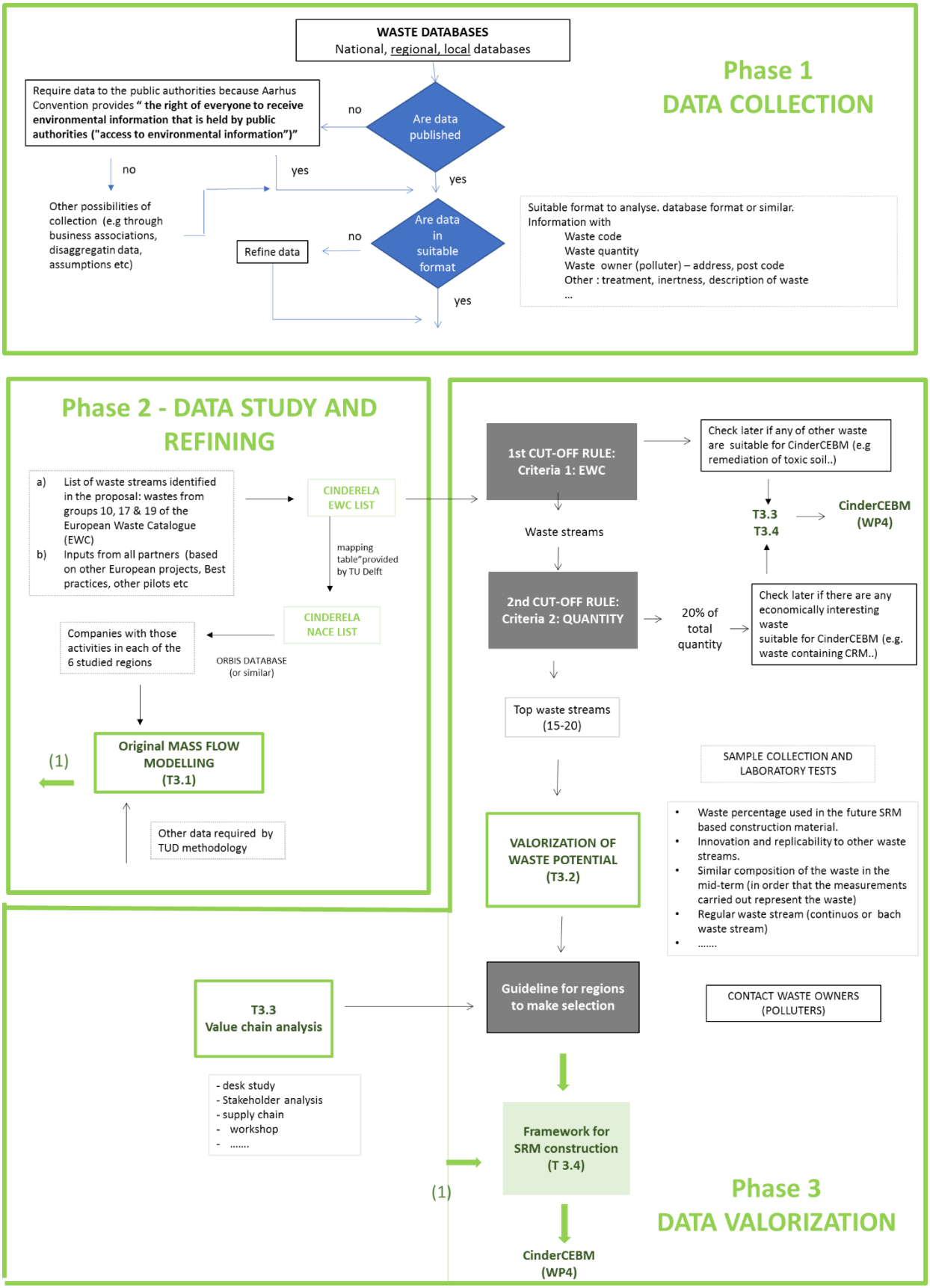

Figure 2 – Flow chart of the WP3 Methodology.

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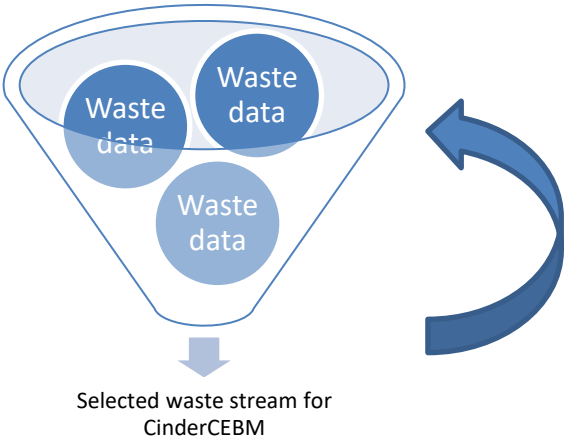

Figure 3 – Schematic process of funnelling down large waste data batch.

1.2. Reading guide

The document provides descriptions on the different steps along the process of waste data assessment and further provides insights on the application of the process in concrete case studies. Each case study has had the occasion to experience the full process of data collection and processing for their use in an IT platform, i.e. GDSE tool (Geodesign Decision Support Environment) which allows the graphical visualization of waste stocks and flows in a defined geographical area. Depending on the local conditions of access to waste data, waste data formats and administrative procedures to request waste data, resulting sometimes in delays for processing information, the experiences gained have shown diverse local challenges to which tailored mitigation measures and solutions may fit in order to exploit at best the data for sustaining local circular practices for the revalorization of waste streams as Secondary Raw Materials in the construction sector.

In terms of structure, the document consists of the following sections

- Section 1 describes the purpose of this document and its structure with a short and concise overview of the WP3 and task 3.1;
- Section 2 outlines the main steps of the methodology;
- Section 3 to 8, give an insight on the data assessment made in the case study regions following the phases and steps of the framework described above;
- Section 9 draws some conclusions and lessons learned from the overall framework implementation in the case study regions;
- Section 10 lists references; and
- Section 11 annexes.

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2. CINDERELA MFA METHODOLOGY

2.1. Concepts and general overview

The **urban metabolism** can be understood as the "collection of complex sociotechnical and socio-ecological processes by which flows of materials, energy, people, and information shape the city, service the needs of its populace, and impact the surrounding hinterland"[1] The current challenge of urban metabolisms is to transition from a linear perspective to a circular perspective, in which waste is utilised as a resource in the urban environment[2].

One of the methods to understand the metabolism of urban systems is the **Material Flow Analysis (MFA)**. MFA is a systematic assessment of the flows and stocks of materials (Figure 4) within a system defined in space and time. It connects the sources, the pathways, and the intermediate and final sinks of a material. Because of the law of the conservation of matter, the results of an MFA can be controlled by a simple material balance comparing all inputs, stocks, and outputs of a process[3].

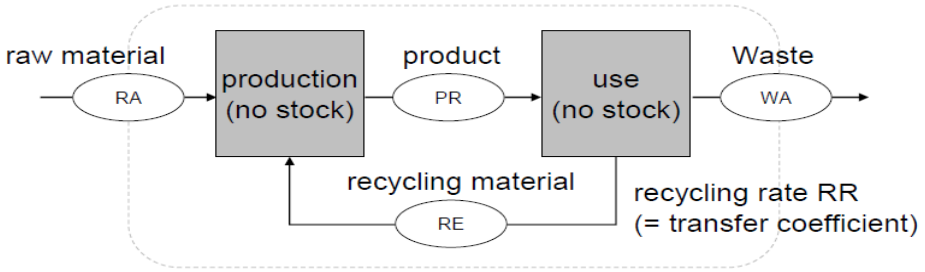

Figure 4 – Flows approach in STAN[4].

MFA is an excellent tool to support decisions regarding waste management and resource management[5]

In comparison to the standard MFA, AS-MFA (Activity-based Spatial Material Flow Analysis) augments the traditional way of executing MFA in two ways: 1) the storage and visualisation of geographical locations of nodes and links of material flows; 2) breaking down aggregated economic activity data into individual actors that can be georeferenced. It maps the geographic dynamics of materials and wastes and their corresponding quantities and qualities. Visualizing AS-MFA in its geographical context also helps to identify data gaps. Finally, due to the spatial dimension, sustainability or impact assessment methods (e.g. LCA) that typically follow the MFA will be able to improve their accuracy and comprehensiveness using spatial differentiation.

[1] Currie and Musango, 2016
[2] Musango, J.K., Currie, P. & Robinson, B. (2017) Urban metabolism for resource efficient cities: from theory to implementation. Paris: UN Environment
[3] Brunner, Paul H, Practical Handbook of material flow analysis, 2004
[4] http://www.stan2web.net/
[5] Brunner, Paul H, Practical Handbook of material flow analysis, 2004

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Waste management is primarily a regional issue but also has global consequences. As different regions of the world have become increasingly interdependent as a result of globalisation, international cooperation and global strategies have become necessary in the field of waste management. One way of international cooperation is knowledge sharing, building up knowledge based upon the lessons from the practices in various regions[6].

Having these premises in mind, the objective of the work described in this document was to implement the CINDERELA framework (see Figure 2) in 6 case study regions using the concepts and tools of urban metabolisms and AS-MFA. The case study regions have been established in the following countries: Spain, Slovenia, Croatia, Poland, Italy and the Netherlands as shown in the Table 1.

Table 1 – Regions of the case studies to carry out the MFA.

No.	Case study	Partner responsible
1	Amsterdam (The Netherlands) (Chapter 3)	TUDelft
2	Basque country (Spain) (Chapter 4)	TECNALIA
3	Katowice (Poland)(Chapter 5	IETU
4	Maribor (Slovenia) (Chapter 6)	NIGRAD
5	Trento (Italy) (Chapter 7)	Opencontent
6	Umag (Croatia) (Chapter 8)	6. MAJ

2.2. Methodology steps in the CINDERELA context

The following sections will describe the key aspects of the different methodology steps which will allow users/stakeholders to collect, process data for their use under the principles of the AS-MFA method. This methodology has been originally developed within the H2020 REPAIR Project (GA No 605779) and has been partly adapted to CINDERELA. In principle, the methodology can be divided in 9 consecutive steps (see Figure 5). This new methodology is organized into nine steps which will be described in the current chapter.

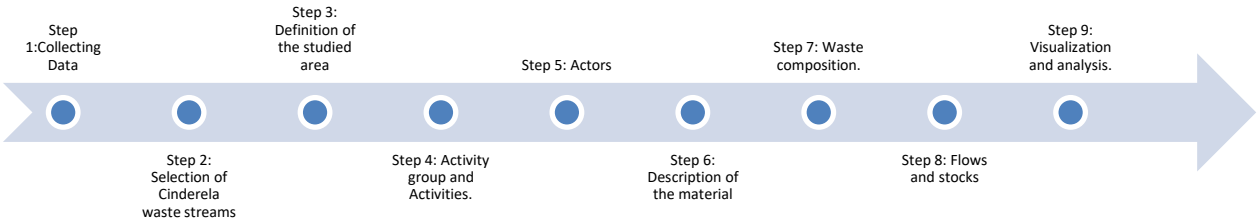

Figure 5 – Simplified flowchart of the CINDERELA AS-MFA methodology.

[6] Support for Waste Management in Cities Based on the Software STAN. Jiao Tang, International Solid Waste Association and Paul H. Brunner, Technical University of Vienna

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As already mentioned previously, the AS-MFA has been executed with support of an innovative, open source tool, developed by TUDelft: GDSE tool. GDSE stands for Geodesign Decision Support Environment and was initiated under the H2020- REPAiR project and further tailored to the purpose and context of CINDERELA (Figure 6).

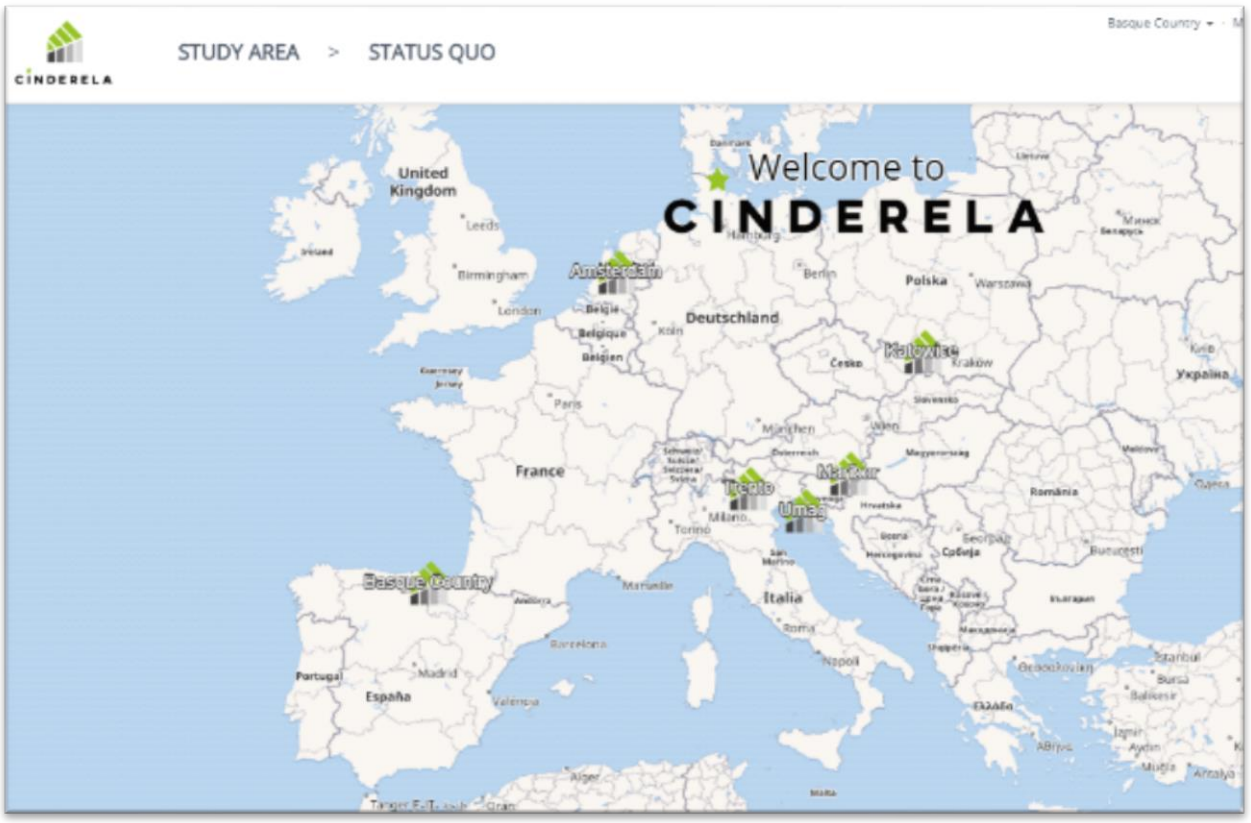

Figure 6 – Principal interface of the GDSE tool.

2.2.1. Step 1: Collecting data (acquisition of all waste generated)

The first step in the methodology is the collection of the data, i.e. data acquisition from the different possible data sources on the areas/regions object of the analysis (Figure 7). Knowledge about existing data sources is a prerequisite to data collection. Depending on the nature of data source, specific methods or means to get access to these data may be put in place. In general, it can be expected that data on waste flows may be in hands of regional, national or international agencies.

In terms of availability of waste data to the general public, 2 options are possible:

- The data is not available; or
- The data is available and easily accessible to public.

If data is not publicly available, the first task will consist in contacting with the administration in possession of waste data. As mentioned above, this is generally a regional authority/agency. Getting access to the data managed by these organizations may require formal procedures of data request. Such procedures may be time consuming; these delays may need to be considered as factor in real case

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project management and implementation. According to the Aarhus convention[7], it is a right of everyone to receive environmental information from public authorities.

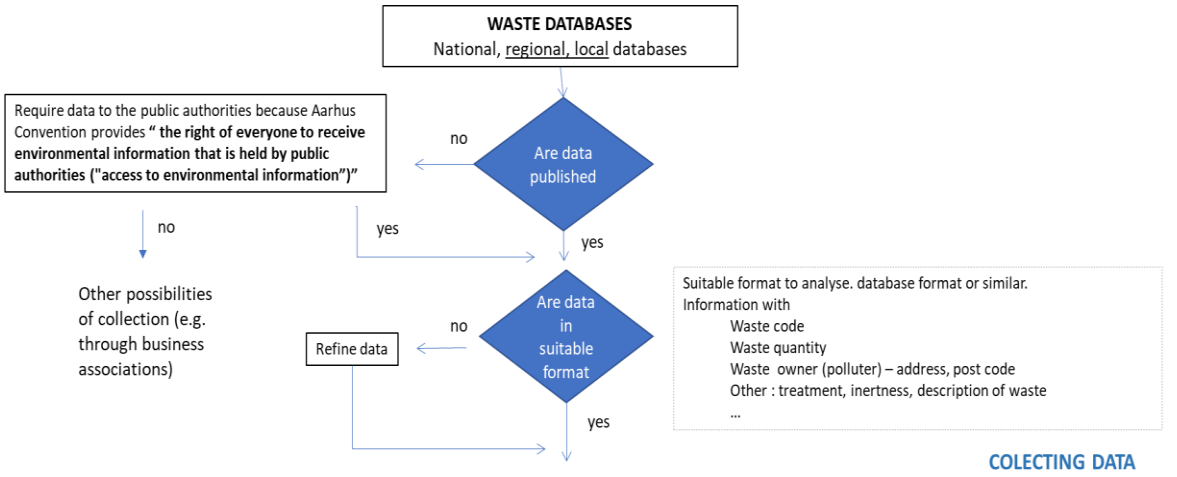

Figure 7 – Phase 1 of the methodology: Collecting data.

Generally, the necessary data are hosted in databases and reports managed and commissioned by national and/or regional authorities. However, situations may exist where relevant waste data may also be available from other data sources. These may be official statistics or reports, surveys and similar sources. In general, the following alternative data sources may need to be considered at regional level:

- Companies;
- Municipalities (households);
- Waste collectors and waste treaters.

Once access to data has been achieved, another important issue will be to adapt the data format to a suitable format of the IT tool used to support the AS-MFA analysis, i.e. in the case of CINDERELA, to the GDSE tool formats. This harmonization is necessary in order to manage and analyse all the data from the different sources under the same IT platform. Key data to be verified are:

- Waste code as specified within the European List of waste[8];
- Waste quantity;
- Waste actors;
    - Waste generator or polluter;
    - Waste collector;
    - Waste treatment, etc.

In relation to waste actors, as it will be further described under step 5 of the methodology, depending on the type of waste data pursued and their availability, 2 different procedures for characterizing the waste actors may be used:

[7] http://www.unece.org/fileadmin/DAM/env/pp/documents/cep43e.pdf
[8] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02000D0532-20150601

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1. "Detailed procedure" - this is the case when the information on waste (i.e. type of waste produced and fate resp. origin) for each individual actor (i.e. company) in the concerned region is available.

2. "Simplified procedure" - this is the case when the waste information is aggregated, i.e. waste is not assigned to a specific economic actor/company but rather available at sectorial level or only given by companies' groups, i.e. IPPC companies.

In order to help in the process of data collection, CINDERELA is developing support materials:

- Data request template to be sent to environmental agencies (see Annex 2);
- Tutorial videos to show the GDSE tool functioning (accessible on CINDERELA's webpage further in the project execution).

2.2.2. Step 2: Selection of CINDERELA waste streams to be studied

Once access to waste data have been provided and waste data collected, the second step in this process consists in screening the full data set in order to select those waste streams to be assessed. In this sense, and previously to starting the AS-MFA procedure, based on expert criteria (i.e. experience on recycling potential of waste for the construction sector) CINDERELA partners have identified specific wastes from the European list of waste (EWC). When necessary, the analysis was completed with bibliographic research. As a result, a shortlist of selected waste streams has been compiled. This CINDERELA list contained 110 non-hazardous[9] waste streams. This first screening made by CINDERELA partners on basis of expert criteria represents the first cut-off rule as described in Figure 2. A quick scan through the selected waste streams shows that these belong to the following economic activities:

- Mining processes;
- Thermal processes as slags and ashes;
- Construction and demolition waste as concrete, bricks, tiles and ceramics;
- Waste packaging as plastic, glass, textile packaging;
- Waste from waste management facilities as remaining of treatment of municipal solid waste and wastewater and;
- Municipal wastes as wood and glass among others.

The CINDERELA list with all the EWC selected is shown in the Table 2.

Table 2 – CINDERELA EWC list.

EWC Code 2	EWC Code	Description
01 01	10102	Wastes from mineral non-metalliferous excavation
01 03	10308	Dusty and powdery wastes other than those mentioned in 01 03 07
01 04	10408	Waste gravel and crushed rocks other than those mentioned in 01 04 07
01 04	10409	Wste sand and clays
01 04	10410	Dusty and powdery wastes other than those mentioned in 01 04 07
01 04	10413	Wastes from stone cutting and sawing other than those mentioned in 01 04 07

[9] By addressing only non-hazardous wastes (those without asterix*) it doesn't mean that the latter are not suitable for CinderCEBM. Hazardous waste can be immobilized and as such if they have appropriate properties are suitable for construction sector. Hazardous waste can be studied in one of the next iterations.

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EWC Code 2	EWC Code	Description
01 05	10504	Freshwater drilling muds and wastes
02 01	20103	Plant-tissue waste
02 03	20304	Materials unsuitable for consumption or processing
03 03	30301	Waste bark and wood
03 03	30302	Green liquor sludge (from recovery of cooking liquor)
03 03	30305	De-inking sludges from paper recycling
03 03	30309	Lime mud waste
03 03	30310	Fibre rejects, fibre-, filler- and coating-sludges from mechanical separation
03 03	30311	Sludges from on-site effluent treatment other than those mentioned in 03 03 10
07 06	70699	Wastes not otherwise specified
10 01	100101	Bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)
10 01	100102	Coal fly ash
10 01	100103	Fly ash from peat and untreated wood
10 01	100105	Calcium-based reaction wastes from flue-gas desulphurisation in solid form
10 01	100107	Calcium-based reaction wastes from flue-gas desulphurisation in sludge form
10 01	100115	Bottom ash, slag and boiler dust from co-incineration other than those mentioned in 10 01 14
10 01	100117	Fly ash from co-incineration other than those mentioned in 10 01 16
10 01	100119	Wastes from gas cleaning other than those mentioned in 10 01 05, 10 01 07 and 10 01 18
10 01	100121	Sludges from on-site effluent treatment other than those mentioned in 10 01 20
10 01	100123	Aqueous sludges from boiler cleansing other than those mentioned in 10 01 22
10 01	100124	Sands from fluidised beds
10 01	100125	Wastes from fuel storage and preparation of coal-fired power plants
10 01	100126	Wastes from cooling-water treatment
10 01	100199	Wastes not otherwise specified
10 02	100201	Wastes from the processing of slag
10 02	100202	Unprocessed slag
10 02	100208	Solid wastes from gas treatment other than those mentioned in 10 02 07
10 02	100210	Mill scales
10 02	100212	Wastes from cooling-water treatment other than those mentioned in 10 02 11
10 02	100214	Sludges and filter cakes from gas treatment other than those mentioned in 10 02 13
10 02	100215	Other sludges and filter cakes
10 02	100299	Wastes not otherwise specified
10 03	100316	Skimmings other than those mentioned in 10 03 15
10 03	100330	Wastes from treatment of salt slags and black drosses other than those mentioned in 10 03 29
10 09	100903	Furnace slag
10 09	100906	Casting cores and moulds which have not undergone pouring other than those …….
10 09	100908	Casting cores and moulds which have undergone pouring other than those ……..
10 09	100910	Flue-gas dust other than those mentioned in 10 09 09
10 09	100912	Other particulates other than those mentioned in 10 09 11
10 09	100914	Waste binders other than those mentioned in 10 09 13
10 09	100916	Waste crack-indicating agent other than those mentioned in 10 09 15
10 09	100999	Wastes not otherwise specified
10 10	101003	Furnace slag
10 11	101105	Particulates and dust
10 11	101110	Waste preparation mixture before thermal processing, other than those……..
10 11	101112	Waste glass other than those mentioned in 10 11 11
10 11	101114	Glass-polishing and -grinding sludge other than those mentioned in 10 11 13
10 11	101116	Solid wastes from flue-gas treatment other than those mentioned in 10 11 15
10 11	101118	Sludges and filter cakes from flue-gas treatment other than those mentioned in 10 11 17
10 11	101120	Solid wastes from on-site effluent treatment other than those mentioned in 10 11 19
10 11	101199	Wastes not otherwise specified
10 12	101208	Waste ceramics, bricks, tiles and construction products (after thermal processing)
10 12	101208	Waste ceramics, bricks, tiles and construction products (after thermal processing)
10 12	101210	Solid wastes from gas treatment other than those mentioned in 10 12 09
10 12	101299	Wastes not otherwise specified

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EWC Code 2	EWC Code	Description
12 01	120101	Ferrous metal filings and turnings
12 01	120102	Ferrous metal dust and particles
12 01	120103	Non-ferrous metal filings and turnings
12 01	120104	Non-ferrous metal dust and particles
12 01	120105	Plastics shavings and turnings
12 01	120117	Waste blasting material other than those mentioned in 12 01 16
15 01	150102	Plastic packaging
15 01	150105	Composite packaging
15 01	150107	Glass packaging
15 01	150109	Textile packaging
16 10	161004	Aqueous concentrates other than those mentioned in 16 10 03
16 11	161104	Other linings and refractories from metallurgical processes other than those ……..
17 01	170101	Concrete
17 01	170102	Bricks
17 01	170103	Tiles and ceramics
17 01	170107	Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06
17 02	170201	Wood
17 02	170202	Glass
17 02	170203	Plastic
17 03	170302	Bituminous mixtures other than those mentioned in 17 03 01
17 05	170504	Soil and stones other than those mentioned in 17 05 03
17 05	170506	Dredging spoil other than those mentioned in 17 05 05
17 05	170508	Track ballast other than those mentioned in 17 05 07
17 06	170604	Insulation materials other than those mentioned in 17 06 01 and 17 06 03
17 08	170802	Gypsum-based construction materials other than those mentioned in 17 08 01
17 09	170904	Mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03
19 01	190112	Bottom ash and slag other than those mentioned in 19 01 11
19 05	190502	Non-composted fraction of animal and vegetable waste
19 05	190503	Off-specification compost
19 06	190604	Digestate from anaerobic treatment of municipal waste
19 06	190606	Digestate from anaerobic treatment of animal and vegetable waste
19 08	190801	Screenings
19 08	190802	Waste from desanding
19 08	190805	Sludges from treatment of urban waste water
19 08	190814	Sludges from other treatment of industrial waste water other than those mentioned in 19 08 13
19 12	191204	Plastic and rubber
19 12	191205	Glass
19 12	191208	Textiles
19 12	191209	Minerals (for example sand, stones)
19 12	191212	Other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11
20 01	200102	Glass
20 01	200110	Clothes
20 01	200111	Textiles
20 01	200138	Wood other than that mentioned in 20 01 37
20 01	200139	Plastics
20 02	200202	Soil and stones
20 02	200203	Other non-biodegradable wastes
20 03	200303	Street-cleaning residues
20 03	200306	Waste from sewage cleaning

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Taking this list into consideration, each study region crossed this list with the list of wastes identified in their region and came up with their respective regional CINDERELA waste list. In order to further narrow down the number of waste streams to undergo urban metabolism analysis supported by AS-MFA, a second cut-off rule was implemented in each case study. As indicated in the CINDERELA framework, this second cut-off rule consists in selecting those waste streams which by mass represent together 80% of the total mass of wastes in the region. After the first cut-off rule based on qualitative criteria, the purpose of the second cut-off rule is to introduce a quantitative criterion within the screening of waste streams at regional level. Hence, for the purpose of CINDERELA project as an experimental work, we estimate that the combination of the 2 cut-off rules (i.e. one qualitative and 1 quantitative) enables without major efforts to rapidly identify waste streams which either represent good potentials for their use as secondary raw materials in the construction sector as well as decent figures in terms of offer (i.e. availability in large volumes) at local level. Please note that other cut-off criteria, alternative to "waste quantities", could have been applied, i.e. waste hazardousness, waste containing Critical Raw Materials and others. The choice of the cut-off criteria in real project implementation shall be made on basis of local circumstances (i.e. economic, technical, social, geographical, environmental, administrative) and priorities agreed among the local stakeholders. These criteria may vary greatly in function of the local circumstances, however, as soon as they are agreed among the local stakeholders, they are all valid for the purpose of AS-MFA. The only condition for their use is to dispose of data about the. It is therefore recommended to assess previously the availability of cut-off criteria valid data. A further insight on possible alternative cut-off criteria, including a short evaluation of their pros and cons is given in CINDERELA deliverable [D3.2 Report on the valorization of wastes for the purpose of SRM-based construction materials].

2.2.3. Step 3: Selection and delimitation of the geographical area of the case study (Administrative units)

The third step consists in defining the geographical area of on which AS-MFA will be applied. Typically, this area could correspond to a city, an urban and peri-urban area, a province, a region and/or a country.

For the purpose of the exercise performed within CINDERELA, the geographical area of each case study has been defined by the respective responsible partners. Therefore 3 to 4 levels of administrative units have been chosen per case study, according to the granularity of available data, size of the focus area and governance structures in place (Figure 8).

For reproducibility of the methodology and overall consistency, we estimate that the geographical units as those defined under the Nomenclature of Territorial Units for Statistics, i.e. NUTS system is mostly suited and should be used as framework for geographical area assessment in AS-MFA. The NUTS classification is a hierarchical system of division of EU economic territories. The current NUTS 2016 classification is valid January 1st, 2018 and lists 104 regions at NUTS 1, 281 regions at NUTS 2 and 1348 regions at NUTS 3 level. A short definition of each of these NUTS units is given hereafter.

- NUTS 1: major socio-economic regions;
- NUTS 2: basic regions for the application of regional policies;
- NUTS 3: small regions for specific diagnoses.

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Table 3 shows an example of administrative unit levels.

Table 3 – Example of levels for the administrative units.

1	World
2	Continent
3	Country
4	NUTS1
5	NUTS2
6	NUTS3
7	District
8	Municipality
9	CityDistrict
10	CityNeighbourhood
11	CityBlock
12	StreetSection
13	House

Based on the internationally accepted NUTS nomenclature, geometries of the study regions need to be converted in WGS84 - World Geodetic System 1984 or EPSG: 4326 format (European Petroleum Survey Group 4326) to be uploaded into the GDSE.

Figure 8 – Example of a map for the Administrative Units – here, the Basque Country.

2.2.4. Step 4: Activity Group and Activities

After waste streams have been selected and study areas defined, the fourth step consists in the identification of the companies that generate these waste streams. In fact, during this step, information on waste, i.e. waste code will be used to trace-back the type of companies or economic activities that are generating the wastes of interest. This process will be undertaken in 2 small steps, first resulting in the identification of economic activities at the origin of the wastes and a second step which will consist in identifying the single company at the origin of the waste. In the frame of CINDERELA experimental work this assessment has been possible with the support of a mapping table developed by TU-DELFT. As

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a result of this work, the CINDERELA NACE list has been compiled (see Table 4). In substance, the mapping table links an economic activity with a determined waste.

The trace-back system underpinning the mapping table (i.e. linking a waste with an activity) follows the hierarchy of the Statistical Classification of Products by Activity (CPA) in the European Community (2008 version) and the Statistical Classification of Economic Activities in the European Community (NACE)[10]. CPA product categories are related to activities.

CPA has a hierarchical structure with six levels, each identified with a specific code:

- First level: 21 sections (alphabetical code);
- Second level: 88 divisions (two-digit numerical code);
- Third level: 261 groups (three-digit numerical code);
- Fourth level: 575 classes (four-digit numerical code);
- Fifth level: 1 342 categories (five-digit numerical code);
- Sixth level: 3 142 subcategories (six-digit numerical code).

[10]https://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=CPA_2008&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC

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Using the CINDERELA EWC list (see Table 2) as inputs of the mapping table, a list of NACE activities generating the wastes could be established. This CINDERELA NACE list will be further used to identify single companies (as it will be explained in the upcoming sections) generating the wastes of interest of CINDERELA's case study regions.

Table 4 – Mapping table EWC / NACE.

NACE	NACE lvl1	NACE level	Haz.	EWC code	EWC name	EWC code 1	EWC code 2	EWC_name_1	EWC_name_2	Item descr.
A-0111	A	1	Non-hazardous	20103	Plant-tissue waste	2	02 01	WASTES FROM AGRICULTURE, HORTICULTURE, AQUACULTURE, FORESTRY, HUNTING AND FISHING, FOOD PREPARATION AND PROCESSING	Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing	Vegetal wastes
A-0111	A	1	Non-hazardous	20304	Materials unsuitable for consumption or processing	2	02 03	WASTES FROM AGRICULTURE, HORTICULTURE, AQUACULTURE, FORESTRY, HUNTING AND FISHING, FOOD PREPARATION AND PROCESSING	Wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee, tea and tobacco preparation and processing; conserve production; yeast and yeast extract production, molasses preparation and fermentation	Vegetal wastes
…….										
……..										

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Table 5 gives an overview of the activity groups defined at level 1 are shown. The table also lists those activities that have been identified in the CINDERELA list.

Table 5 – Activity group table for the GDSE tool.

Code	Description	
A	PRODUCTS OF AGRICULTURE, FORESTRY AND FISHING	x
B	MINING AND QUARRYING	x
C	MANUFACTURED PRODUCTS	x
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING	x
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION SERVICES	x
F	CONSTRUCTIONS AND CONSTRUCTION WORKS	x
G	WHOLESALE AND RETAIL TRADE SERVICES; REPAIR SERVICES OF MOTOR VEHICLES AND MOTORCYCLES	x
H	TRANSPORTATION AND STORAGE SERVICES	x
I	ACCOMMODATION AND FOOD SERVICES	
J	INFORMATION AND COMMUNICATION SERVICES	
K	FINANCIAL AND INSURANCE SERVICES	
L	REAL ESTATE SERVICES	
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL SERVICES	x
N	ADMINISTRATIVE AND SUPPORT SERVICES	
O	PUBLIC ADMINISTRATION AND DEFENCE SERVICES; COMPULSORY SOCIAL SECURITY SERVICES	
P	EDUCATION SERVICES	
Q	HUMAN HEALTH AND SOCIAL WORK SERVICES	X
R	ARTS, ENTERTAINMENT AND RECREATION SERVICES	
S	OTHER SERVICES	X
T	SERVICES OF HOUSEHOLDS AS EMPLOYERS; UNDIFFERENTIATED GOODS AND SERVICES PRODUCED BY HOUSEHOLDS FOR OWN USE	x
U	SERVICES PROVIDED BY EXTRATERRITORIAL ORGANISATIONS AND BODIES	

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At a lower aggregation level to the activity groups, specific or individual activities can be defined using the NACE 4 digits codes. An example of activity and its description is given in Table 6. A more complete list of the CINDERELA activities can be found in Annex 1.

Table 6 – Template of the Activities table for the GDSE tool.

NACE	Name	AG
A-0111	A-0111 Growing of cereals (except rice), leguminous crops and oil seeds	A
…….		

Additional activities can be added to the system, ever if the activity is assigned to an activity group (i.e. AGsee Table 7.

Table 7 – Example of other activities for the GDSE tool.

NACE	Name	AG
V-0000	V-0000 Consumption in households.	V
…….		

2.2.5. Step 5: Actors

As already mentioned above, the identification of single companies or actors based on the available data on waste may be achieved by 2 different procedures:

1. “Detailed procedure” - this is the case when the information on waste (i.e. type of waste produced and fate resp. origin) for each individual actor (i.e. company) in the concerned region is available;

2. “Simplified procedure” - this is the case when the waste information is aggregated, i.e. waste is not assigned to a specific economic actor/company but rather available at sectorial level or only given by companies’ groups, i.e. IPPC companies.

2.2.5.1. Detailed option

With the help of ORBIS database (or similar database) this step consists in identifying existing companies belonging to the NACE codes defined in the previous step (Figure 9).

In Table 8 below, an example of the listing of actors for the CINDERELA’s actors list is given. The information featured in there is based on the extracts of the ORBIS database. The actors can be added either manually one by one using a GDSE interface or by uploading them all together using this template as a file. A prerequisite is that all actors added on the list need to belong to one of the activities in the “Activities” table defined in the previous section.

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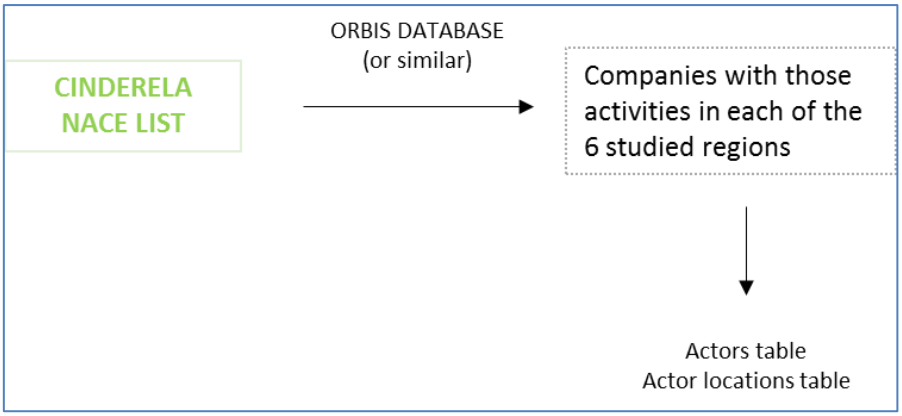

Figure 9 – Generation of CINDERELA's actors table – step 5.

Remark: not all actors are necessarily companies. For example, households could be considered as actors and could also be added to the GDSE database structure. Additional actors can be created upon request.

Table 8 – Templates of the Actors table for the GDSE tool.

BvDid*	Name	Code	Year	Description English	Description original
Identification used by ORBIS. Can also be any other custom unique identifier.	Name of the company	Consolidation code according to ORBIS (optional)	Last time the company has been reported	Description (optional)	(optional)
NL000786543	Orgaworld B.V.	C1	2016		
….					
…..					

Website	Employees	Turnover	NACE
(optional)	(optional)	thousands in EUR (optional)	4 digits, must be present in the list of Activities
www.orgaworld.nl	298	1200	E-3623
…..			
…..			

2.2.5.2. Simplified option

For those cases where data on waste flows are lacking or competent authorities are not willing to provide expected data (some local governments are not willing to give this kind of information), CINDERELA has developed an alternative procedure to add data to the GDSE Tool. This simplified procedure helps overcoming the data gap in cases where only partial data are available (i.e. data

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available only for a limited number of companies in the region, data are aggregated by sectors or company groupings like IPPC companies).

In this case, sectorial information or information on main companies as IPPC can be added. Hence, instead of uploading individual companies from study area, the methodology allows to upload municipalities or sectorial waste aggregated data, etc.

In order to help users in the process of data uploading, CINDERELA has developed tutorial videos to show the GDSE tool functionalities

2.2.6. Step 6: Detailed description of the materials

This step includes the definition of the activities where materials become waste, and identification of the fractions present in the different waste streams.

The code structure for materials can be downloaded from Eurostat databases. Its classification follows the hierarchical classification of CPA (see above). Concretely, the hierarchical structure counts six levels, each identified with a specific code:

- LEVEL 1: 21 sections (alphabetical code);
- LEVEL 2: 88 divisions (two-digit numerical code);
- LEVEL 3: 261 groups (three-digit numerical code);
- LEVEL 4: 575 classes (four-digit numerical code);
- LEVEL 5: 1 342 categories (five-digit numerical code);
- LEVEL 6: 3 142 subcategories (six-digit numerical code).

An example of such codification is reflected in Table 9. In this table, the "PARENT" column indicates the code of the LEVEL above in the classification's hierarchy, i.e. the material group identified with 22.2 belongs to the material division 22. In this case, 22 is the PARENT code of the material group 22.2.

Table 9 – Material table for Eurostat.

Level	Code	Parent	Description	Rul
3	22.2	22	Plastic products	
4	22.21	22.2	Plastic plates, sheets, tubes and profiles	
5	22.21.1	22.21	Monofilament > 1 mm, rods, sticks and profile shapes, of plastics	
6	22.21.10	22.21.1	Monofilament > 1 mm, rods, sticks and profile shapes, of plastics	
5	22.21.2	22.21	Tubes, pipes and hoses and fittings thereof, of plastics	
6	22.21.21	22.21.2	Artificial guts, of hardened proteins or of cellulosic materials; tubes, pipes and hoses, rigid, of plas	
6	22.21.29	22.21.2	Other tubes, pipes, hoses and fittings thereof, of plastics	
5	22.21.3	22.21	Plates, sheets, film, foil and strip, of plastics, not supported or similarly combined with other mater	
6	22.21.30	22.21.3	Plates, sheets, film, foil and strip, of plastics, not supported or similarly combined with other mater	
5	22.21.4	22.21	Other plates, sheets, film, foil and strip, of plastics	
6	22.21.41	22.21.4	Other plates, sheets, film, foil and strip, of plastics, cellular	
6	22.21.42	22.21.4	Other plates, sheets, film, foil and strip, of plastics, non-cellular	
5	22.21.9	22.21	Sub-contracted operations as part of manufacturing of plastic plates, sheets, tubes and profiles	
6	22.21.99	22.21.9	Sub-contracted operations as part of manufacturing of plastic plates, sheets, tubes and profiles	
4	22.22	22.2	Plastic packing goods	
5	22.22.1	22.22	Plastic packing goods	
6	22.22.11	22.22.1	Sacks and bags (including cones), of polymers of ethylene	
6	22.22.12	22.22.1	Sacks and bags (including cones), of other plastics than polymers of ethylene	

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Before uploading data on materials (i.e. in excel format) to the CINDERELA AS-MFA IT support tool GDSE a series of previous screening steps of the full materials table (i.e. as for example Table 9 above) need to be implemented. An outcome of this work will be a CINDERELA material table with detailed information as shown in the following Figure 10.

			Level I	Level II	Level III	level IV		Parent	Name
1	C		Manufactured products						MANUFACTURED PRODUCTS
2	23	C		Glass and glass products				MANUFACTURED PRODUCTS	Glass and glass products
3	23.1	23			Flat glass			Glass and glass products	Flat glass
4	23.11	23.1				Flat glass		Flat glass	Flat glass
4	23.12	23.1				Shaped and processed flat glass		Flat glass	Shaped and processed flat glass
4	23.13	23.1				Hollow glass		Flat glass	Hollow glass
4	23.14	23.1				Glass fibres		Flat glass	Glass fibres
4	23.19	23.1				Other glass, semi-finished		Flat glass	Other glass, semi-finished

Figure 10 – Example of the Materials hierarchy and its corresponding table for the GDSE.

Screening steps for filtering out CINDERELA materials data table to be uploaded on GDSE tool:

1) Select product range in CPA level 1 that are relevant for the CINDERELA key flows, i.e. MINING AND QUARRYING, MANUFACTURED PRODUCTS, etc.

Please consider that if the material belongs to LEVEL 1 of the hierarchy, logically the "PARENT" column will be left empty. Within LEVEL 1 product range, select products relevant for CINDERELA key flows from lower levels progressively until LEVEL 4.

2) [*Optional*] in order to simplify the table, you may consider that if one category refers to only one other category in a lower level, then this level can be eliminated. To illustrate this situation, please see the example of the refractory products in red and crossed out in Figure 11.

			Level I	Level II	Level III	level IV		Parent	Name
1	C		Manufactured products						MANUFACTURED PRODUCTS
2	23	C		Glass and glass products				MANUFACTURED PRODUCTS	Glass and glass products
3	23.1	23			Flat glass			Glass and glass products	Flat glass
4	23.11	23.1				Flat glass		Flat glass	Flat glass
4	23.12	23.1				Shaped and processed flat glass		Flat glass	Shaped and processed flat glass
4	23.13	23.1				Hollow glass		Flat glass	Hollow glass
4	23.14	23.1				Glass fibres		Flat glass	Glass fibres
4	23.19	23.1				Other glass, semi-finished		Flat glass	Other glass, semi-finished
3	23.2	23			Refractory products			Glass and glass products	Refractory products
4	23.20	23.2				Refractory products		~~Refractory products~~	~~Refractory products~~

Figure 11 – Example II of the material table for the GDSE.

3) Auxiliary materials may be added on the list, e.g. packaging materials, waste material. While doing so, please respect the coding procedure and follow the established classification hierarchy.

- The material list of packaging materials has been taken from the "Municipal solid waste composition" by Davide Tonini[11].
- The waste composition table has been made based on the EWC CINDERELA list (Figure 12).

[11] 2014. Maklawe Essonanawe Edjabou et all. Municipal solid waste composition: Sampling methodology, statistical analyses, and case study evaluation. https://doi.org/10.1016/j.wasman.2014.11.009

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	Waste material
Waste material	100101 bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)
Waste material	100102 coal fly ash
Waste material	100103 fly ash from peat and untreated wood
Waste material	100105 Calcium-based reaction wastes from flue-gas desulphurisation in solid form
Waste material	100107 calcium-based reaction wastes from flue-gas desulphurisation in sludge form
Waste material	100115 Bottom ash, slag and boiler dust from co-incineration other than those mentioned in 10 01 14
Waste material	100117 fly ash from co-incineration other than those mentioned in 10 01 16
Waste material	100119 wastes from gas cleaning other than those mentioned in 10 01 05, 10 01 07 and 10 01 18
Waste material	100121 sludges from on-site effluent treatment other than those mentioned in 10 01 20
Waste material	100123 aqueous sludges from boiler cleansing other than those mentioned in 10 01 22
Waste material	100124 sands from fluidised beds
Waste material	100125 wastes from fuel storage and preparation of coal-fired power plants
Waste material	100126 wastes from cooling-water treatment
Waste material	100199 wastes not otherwise specified

Figure 12 – Example III of the material table for the GDSE.

- In some cases, more detailed information than the official description of the EWC-code itself exists. Figure 13 shows the example of the material hierarchy for the Amsterdam Metropolitan Area case-study for concrete.

Level I	Level II	Level III	Level IV	Level V	Parent	Name
concrete, bricks, tiles and ceramics						concrete, bricks, tiles and ceramics
	concrete				concrete, bricks, tile	concrete
		concrete debris			concrete	concrete debris
			mixed concrete debris		concrete	concrete sludge
			clean concrete debris		concrete	rinsed concrete
			reinforced concrete debris		concrete	mineral concrete
		concrete sludge			concrete debris	mixed concrete debris
			contaminted concrete sludge s		concrete debris	clean concrete debris
		rinsed concrete			concrete debris	reinforced concrete debris
		mineral concrete			concrete sludge	contaminated concrete sludge spoil
			mineral concrete debris contar		mineral concrete	mineral concrete debris contaminated

Figure 13 – Example IV of the material table for the GDSE.

As a result of the above actions, a CINDERELA materials table has been created project. If needed, further details or new materials can be added manually by using the GDSE interface, thus offering the users the possibility to adapt the materials list in function of occurring opportunities.

2.2.7. Step 7: Product / Waste Composition

Heading towards the description of single flow characterization, a composition table needs to be developed (Table 10). A composition table is needed to clarify what exactly every single flow consists of. As data can refer to different composition mixes all representative of a same material, it is important to split a flow into its fractions as much as the data allows to do so. As a rule, the sum of fractions in one flow always needs to be equal to 1. An example of the flow composition would be the waste flow from a building project which generates 1 tonne of construction and demolition waste, being a 70% concrete and 30% bricks, tiles and ceramics. All composing materials need to be listed in the CINDERELA Material list (see section 2.2.6). The material list can be adapted based on data availability and quality (i.e. level of detail on the material description) at any time during the project. New materials can be added at any time at any of the hierarchical levels. In the example of the composition table below, the column "NACE" refers to the primary activity as producer of a particular composition

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Table 10 – Example a composition table for the GDSE.

NACE	Name	Material	Fraction	Avoidable	Source	Item_descr
F-4110	F-4110 Development of building projects 170101	170101 concrete	1	FALSE	Ambiente2016a	Mineral waste from construction and demolition
F-4110	F-4110 Development of building projects 170102	170102 bricks	1	FALSE	Ambiente2016a	Mineral waste from construction and demolition
F-4110	F-4110 Development of building projects 170103	170103 tiles and ceramics	1	FALSE	Ambiente2016a	Mineral waste from construction and demolition
F-4110	F-4110 Development of building projects 170107	170107 Concrete	0.7	FALSE	Ambiente2016a	Mineral waste from construction and demolition
F-4110	F-4110 Development of building projects 170107	170107 bricks, tiles and ceramics.	0.3	FALSE	Ambiente2016a	Mineral waste from construction and demolition

Each material should be tagged with Avoidable ("TRUE"), or Unavoidable ("FALSE"). In the CINDERELA project we consider all waste unavoidable and tag therefore "FALSE".

Additional descriptions can be given for each individual flow defining collection method, quality, additional materials, and type of waste (as the example above).

Each data should be referred to some "Data Sources". To ensure scientific integrity and in order to prevent mistakes and facilitate their eventual correction, every number that is used for the AS-MFA needs to be traceable back to its original source. Therefore, the data structure supports referencing of each flow and composition. Flows and compositions may have separate data sources, e.g. the amounts of household waste generated in a certain municipality can be provided by the municipality, while the composition of household waste may be researched by a different institution and for a different purpose. All used data sources must be described using a BibTex format (more information available in the web page[12]).

As a result of the above described procedures, a composition table for the common NACE activities has been compiled specifically for the purpose of CINDERELA.

A waste composition table for the common NACE activities has been created for the CINDERELA project.

[12] http://www.bibtex.org/

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2.2.8. Step 8: Flows and stocks

The assessment of flows and stocks is the ultimate objective of the AS-MFA framework as they demonstrate i) how the materials are flowing from one actor to another and ii) where materials accumulate, i.e. where they stay for longer than a year.

The only difference between the Flow and Stock tables is that Stocks do not have destination, which means that materials are kept at the location of the actor of origin. Flows are always moving in a direction from the origin to the destination (Table 11). The amounts are added in tonnes per year (t/year).

Table 11 – Example of the corresponding flow table for the GDSE[13].

Origin*	Destination*	Process	Amount	Composition*	Year	Waste	Source	Description
BvDid or other identifier (must be present in the list of Actors)	Flow-only: BvDid or other identifier (must be present in the list of Actors)	Flow-only: sub-NACE process, Relates to "name" in process table	t/year	Name of the composition, must be present in the list of waste composition		TRUE if it is waste, FALSE if it is product	BibTEX key for the source (must be present in the list of publications)	
LMA00001	LMA00024		900	F-4110 Development of building projects 170101	2016	TRUE	lma2016	--

Composition refers to the unique name of a composition that has been provided in the "Composition table". Multiple flows and stocks can refer to the same composition.

2.2.9. Step 9: Visualization and analysis

Material Flow Analysis works best when translated into images. In the frame of CINDERELA stocks and flows have been graphically represented with support of the GDSE tool.

[13] Both the origin and the destination are actors that must be present in the Actors table. If flows need to involve actors that are not yet present in the actor table, those new actors need to be added first. The origin and the destination columns refer to the unique identifier of an actor that in most cases is the BvDid number taken from the ORBIS database, otherwise it can be an identifier of the administrative area (in case of households) or a unique identifier.
Composition refers to the unique name of a composition that has been provided in the "Composition table". Multiple flows and stocks can refer to the same composition.
Each flow must have a unique combination of Origin-Destination-Composition. If there are two or more flows with the same combination, they must be added up together before entering the system, otherwise one may overwrite the other. Each stock must have a unique combination of Origin-Composition.
The "process" column refers to the treatment process of waste, e.g. recycling, composting, biodegrading, etc.
"Source" column is for "Data Sources" the same as explained in the step 7 for the waste composition.
Flows and stocks should be written in separate files with appropriate naming.

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Depending on the needs, the use of GDSE tool allows to apply different criteria on the visualised waste streams such as:

- Quantity (i.e. the amount of waste produced);
- Quality (i.e. composition and characteristics of specific waste products);
- Treatment (i.e. destination of the waste produced: landfilled, incinerated, recycled);
- Economic; actor-specific; and
- Geo-specific, etc.

The two images below present one example of the outcome of the GDSE tool. A Sankey diagram (Figure 14) illustrates the quantities for 4 specific waste-flows from production to treatment.

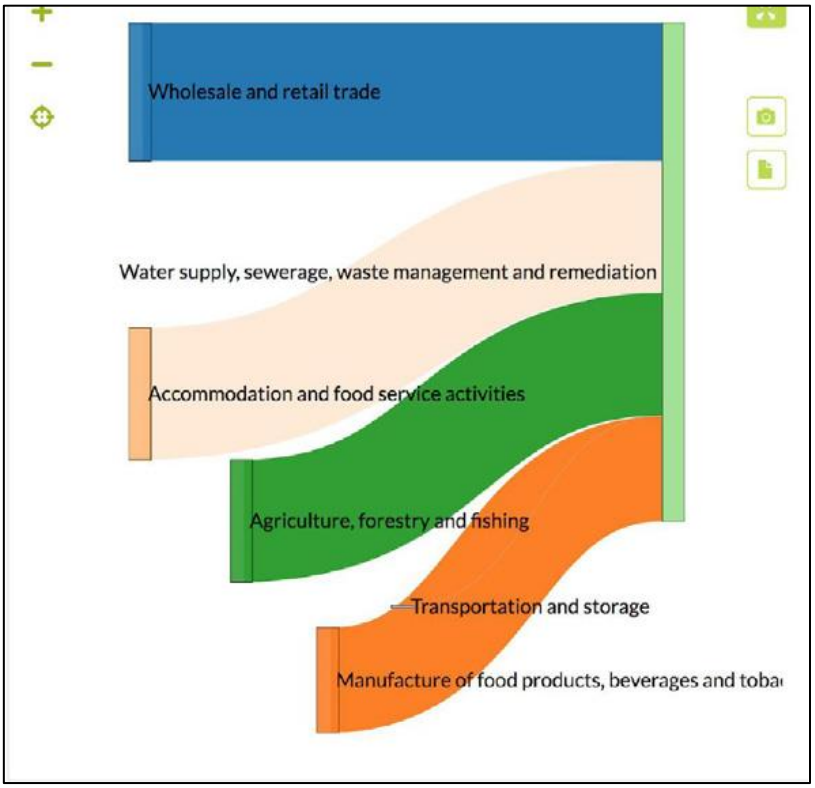

Figure 14 – Example of a Sankey diagram.

An AS-MFA visualization (Figure 15) shows the specific locations and flows of these materials on a map.

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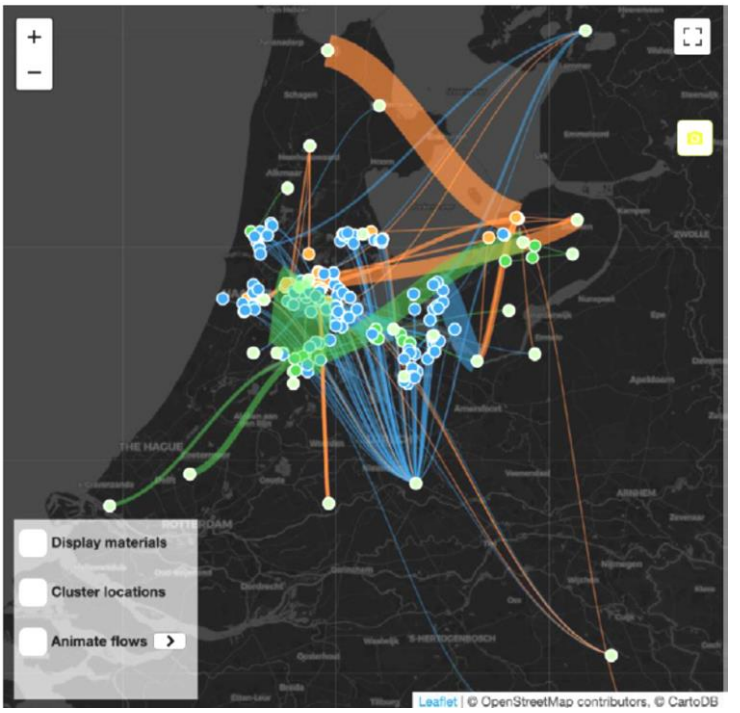

Figure 15 – Example AS-MFA visualization.

2.3. GDSE Tool

The GDSE tool has three differentiated sections:

i) **Bulk upload** - in this section, the prepared data excel sheets are upload: activity group, activities, actor, actor location, materials, wastes, actor to actor flows, actor stocks files;

ii) **Edit actors/Flows** - in this section, where apply the different criteria in the filter setting are applied. This will allow generating Sankey diagrams and the geographic visualization. This section contains several question marks buttons to support the user during the process. Once the filter settings are defined, the outcomes can visualize. The Sankey diagram section has some buttons to export the diagram as image or the data as csv file, and the Sankey map, has different configuration options to display the result (show stocks, show actors, show flows, display materials , cluster locations, animate flows options);

iii) **Edit Materials** - this is where extra details/materials can be added manually to the project.

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3. AMSTERDAM (THE NETHERLANDS) CASE STUDY

3.1. Introduction to the case study

The Amsterdam Metropolitan Area (Metropoolregio Amsterdam) is located in the Netherlands, spans the boundaries of two provinces (North-Holland and Flevoland) and encompasses the city of Amsterdam as well as 32 municipalities (Metropoolregio Amsterdam, 2017). For this deliverable, the 2016 statistics are used which show that, in the AMA, there are 33 Municipalities with 339 neighbourhoods containing 2,410,330 inhabitants, covering an area of 2580 km^2. The region is responsible for a range of policies including economic development, transport, and aspects of spatial planning related to urbanisation, landscape management, and sustainability[14]. Besides the former port areas, its airport is a crucial part of the AMA. Amsterdam Airport Schiphol is located 9 kilometres southwest of Amsterdam in the municipality of Haarlemmermeer and is the third busiest airport in Europe by passenger numbers[15].

The Amsterdam case is embedded in the Dutch national ambitions to transition towards a Circular Economy, which were formulated in the policy report 'Nederland Circulair in 2050' that states the necessity to strive for a transition towards a circular economy for three reasons: substantial growth in resource use, dependency of the Netherlands on other countries for resource supply and the relation to climate change in the form of CO_2 emissions. Next to facing these problems, the national government saw many benefits in transitioning to a circular economy, such as economic opportunities[16].

The municipality of Amsterdam has high ambitions for this subject and wants to be one of the leading transition cities. Amsterdam's CE ambitions already began in 2009 with the initiation of circular Buiksloterham[17] an urban regeneration project testing and implementing CE principles. Within this new housing development, circular concepts were used to develop a zero-waste neighbourhood. Afterwards, Amsterdam adopted circular economy within their 'sustainability agenda' and promoted the concept of CE as one of the biggest opportunities to facilitate sustainable growth in the future[18]. After including the transition within their sustainability agenda, a roadmap towards CE, 'Amsterdam Circular' was presented in 2015.

[14] Metropoolregio Amsterdam, 2017.
[15] www.aci.aero. Geldermans et al., 2018. Geldermans, B., Bellstedt, C., Formato, E., Varju, V., Grunhut, Z., Cerreta, M., Amenta, L., Inglese, P., Leer, J. van der, Wandl, A., (2017) Introduction to methodology for integrated spatial, material flow and social analyses, Resource Management in Peri-urban Areas (REPAiR), Horizon2020, European Commission
[16] Rijksoverheid, 2016.
[17] Metabolic, 2014,
[18] Gemeente Amsterdam, 2015

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3.2. Application of the methodology to the case study

3.2.1. Step 1: Collecting data

The waste-data was received through a data processing agreement with the LMA (Landelijk Meldpunt Afvalstoffen), the Dutch governmental agency responsible for reporting all interior transport movements of waste in the Netherlands. LMA is part of the Dutch Ministry of Water and Infrastructure (Rijkswaterstaat) and makes the reported data available to governments for law enforcement, policy and licensing.

Through a concurrent Research and Innovation Action H2020-project REPAiR (REsource Management in Peri-urban Areas: Going Beyond Urban Metabolism, Grant Agreement ID: 688920), coordinated by the Delft University of Technology, an existing data processing agreement with the LMA was amended to receive the required datasets for the usage within the CINDERELA project.

3.2.2. Step 2: Selection CINDERELA waste streams to be studied

This step is common for all the case studies. See the CINDERELA EWC LIST in Table 2.

3.2.3. Step 3: Selection and delimitation of the geographical area

The geographical area is defined by the boundaries of the 33 municipalities in the Amsterdam Metropolitan Area, as outlined in the introduction of this case-study. Figure 16 illustrates region to which 33 municipalities - the COROP (grouping of municipalities for statistical purposes) (Figure 17) - belong to.

Figure 16 – Amsterdam Metropolitan Area.

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Municipality	COROP	Province
Aalsmeer	Groot-Amsterdam	Noord-Holland
Almere	Flevoland	Flevoland
Amstelveen	Groot-Amsterdam	Noord-Holland
Amsterdam	Groot-Amsterdam	Noord-Holland
Beemster	Groot-Amsterdam	Noord-Holland
Beverwijk	Ijmond	Noord-Holland
Blaricum	Gooi en Vechtstreek	Noord-Holland
Bloemendaal	Agglomeratie Haarlem	Noord-Holland
Diemen	Groot-Amsterdam	Noord-Holland
Edam-Volendam	Groot-Amsterdam	Noord-Holland
Gooise Meren	Gooi en Vechtstreek	Noord-Holland
Haarlem	Agglomeratie Haarlem	Noord-Holland
Haarlemmerliede en Spaarnwoude	Agglomeratie Haarlem	Noord-Holland
Haarlemmermeer	Groot-Amsterdam	Noord-Holland
Heemskerk	Ijmond	Noord-Holland
Heemstede	Agglomeratie Haarlem	Noord-Holland
Hilversum	Gooi en Vechtstreek	Noord-Holland
Huizen	Gooi en Vechtstreek	Noord-Holland
Landsmeer	Groot-Amsterdam	Noord-Holland
Laren (NH.)	Gooi en Vechtstreek	Noord-Holland
Lelystad	Flevoland	Flevoland
Oostzaan	Groot-Amsterdam	Noord-Holland
Ouder-Amstel	Groot-Amsterdam	Noord-Holland
Purmerend	Groot-Amsterdam	Noord-Holland
Uitgeest	Ijmond	Noord-Holland
Uithoorn	Groot-Amsterdam	Noord-Holland
Velsen	Ijmond	Noord-Holland
Waterland	Groot-Amsterdam	Noord-Holland
Weesp	Gooi en Vechtstreek	Noord-Holland
Wijdemeren	Gooi en Vechtstreek	Noord-Holland
Wormerland	Zaanstreek	Noord-Holland
Zaanstad	Zaanstreek	Noord-Holland
Zandvoort	Agglomeratie Haarlem	Noord-Holland

Figure 17 – Municipalities of the Amsterdam case study.

3.2.4. Step 4: Activity Group and Activities

Based on the identified EWC-codes for the CINDERELA-project, a CINDERELA NACE list was developed accordingly (see chapter 2.2 Methodology in this deliverable). NACE-codes (Nomenclature des Activités Economiques dans la Communauté Européenne) is an industry standard classification system that describes the economic activities in the European Union. As described in Chapter 2.2.1.1 above, the relationship table between EWC- and NACE-codes (see Table 4) allowed a query in the ORBIS-database. This company database allows targeting which specific companies in the Amsterdam Metropolitan Area are embedded within a specific type of economic activities (NACE-codes), responsible for the generation of determined wastes (EWC-codes) that are being researched in this project.

Table of the Annex 1 describes which economic activities were being recognized in the AMA through the ORBIS-query. A rapid analysis of the identified activities according to their activity groups (see Figure 18 below), reveals that Activity Group 'F Construction' is responsible for the majority of the production of the identified waste-types in the project.

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Activity group	Count
A AGRICULTURE, FORESTRY AND FISHING	76
B MINING AND QUARRYING	6
C MANUFACTURING	340
D ELECTRICITY, GAS, STEAM AND AIR CONDIT	22
E WATER SUPPLY; SEWERAGE, WASTE MANA	490
F CONSTRUCTION	1412
G WHOLESALE AND RETAIL TRADE; REPAIR O	515
H TRANSPORTATION AND STORAGE	214
I ACCOMMODATION AND FOOD SERVICE ACT	44
J INFORMATION AND COMMUNICATION	34
K FINANCIAL AND INSURANCE ACTIVITIES	261
L REAL ESTATE ACTIVITIES	143
M PROFESSIONAL, SCIENTIFIC AND TECHNICA	224
N ADMINISTRATIVE AND SUPPORT SERVICE A	359
O PUBLIC ADMINISTRATION AND DEFENCE; C	390
P EDUCATION	13
Q HUMAN HEALTH AND SOCIAL WORK ACTIV	83
R ARTS, ENTERTAINMENT AND RECREATION	54
S OTHER SERVICE ACTIVITIES	49
Unknown	2840

Figure 18 – Activity group in the Amsterdam case study.

3.2.5. Step 5: Actors

The LMA dataset identifies seven figures/stages in every waste-flow: a disposer (ontdoener); a sender (afzender); a collector (inzamelaar); a broker (bemiddelaar); a trader (handelaar), a receiver (ontvanger) and finally a processor (verwerker). Not every flow contains all of the seven stages, but coupling the queried NACE-codes and economic activities from the ORBIS-database with the LMA database, allowed for a more specified and detailed knowledge about the types of economic activities every actor is involved in. In total 31906 unique actors were recognized in the LMA-dataset.

3.2.6. Step 6: Detail description of the materials

Unique for the AMA-case within the CINDERELA-project, is the additional description that is provided in the LMA dataset attached to the official EWC-code for every waste flow. This additional description provides a more detailed and specified characterization of the type of waste. For instance: EWC-code 170101 for concrete is adjoined by the extra description ‘mineral concrete contaminated debris. This allows a much more specified and detailed materials and waste composition hierarchy, as depicted in the Figure 19.

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Level I	Level II	Level III	Level IV	Level V		
concrete, bricks, tiles and ceramics						
	concrete					
		concrete debris				
			mixed concrete debris			
			clean concrete debris			
			reinforced concrete debris			
		concrete sludge				
			contaminted concrete sludge spoil			
		rinsed concrete				
		mineral concrete				
			mineral concrete debris contaminated			
		concrete slabs and beams				
			concrete beams			
			concrete slabs			
		concrete masonry and bricks				
			concrete masonry and bricks debry			
		concrete foundations				
		aerated concrete				
		cellular concrete				
		expanded polysterene concrete				
		repec concrete				
		concrete railroad crossing slabs				
	stones					
		talc stones				
		masonry debris				
		stone debris				
			mixed stone debris			
			clean stone debris			
		contaminated stones				

Figure 19 – Example of the material table for the Amsterdam case study.

3.2.7. Step 7: Waste composition

We kept and uploaded the original set provided by the consortium as described chapter 2.2.7.

3.2.8. Step 8: Flows and stocks

An overview of all the EWC-codes and their respective quantities are listed below in Table 12.

Table 12 – Overview of all the EWC and their quantities.

Row Labels	Sum of weight [kg]	% of total	
(blank)	14745349339		
17 05 04	2825243914	19%	19%
17 05 06	2348705693	16%	35%
17 01 07	1987483958	13%	49%
17 03 02	1464702671	10%	59%
17 01 01	1367733628	9%	68%
19 08 05	1233075835	8%	76%
17 09 04	1073096205	7%	83%
19 12 12	600961670	4%	87%
19 01 12	411163814	3%	90%
17 02 01	290784089	2%	92%
20 03 03	153436562	1%	93%
17 05 08	149639515	1%	94%

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Row Labels	Sum of weight [kg]	% of total	
20 01 02	141614221	1%	95%
19 12 09	109221409	1%	96%
20 01 39	83238658	1%	97%
02 03 04	73109120	0%	97%
19 06 06	57966360	0%	97%
20 03 06	55993976	0%	98%
02 01 03	55734849	0%	98%
10 01 01	43872090	0%	99%
20 01 38	32168918	0%	99%
17 08 02	21968846	0%	99%
19 08 01	17122240	0%	99%
19 08 02	13759420	0%	99%
15 01 02	13698306	0%	99%
19 12 04	13432979	0%	99%
17 01 02	12960436	0%	99%
12 01 01	12657287	0%	99%
16 10 04	10872696	0%	100%
10 01 17	9282579	0%	100%
20 01 11	8631606	0%	100%
10 09 08	8422080	0%	100%
20 02 02	7961279	0%	100%
10 01 02	6802381	0%	100%
17 02 02	5370853	0%	100%
03 03 10	3987740	0%	100%
20 02 03	2963730	0%	100%
12 01 17	2637499	0%	100%
17 02 03	2442504	0%	100%
10 01 15	1664873	0%	100%
19 05 03	1361920	0%	100%
15 01 09	1321450	0%	100%
17 06 04	1250560	0%	100%
19 05 02	924640	0%	100%
07 06 99	785692	0%	100%
19 12 05	684680	0%	100%
12 01 03	656385	0%	100%
01 04 13	378460	0%	100%
01 04 10	352680	0%	100%
10 02 01	343820	0%	100%
01 03 08	324440	0%	100%
01 05 04	301860	0%	100%
19 08 14	245120	0%	100%
10 01 03	204840	0%	100%
10 01 26	186640	0%	100%
17 01 03	153707	0%	100%
19 12 08	118340	0%	100%
01 04 09	56220	0%	100%
15 01 07	35527	0%	100%
15 01 05	30040	0%	100%
10 09 12	15620	0%	100%
01 01 02	15040	0%	100%
10 02 02	8700	0%	100%
10 11 12	3980	0%	100%

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Row Labels	Sum of weight [kg]	% of total	
10 10 03	1789	0%	100%
20 01 10	700	0%	100%
Grand Total	29490698678	1	

3.2.9. Step 9: Visualization and analysis

An overview of all the 15589 waste flows for the identified EWC-codes in the Amsterdam Metropolitan Area are being visualized both on a Sankey diagram below (Figure 20) and geographically (Figure 21), illustrating the amounts and types of wastes between the different activity groups.

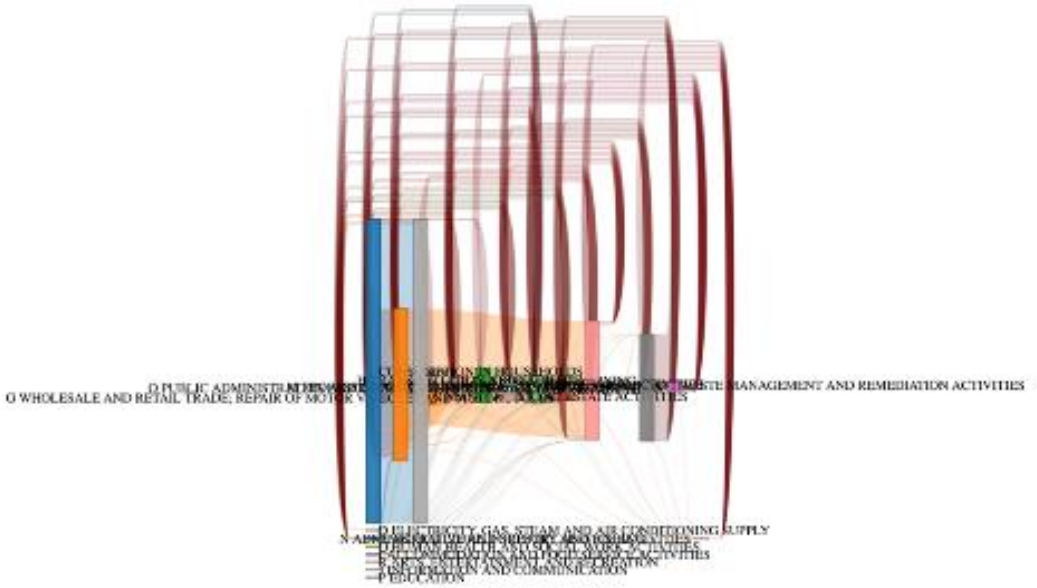

Figure 20 – Sankey diagram of the Amsterdam case study.

Figure 21 – Flows visualization of the Amsterdam case study.

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Figure 22 to Figure 24 illustrate the Sankey diagrams and flow maps for the 3 largest (in quantity) waste types in the Amsterdam Metropolitan Area: (i) soil, including excavated soil, (EWC-code 17 05); (ii) concrete, bricks, tiles and ceramics (EWC-code 17 01); and (iii) bituminous mixtures, coal tar and tarred products (17 03).

Soil, including excavated soil (EWC-code 17 05)

Both, the Sankey diagram as the flow map (Figure 22) show a multitude of activity groups (AG) dealing with soil, including excavated soil. The largest AG however is O 'Public administration and defence; compulsory social security' generating 12,681,772 tonnes per year of soil, including excavated soil, of which 88.85% is dredging spoil and 11.15% are soil and stones. The second largest producer of EWC-code 17 05 is the consumption in households: 15,260,690 tonnes of soil per year have been generated in the year 2016.

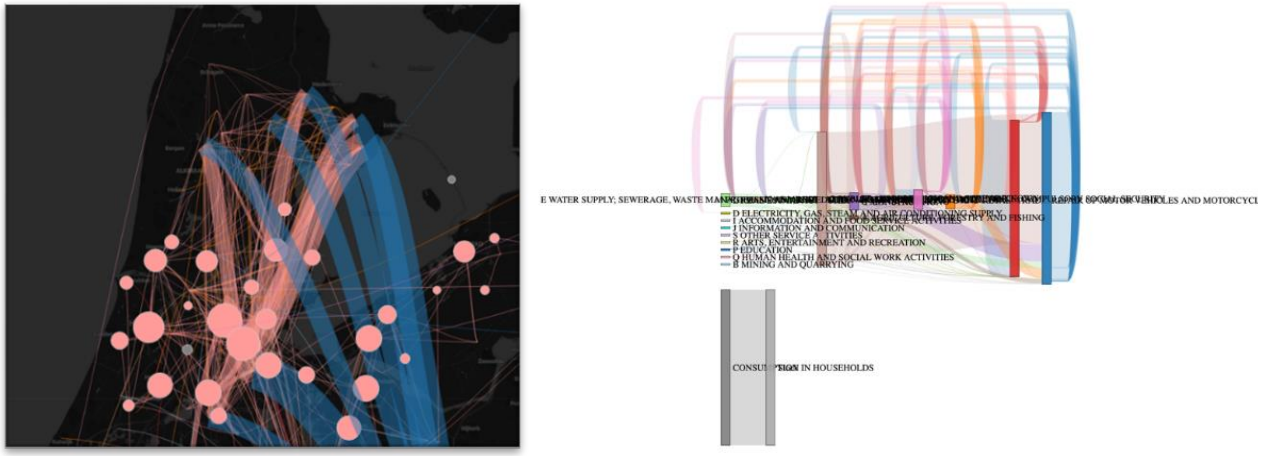

Figure 22 – Visualization for the 17 05: soil (including excavated soil…) waste stream in the GDSE.

Concrete, bricks, tiles and ceramics (EWC-code 17 01)

Both, the map as the Sankey diagram (Figure 23) show large accumulations of stocks of concrete, bricks, tiles and ceramics: in total 15,835,837 tonnes of which 91.443% stones and 8.557% tiles and ceramics. These stocks are predominantly divided over municipalities, as the grey dots in the map illustrate. Furthermore, at least 4 large flows (both in terms of quantity transported as in terms of distance) can be recognized, spanning a large area of the Netherlands.

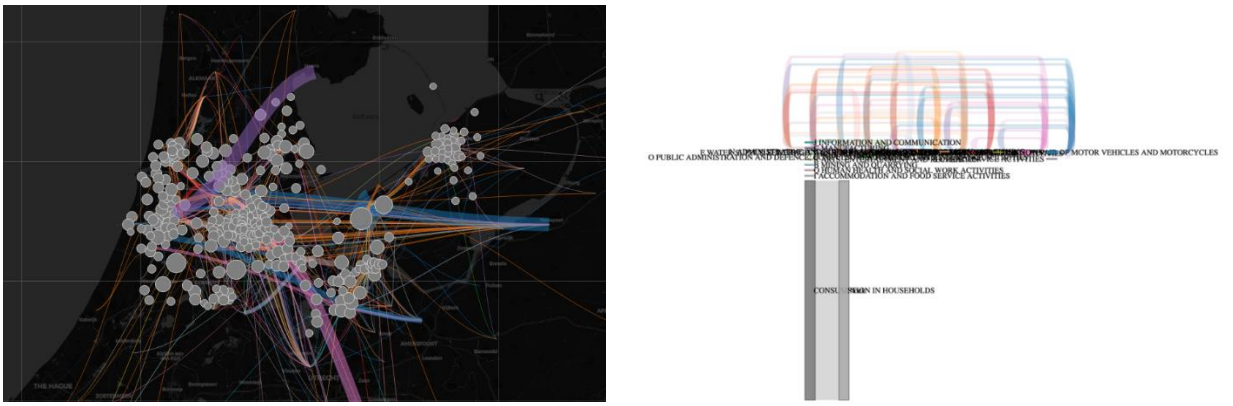

Figure 23 – Visualization for the 17 01: concrete, bricks, tiles and ceramics waste stream in the GDSE.

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Bituminous mixtures, coal tar and tarred products (17 03)

A remarkable smaller amount of stocks of bituminous mixtures, coal tar and tarred products can be found for EWC-group 17 03 (Figure 24). AG O 'Public administration and defence; compulsory social security' is the largest producer of this type of waste, generating 547,408 tonnes a year, of which 75.015% are bituminous mixtures containing coal tar and 24.983% are other bituminous mixtures for AG E 'Water supply and sewerage, waste management and remediation activities'.

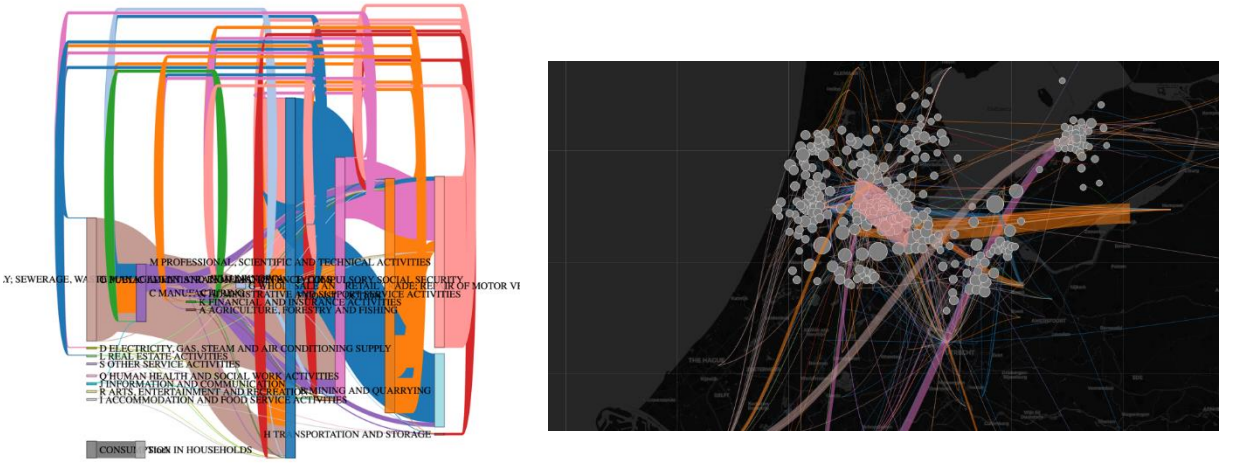

Figure 24 – Visualization for the 17 03: bituminous mixtures, coal tar and tarred products waste stream.

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4. BASQUE COUNTRY (SPAIN) CASE STUDY

4.1. Introduction to the case study.

The Basque Country (Figure 25) is in the north of Spain. This region shares its borders with Cantabria and the province of Burgos in the west; the Cantabrian Sea in the north; France and Navarra in the east; and La Rioja (the Ebro River) in the south. It is made up of three provinces: Araba, Gipuzkoa and Bizkaia, bringing together 251 municipalities. It has an area of 7,230 km^2 and registered 2,167,323 inhabitants in 2017, with quite a high population density of around 300 people/ km^2. The Basque Country is currently one of the wealthiest regions in Spain (Eurostat, 2018).

Figure 25 – Map and general information about Basque Country.

The Basque Country is one of the most important industrial concentrations in Spain. The regional gross domestic product (GDP) in 2016 was at €68,817 m, which is the highest in recent years. The available Eurostat figures (2018) show, in 2016, a GDP per capita in purchasing power standards (PPS) of 35,300, value which is far above the national (26,700) and EU28 (29,200) average (Eurostat, 2018). The services sector generates 63% of the GDP in market prices, while the industry sector generates 29.9% (of which manufacturing industries represent 26.3%), construction 5.9% and agriculture and fisheries 0.8%.

The Basque Country's economy has been strongly manufacturing-based since the beginning of the 20th century. In 2016, manufacturing accounts for 46.7% of industrial gross value added (GVA) and 25.4% of total GDP. However, the 2008 economic crisis has had a significant negative impact on the region's manufacturing activities.

The Industrial production is diverse. All of the activities from metals, such as the production of steel and machine-tools, are very important. However, other sectors such as the chemical and petrochemical industry and refineries are also noteworthy, accounting for a very significant part of the region's GDP. The strongest industrial sectors of the Basque economy are machinery, aeronautics and energy. New technologies and research and development (R&D) initiatives are becoming very relevant, and the same applies to technology parks. Basque companies manufacture a wide variety of capital goods, durable goods and other intermediate products.

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Currently, the waste management framework is defined by the Waste Prevention and Management Plan 2020, which establishes the following strategic objectives:

1. Reduce by 10% of the total amount of waste generated by 2020 (comparing with the generated in 2010), as well as its hazardousness;
2. Increase to at least up to 75% the collection and the selective separation of wastes by 2020 and establish collection systems for some main waste streams;
3. Increase to 60% the preparation of waste for reuse, recycling and recovery by 2020, solving the main problems of the Basque Country;
4. Optimize waste disposal, avoiding the dumping of primary waste, developing instruments for its minimization, applying the principles of proximity and self-sufficiency in the recovery and elimination of waste, minimizing the impact of existing landfills;
5. Improve the information and transparency in waste publications; simplify administrative procedures in waste management following new waste regulations and promote the green market and job creation through the development and implementation of the Plan.

Regarding urban waste (domestic and commercial), non-hazardous waste and hazardous waste, 4.83 million tonnes of waste are generated annually in the Autonomous Community of the Basque Country, 1.94 million, 40.2%, are disposed in landfills. According to the waste hierarchy, landfilling is the least suitable option for waste management. Achieving a reduction in the total generation of waste will achieve a decrease in the number of tonnes of waste disposed in landfills.

Of the total value of waste generated in the Basque Country (excluding construction and demolition waste), 3.45 million tonnes, or 71.54%, are generated in the industrial sector (Table 13). Hence, the challenge of reducing the generation of waste is particularly important in this sector. Together with the industrial sector, another intensive sector in the generation of waste is the construction sector, with 1.26 million tonnes generated in 2016, of which 12.32% were landfilled[19].

Table 13 – Waste information in the Basque country.

Waste	Total (t)	Industrial Sector (t)
Waste generated	4,827,326	3,453,621
Recycled waste	2,480,389	1,818,817
Waste for energy recovered	407,246	163,679
Waste landfilled	1,939,691	1,471,125

[19] "Economía circular en la industria del País Vasco - Diagnóstico", Departamento de Medio Ambiente, Gobierno Vasco, 2018

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4.2. Application of the methodology to the case study

4.2.1. Step 1: Collecting data

The project team has first identified available studies and stakeholders involved in the waste management and related topics in the Basque country. The information sources for data on waste streams generated in 2016 in all different activities have been the following:

- Basque Government – Environmental department. The Environmental department of the Basque government published several data on their website[20], e.g.:
    - Statistics of the non-hazardous waste generated by industrial activities;
    - Statistics of Municipal wastes (household waste and commercial); and
    - Inventory of the construction and demolition wastes. (several reports);
- Public information of each of the three Basque provinces, Bizkaia´s observatory[21], Alava´s Observatory[22], and the Gipuzkoa´s Observatory[23];
- 2016 EPER - Basque Register of emissions and polluting hotspots (EPER Euskadi / E-PRTR[24]);
- Open data Euskadi[25]. Data from the Basque Government, dependent entities and other regional and municipal administrations of Basque Country can be found here;
- Consultation of stakeholders -relevant stakeholders involved in the Waste management in the Basque country have been consulted.

According to Article 15 of the IPPC Directive, the European Commission must publish every three years an inventory of the main emissions and responsible sources. To comply with this objective, the European inventory EPER (European Pollutant Emission Register) was adopted through the Commission Decision of 17 July 2000 on the implementation of a European inventory of polluting emissions. The register collects data on discharges into waters and emissions to the atmosphere.

The European Pollutant Release and Transfer Register (E-PRTR) is the Europe-wide register that provides easily accessible key environmental data from industrial facilities in European Union Member States and in Iceland, Liechtenstein, Norway, Serbia and Switzerland. In 2007, It replaced and improved upon the previous European Pollutant Emission Register (EPER)[26]. This new one extends the obligations of the EPER register in aspects as the type of facilities, emissions to the ground, wastes streams, emissions from diffuse sources, etc.

[20] http://www.euskadi.eus/informacion/inventarios-estadisticas//web01-a2inghon/es/
[21] http://www.bizkaia.eus/home2/Temas/DetalleTema.asp?Tem_Codigo=7709&idioma=CA
[22] https://www.araba.eus/cs/Satellite?c=Page&cid=1224001265949&language=es_ES&pagename=DiputacionAlava%2FPage%2FDPA_contenidoFinal
[23] https://www.gipuzkoa.eus/es/web/ingurumena/residuos-urbanos/observatorio/datos-gestion
[24] http://www.euskadi.eus/registro-vasco-de-emisiones-y-fuentes-contaminantes-del-2016-eper-euskadi-e-prtr/web01-a2ingkut/es/
[25] http://opendata.euskadi.eus/inicio/
[26] https://prtr.eea.europa.eu/#/home

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After data have been collected from different sources, they were aggregated in a unique excel file. Following the Bulk data upload Procedure in GDSE (step 2 to step 8). All the information has been processed and organized in individual excel files. After this step, the different xls formats were uploaded into the GDSE tool.

4.2.2. Step 2: Selection CINDERELA waste streams to be studied

AS well as in the other 5 CINDERELA case studies, inputs to the proposed waste list according to the EWC were provided. The final CINDERELA EWC LIST is shown in Table 2 (see section 2.2.2 above). From the full CINDERELA EWC list, only 65 waste streams were met in the Basque region, reaching a total amount of 3,452,490 tonnes of waste. The Table 14 shows the main streams at the 1-digit EWC level for the year 2016

Table 14 – Quantities of waste generated in Basque country by EWC.

EWC	EWC_name_1	Quantity [tonnes]
1	WASTES RESULTING FROM EXPLORATION, MINING, QUARRYING, AND PHYSICAL AND CHEMICAL TREATMENT OF MINERALS	1,641
3	WASTES FROM WOOD PROCESSING AND THE PRODUCTION OF PANELS AND FURNITURE, PULP, PAPER AND CARDBOARD	174,187
10	WASTES FROM THERMAL PROCESSES	867,998
12	WASTES FROM SHAPING AND PHYSICAL AND MECHANICAL SURFACE TREATMENT OF METALS AND PLASTICS	715,222
15	WASTE PACKAGING; ABSORBENTS, WIPING CLOTHS, FILTER MATERIALS AND PROTECTIVE CLOTHING NOT OTHERWISE SPECIFIED	37,744
16	WASTES NOT OTHERWISE SPECIFIED IN THE LIST	42,050
17	CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)	1,029,433
19	WASTES FROM WASTE MANAGEMENT FACILITIES, OFF-SITE WASTE WATER TREATMENT PLANTS AND THE PREPARATION OF WATER INTENDED FOR HUMAN CONSUMPTION AND WATER FOR INDUSTRIAL USE	360,015
20	MUNICIPAL WASTES (HOUSEHOLD WASTE AND SIMILAR COMMERCIAL, INDUSTRIAL AND INSTITUTIONAL WASTES) INCLUDING SEPARATELY COLLECTED FRACTIONS	224,200
Total		3,452,490

4.2.3. Step 3: Selection and delimitation of the geographical area

As described in chapter 2.2.3, the third step is the definition of the study area. In this case, the area of study is the Basque country, which counts 3 provinces, 17 regions and 251 municipalities. Table 15 shows the levels of the Basque case study to be introduced into the GDSE tool based on geometric data (WGS84 EPSG: 4326).

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Table 15 – Area of the Basque case study.

1	World		
2	Continent	Europe	
3	Country	Spain	
4	NUTS2	Basque country	
5	NUTS3	provinces	3 provinces
6	Region	Region/County	17 regions
7	Municipality	Municipality (LAU NAME)	251 municipalities

The Figure 26 represents the Basque map with the different levels of the case study.

Figure 26 – Basque Country case study area.

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4.2.4. Step 4: Activity Group and Activities

Here, four new codes have been added to the twelve common activity groups (Table 16).

Table 16 – Activity group added in the Basque case study.

Code	Description	
U	Regions, municipalities etc.	X
V	Authorized waste processors	X
W	Authorized landfilled and other municipal waste installations	X
Z	Other	X

Following to the activity groups, the next new activities have been defined for the Basque country case study (Table 17).

Table 17 – New activities added in the Basque case study.

NACE	Name	AG
U-0000	U-0000 Regional or municipal activities	U
V-0001	V-0001 Authorized waste processor activities	V
W-0002	W-0002 municipal waste installation activities	W
Z-0003	Z-0003 Other activities	Z

4.2.5. Step 5: Actors

The List of actors is based on the Orbis query done with the NACE codes defined in Annex 1. The results show 28,301 companies in the study area, of which only 25,331 are active. The split across provinces is as following:

- 4,852 companies in Alava;
- 8,344 in Gipuzkoa;
- 12,135 in Bizkaia.

368 companies have more than 50 employees, 63% of all companies belong to the construction sector. In addition to the above-mentioned actors, 234 accredited waste treatment facilities[27], 35 authorized waste disposal facilities and 271 regions, provinces and municipalities were added.

4.2.6. Step 6: Detail description of the materials part of the waste

Following the instructions of Chapter 2.2.6, excel file with material information until level IV and the waste material until level II were uploaded.

[27]http://www.euskadi.eus/contenidos/informacion/registro_residuos/es_def/adjuntos/gestores_rnp_cer_es.pdf

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4.2.7. Step 7: Waste Composition

Although the purpose of this step is to describe in more details (i.e. beyond EWC code description) the composition of the waste material (i.e. detailed composition of single flows), this could not be achieved in the case of the Basque Country due to the lack of such information in the datasets at hand. As a consequence, the information introduced into the IT platform to generate AS-MFA is corresponding to the level of EWC material description. This situation suggests that further steps of material characterization to determine the composition of the flows and their eventual fit for specific revalorization in the construction sector would be required. Despite this fact, we estimate that qualitative information on the composition of the flows, knowledge of the sector at local level by experts may help to either discard or select a flow for its further consideration as Secondary Raw Material in the construction sector. Hence, we estimate that the absence of detailed information on waste composition at this stage of the procedure towards building circular economy business models does not represent a barrier for its completion but indicates that more resources will be need in further steps to gain information on this aspect.

4.2.8. Step 8: Flows and stocks

The background for developing the new Circular Economy Business Models for the construction sector consists in getting an "as accurate as possible" knowledge of the waste streams in urban and peri urban areas. In the case of the Basque Country the focus was put on 2 main waste streams and its corresponding data/information:

- Industrial waste;
- Municipal waste.

Industrial waste information

Regarding this waste stream, information on companies and producers of waste is needed. This information is delivered by companies to the environmental agency through the electronic IKS-eeM Euskadi[28]. The information provided contains details on the quantities of the waste streams, transport, type of treatment and the final waste processor.

In the electronic IKSeeM Euskadi, companies identify their activity with the same NACE codes as done in the in CINDERELA GDSE TOOL

IKS-eeM contains all needed information as recommended for the AS-MFA analysis, however, its access is not open to public. Hence, this information could not be made available by the Basque Government for our test area by the moment. As an alternative, aggregated data of industrial waste in the three provinces could be gathered (Table 18).

[28] http://www.euskadi.eus/web01-a2inguru/es/contenidos/informacion/ikseem/es_ikseem/index.shtml

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Table 18 – Aggregated data of the industrial waste in the three provinces.

EWC	Description	Total	Álava	Bizkaia	Gipuzkoa
12 01 01	Ferrous metal filings and turnings	**621,313**	75,543	188,875	356,895
10 02 02	Unprocessed slag	**517,099**	69,664	272,207	175,228
17 01 01	Concrete	**317,560**	60,011	143,653	113,896
17 01 03	Tiles and ceramics	**237,108**	44,808	107,259	85,041
19 12 12	Other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	**217,639**	135,092	41,748	40,799
17 02 02	Glass (150107, 160120, 191205)	**206,318**	30,194	100,702	75,422
20 01 38	Wood (170201; 200138; 30301; 150103; 191207; 150103; 150103)	**149,148**	19,532	59,074	70,541
17 03 02	Bituminous mixtures	**113,948**	21,534	51,546	40,869
03 03 09	Lime mud waste	**89,701**	0	67,293	22,408
10 09 08	Casting cores and moulds which have undergone pouring other than those mentioned in 10 09 07	**80,846**	13,628	29,789	37,429
10 02 10	Mill scales	**74,320**	12,870	18,556	42,893
17 09 04	Mixed construction and demolition wastes	**63,248**	11,952	28,611	22,685
17 01 02	Bricks	**58,347**	11,026	26,394	20,927
10 09 06	Casting cores and moulds which have not undergone pouring other than those mentioned in 10 09 05	**53,338**	12,288	15,913	25,137
03 03 11	Sludges from on-site effluent treatment other than those mentioned in 03 03 10	**48,643**	0	21,380	27,263
10 09 03	Furnace slag	**48,049**	9,334	23,823	14,891
12 01 03	Non-ferrous metal filings and turnings	**44,262**	3,853	24,299	16,110
19 01 12	Bottom ash and slag other than those mentioned in 19 01 11	**43,865**	0	43,865	0
19 08 05	Sludges from treatment of urban waste water	**41,485**	3,510	26,882	11,092
20 01 11	Textile	**35,821**	4,816	19,950	11,055
12 01 17	Waste blasting material other than those mentioned in 12 01 16	**33,449**	447	22,807	10,195

Even though the information is not as detailed as desired, we estimate that the information at hand already allows stakeholders to gain a first understanding of major waste streams and their origins by sectors. While we estimate that this lack of information is not optimal in early stages of project design for identifying new opportunities of circular value chains at local level, we believe this can be solved in further stages by complementary characterization of waste streams to determine their composition and decide on their suitability for Secondary Raw Materials in the construction sector.

Regarding IPPC companies, the composition of waste streams and their quantities are publicly available data. While information on the applied process to the waste was known i.e. processing through recycling, incineration, landfilling etc., information concerning the exact location of the waste recipients (i.e. name of the recipient company) was missing.

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Within the CINDERELA project scheduled objectives and milestones, this information on destination of flows could unfortunately not be obtained. Because of this situation, the project team has decided to pursue its work and analysis with the information available, i.e. stocks and destination of waste to processes. This information was provided for a total of 114 individual companies. The impact of this situation on the CINDERELA project has been estimated as rather low, given the fact that the case study is not object of further Demonstration project implementation on site.

Information on municipal waste

Regarding this waste streams, municipalities are required to provide the information. This information is delivered to the Provinces' governments and later to the environmental agency at regional level. This information is publicly available. For the purpose of the case study assessment, information on the flows of municipal waste has been gathered from a total of 112 municipalities of the Bizkaia Province.

4.2.9. Step 9: Visualization and analysis.

An overview of all the municipal waste flows in the Bizkaia provinces is given in the next figures both on a Sankey diagram (Figure 27) and geographically (Figure 28 to Figure 30). The information embedded in these diagrams reveals the amounts and types of wastes flowing between the different activity groups.

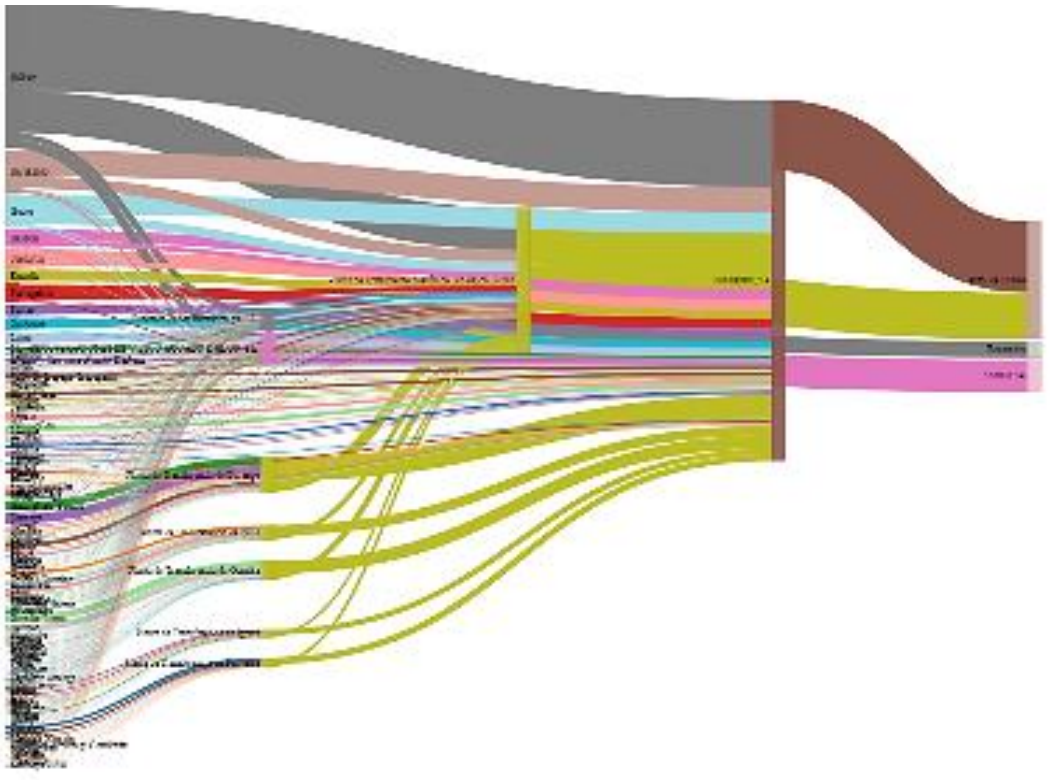

Figure 27 – Sankey Diagram of the Basque Country case study for the municipal waste stream.

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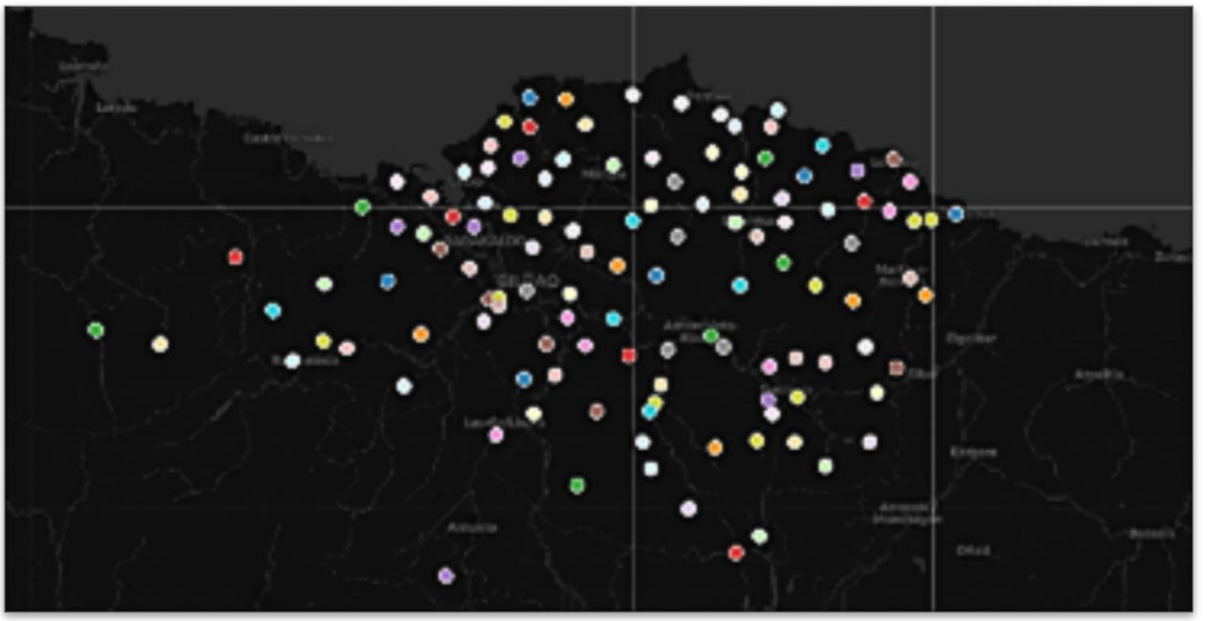

Figure 28 – Visualization of the Basque Country municipalities (actor of the GDSE tool).

The Figure 29 is a screenshot of the visualization of the geographic flows of the municipal waste streams, where each colour represents a different waste stream. On the screen, the IT tool allows the visualization of animated flows. On the screenshot featured in the Figure 29, we can see the purple lines illustrating the flow of unsorted collection waste to the installations of treatment plants located in Artigas, an Eco park where different treatment plants are integrated in the same area (i.e. Zabalgarbi a waste-to energy facility, a landfill and mechanical waste treatment facility to recover some recyclable waste). The red lines are illustrating the glass packaging waste flow that it is transported and treated in a unique place in the province managed by Ecovidrio (Collective System of Extended Producer Responsibility) and its further transfer towards a glass manufacturer company (outside the province).

Figure 29 – Visualization of the Basque country municipal waste flows.

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In Bizkaia, the unsorted collection waste stream goes to the Biological Mechanical Treatment (TMB) plant for the pre-treatment and recovery of materials. Those municipalities far away from the treatment plant deposit their waste first in a transfer plant where the waste is compacted and transferred to the treatment plant in Bilbao. In Bizkaia there are 5 transfer plants and they have a fundamental environmental mission, concentrating the transport of waste. If we select only the unsorted collection waste streams, we can see easily see the five transfer plants in the province on the Figure 30.

Figure 30 – Visualization of the Basque country unsorted collection waste stream.

Since data to visualize flows of industrial waste could not be obtained (see explanation above), the visualization addresses waste stocks. The first representation in Figure 31 represents the Sankey diagram. Figure 32 represents the geographic visualization of the stocks. The visualization allows to display the actors as well as the share of each waste they produce in a pie chartformat.

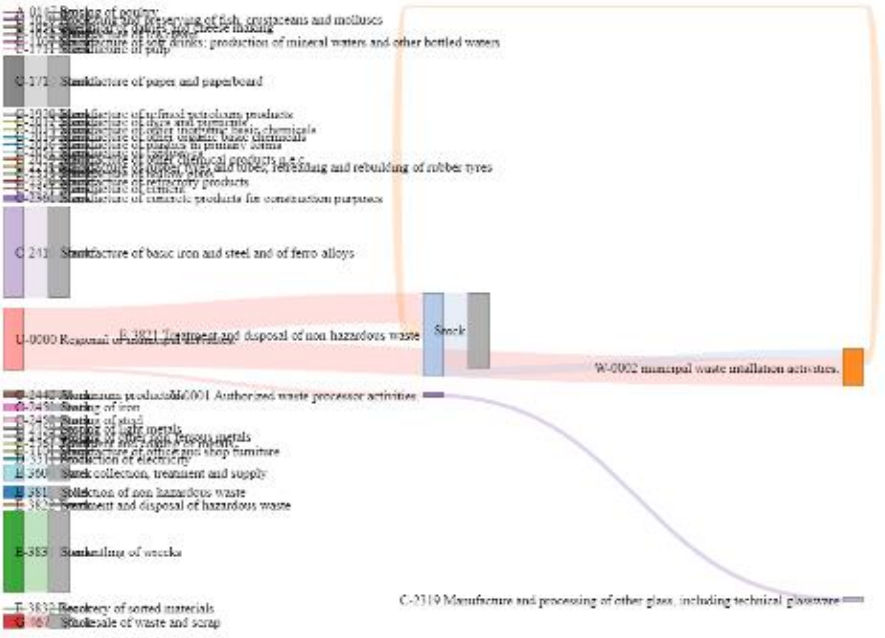

Figure 31 – Visualization of the Basque Country case study.

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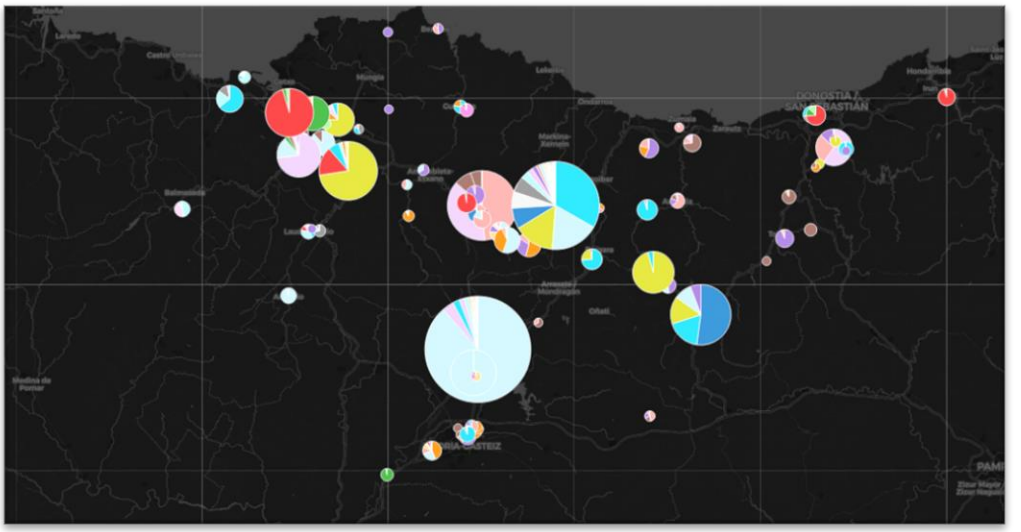

Figure 32 – Visualization of the stocks in the Basque Country case study.

While the ultimate information provided in the visualization is not addressing flows of industrial non IPPC wastes, we estimate that the information gained through the case study assessment represents already a relevant step towards building the basis for designing new circular economy business models at local level and an improvement to the state of the art situation. Indeed, the information on stocks of industrial waste and their location at regional level is already relevant information and allows decision makers to proceed with first screening of opportunities towards new circular business models. In general, these circumstances of lack of information in early stages of decision-making procedures can be compensated in further steps of the procedure by complementary characterization measures and knowledge/expert criteria brought by local stakeholders. Hence, the lack of information at these early stages of decision making shall not represent a barrier to implement the overall CINDERELA methodology towards AS-MFA assessment.

With data obtained from the local government beyond delays planned within CINDERELA's case study, we have decided to generate AS-MFA outcomes for some selected waste streams (i.e. 2 waste streams which represent major quantities generated in the study region, see above) as for illustrating the GDSE tool capacities. For example, in the Figure 33**,** both, the Sankey diagram and the flow map show the actors that generate unprocessed slag (12 02 02). In Figure 33 the 11 actors are represented. Despite the lack of information on the total flows, a screening can be done to obtain information on the opportunities of waste as resource of the slags that are being landfilled.

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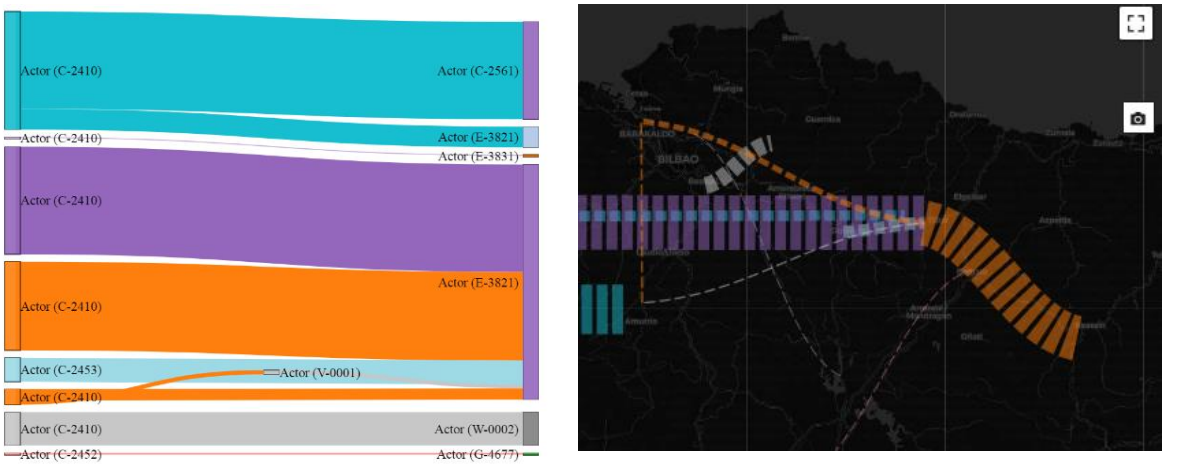

Figure 33 – Visualization for the 10 02 02 waste stream in the GDSE.

In the Figure 34, Sankey diagram and the Sankey flow for the 207 flows of 17 01 01 concrete waste stream are featured. Both diagrams show several activities dealing with concrete waste, in fact 21 flows (flows generated by 21 activities) that end-up in 9 different activities. Among the major producers of these waste streams is the activity F-4211 [Construction of roads and motorways] and the second F4211- [Construction of residential and non-residential buildings].

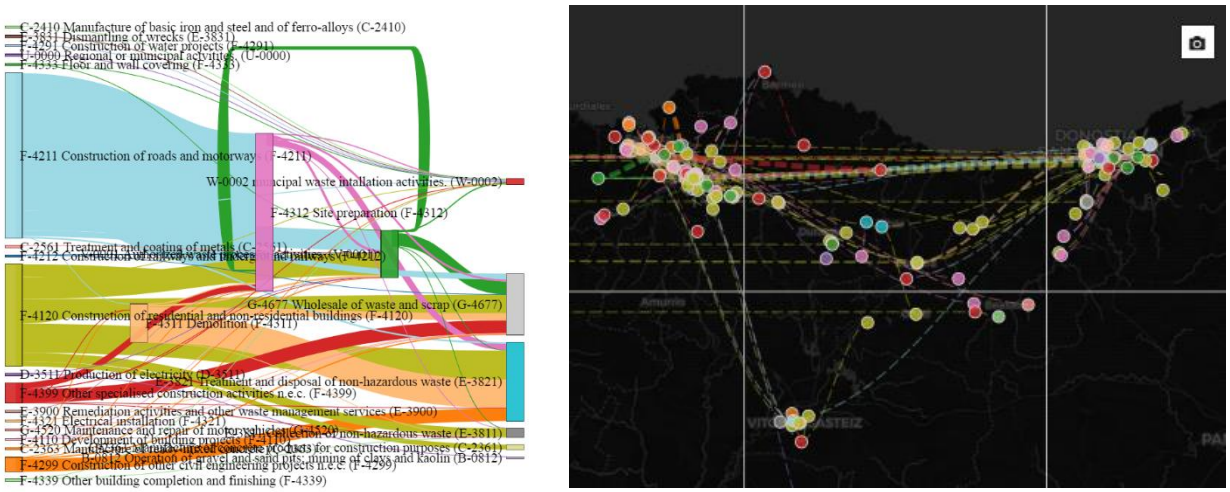

Figure 34 – Visualization for the 17 01 01 concrete waste streams in the GDSE.

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5. KATOWICE (POLAND) CASE STUDY

5.1. Introduction to the case study

The Silesian-Zagłębie Metropolis area is the most industrialized region of Poland. Industrial activities include mainly coal mining, ore and mineral mining, large power plants, metallurgy, foundries, coke production, machine and automotive industry, chemical industry and plastics processing, papermaking, all construction industries and many more. A large population of people creates waste related to living in this area, water supply and sewage disposal. Despite its industrial character, it is also an area of agricultural production, breeding and food processing.

Large amounts of various types of waste are created here (about 30 million Mg/year), including many waste types that that could potentially be used for construction purposes.

5.2. Application of the methodology to the case study

5.2.1. Step 1: Collecting data

Despite previous relations between the local CINDERELA partner IETU and the Provincial Waste System administration, access to the waste data in hands of the Marshal of the Voivodship could not be made available. This situation is due to the fact that formally, the access to waste data is reserved only for local and state administrations. As an alternative, the project team had access to Voivodship reports on waste management which are accessible to the public on their webpage. The format of such reports is in PDF files. In the case of the polish example, this is the most detailed source of information on waste, enabling their connection with producers or recipients. There are also public statistics data, but they are generic and could not be used for the purpose of the project.

Given the format of available information for the purpose of the project, relevant human resources were required to transpose this information into usable format as those supported by GDSE tool for AS-MFA. Crossing the information received with other databases managed by IETU, further information on producers and recipients of waste as required by the methodology could be compiled. This work also required crossing and synchronizing received information with other external databases i.e. - REGON system (single unique identification number and address), the PKWiU database (types of activities) and a public GIS and address database (location of producers / recipients premises).

From the created internal system of the IETU database, information about waste producers and their recipients within the project area were obtained. This was possible through queries generating relevant data tables - about activities, actors, waste / materials presented in further sections 5.1.2 to 5.1.9.

5.2.2. Step 2: Selection CINDERELA waste streams to be studied

For the second step work was carried out jointly with CINDERELA partners. For this, IETU provided expert criteria for amending the list of waste selected from European Waste Codes (EWC) and proposals for its extension. The version of the list adopted in the project is contained in Table 2.

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5.2.3. Step 3: Selection and delimitation of the geographical area

Katowice is the capital of the Silesian-Zagłębie Metropolis. The metropolis consists of 41 municipalities, mainly urban, with a population of over 2.5 million inhabitants. As a project area, we have selected a group of 24 municipalities located around Katowice, in Upper Silesia, with an area of 1650 km^2, in which nearly 1.73 million people live. In this selected project area is generated annually 3.1 million tonnes of waste.

The project area is shown in the Figure 35 (24 municipalities marked with a dark red colour) separated from east by a green border.

No.	Municipality	Area [km^2]	Inhabitants
1	Będzin	37	57 761
2	Bieruń	40	18 575
3	Bobrowniki	52	11 905
4	Bojszowy	35	7 530
5	Bytom	69	170 058
6	Chełm Śląski	23	6 144
7	Chorzów	33	109 541
8	Czeladź	16	32 225
9	Dąbrowa Górnicza	189	122 451
10	Gierałtowice	38	11 834
11	Gliwice	134	182 968
12	Imielin	28	8 888
13	Katowice	165	299 012
14	Knurów	34	38 586
15	Kobiór	46	4 905
16	Lędziny	32	16 807
17	Łaziska Górne	20	22 418
18	Mierzęcice	49	7 532
19	Mikołów	79	40 027
20	Myslowice	66	74 711
21	Ożarowice	46	5 714
22	Piekary Śląskie	40	56 126
23	Pilchowice	70	11 618
24	Psary	48	11 939
25	Pyskowice	31	18 418
26	Radzionków	13	16 965
27	Ruda Śląska	78	139 412
28	Rudziniec	159	10 636
29	Siemianowice Śląskie	25	68 011
30	Sławków	114	12 323
31	Sławków	37	7 092
32	Sosnowiec	91	208 516
33	Sośnicowice	116	8 742
34	Świerklaniec	45	11 888
35	Świętochłowice	13	50 750
36	Tarnowskie Góry	84	61 088
37	Tychy	82	128 416
38	Wojkowice	13	9 078
39	Wyry	35	7 878
40	Zabrze	80	175 887
41	Zbrosławice	148	15 879
	Total:	2 553	2 279 560

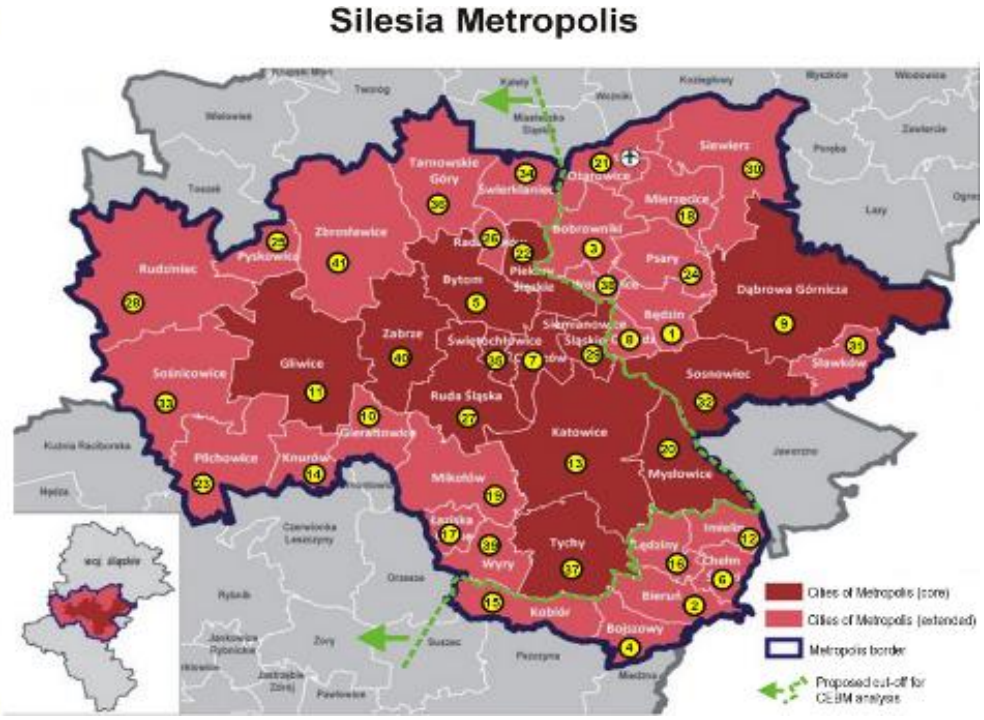

Figure 35 – The Katowice case study area.

Digital data illustrating border polygons and labels with municipal names were entered into the system on the project server according to the format requirements –- geometries provided in WGS84 EPSG:4326.

5.2.4. Step 4: Activity Group and Activities

Using the internal system of IETU databases, we determined the groups of activities and activities of all actors who were located in a selected area of the project and produce or receive waste from the EWC code list adopted in the project.

List of activities is visible in Table 19.

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Table 19 – Activity groups in the Katowice case study.

Code	Name
A	AGRICULTURE, FORESTRY AND FISHING
B	MINING AND QUARRYING
C	MANUFACTURING
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES
F	CONSTRUCTION
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES
H	TRANSPORTATION AND STORAGE
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES
J	INFORMATION AND COMMUNICATION
K	FINANCIAL AND INSURANCE ACTIVITIES
L	REAL ESTATE ACTIVITIES
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES
N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES
O	PUBLIC ADMINISTRATION AND DEFENCE; COMPULSORY SOCIAL SECURITY
P	EDUCATION
Q	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES
R	ARTS, ENTERTAINMENT AND RECREATION
S	OTHER SERVICE ACTIVITIES

In these groups, we identified 237 activities - all of them have been uploaded to the GDSE tool.

5.2.5. Step 5: Actors

Using the internal system of IETU databases, all actors who are located in a selected area of the project and produce or receive waste from the EWC code list adopted in the project were determined.

Within the project area 893 producers and collectors of waste from the CINDERELA EWC list were identified and their locations established. These data have been uploaded to the GDSE tool.

5.2.6. Step 6: Detail description of the materials

Using the internal system of IETU databases, all waste types which are produced in a selected area of the project from the EWC code list adopted in the project were determined (Table 20).

Table 20 – Waste quantities in the Katowice case study.

EWCcode	EWC name	Weight [Mg]
01 01 02	Wastes from mineral non-metalliferous excavation	1,006,522.3
19 12 12	Other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	436,952.2
10 02 01	Wastes from the processing of slag	254,197.4
17 05 04	Soil and stones other than those mentioned in 17 05 03	188,299.6
10 01 24	Sands from fluidised beds	179,361.9
12 01 01	Ferrous metal filings and turnings	176,821.7

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EWCcode	EWC name	Weight [Mg]
19 08 05	Sludges from treatment of urban waste water	137,400.1
10 01 01	Bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)	110,197.2
19 05 03	Off-specification compost	94,378.7
19 12 05	Glass	90,136.0
17 01 01	Concrete	56,773.0
19 12 09	Minerals (for example sand, stones)	50,424.5
17 01 07	Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06	48,219.3
17 01 02	Bricks	48,133.9
16 11 04	Other linings and refractories from metallurgical processes other than those mentioned in 16 11 03	44,586.3
10 01 02	Coal fly ash	33,802.8
15 01 02	Plastic packaging	27,696.1
12 01 02	Ferrous metal dust and particles	20,946.1
10 09 08	Casting cores and moulds which have undergone pouring other than those mentioned in 10 09 07	20,281.5
19 12 04	Plastic and rubber	19,978.8
15 01 07	Glass packaging	15,845.7
10 12 99	Wastes not otherwise specified	15,050.8
17 09 04	Mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	13,166.6
10 02 10	Mill scales	11,362.6
10 02 99	Wastes not otherwise specified	8,792.3
10 02 02	Unprocessed slag	8,316.3
20 03 06	Waste from sewage cleaning	8,256.6
10 02 08	Solid wastes from gas treatment other than those mentioned in 10 02 07	6,604.4
17 03 02	Bituminous mixtures other than those mentioned in 17 03 01	6,363.9
12 01 03	Non-ferrous metal filings and turnings	5,536.2
19 08 02	Waste from desanding	5,259.1
15 01 05	Composite packaging	4,105.5
19 08 01	Screenings	3,402.5
10 12 08	Waste ceramics, bricks, tiles and construction products (after thermal processing)	3,095.5
17 02 01	Wood	2,524.3
20 03 03	Street-cleaning residues	1,910.7
10 01 03	Fly ash from peat and untreated wood	1,891.4
17 05 06	Dredging spoil other than those mentioned in 17 05 05	1,761.4
12 01 04	Non-ferrous metal dust and particles	1,703.2
10 11 99	Wastes not otherwise specified	1,317.6
20 02 02	Soil and stones	1,226.7
19 08 14	Sludges from other treatment of industrial waste water other than those mentioned in 19 08 13	1,074.1

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EWCcode	EWC name	Weight [Mg]
17 06 04	Insulation materials other than those mentioned in 17 06 01 and 17 06 03	1,063.1
10 10 03	Furnace slag	975.3
10 09 12	Other particulates other than those mentioned in 10 09 11	932.2
01 04 08	Waste gravel and crushed rocks other than those mentioned in 01 04 07	803.4
10 02 15	Other sludges and filter cakes	784.7
10 11 12	Waste glass other than those mentioned in 10 11 11	580.3
10 01 05	Calcium-based reaction wastes from flue-gas desulphurization in solid form	536.8
07 06 99	Wastes not otherwise specified	456.8
10 09 03	Furnace slag	421.2
12 01 05	Plastics shavings and turnings	373.6
10 12 10	Solid wastes from gas treatment other than those mentioned in 10 12 09	357.3
15 01 09	Textile packaging	322.9
03 03 11	Sludges from on-site effluent treatment other than those mentioned in 03 03 10	299.0
10 11 05	Particulates and dust	291.4
17 02 03	Plastic	154.3
20 01 39	Plastics	95.0
02 03 04	Materials unsuitable for consumption or processing	83.5
10 01 99	Wastes not otherwise specified	83.4
17 02 02	Glass	80.1
12 01 17	Waste blasting material other than those mentioned in 12 01 16	76.8
10 01 21	Sludges from on-site effluent treatment other than those mentioned in 10 01 20	65.0
17 01 03	Tiles and ceramics	55.0
10 02 12	Wastes from cooling-water treatment other than those mentioned in 10 02 11	42.1
10 09 10	Flue-gas dust other than those mentioned in 10 09 09	33.5
10 01 23	Aqueous sludges from boiler cleansing other than those mentioned in 10 01 22	27.7
01 04 09	Waste sand and clays	25.4
10 05 04	Other particulates and dust	24.5
16 10 04	Aqueous concentrates other than those mentioned in 16 10 03	18.9
10 01 25	Wastes from fuel storage and preparation of coal-fired power plants	18.8
10 11 14	Glass-polishing and -grinding sludge other than those mentioned in 10 11 13	14.0
10 01 19	Wastes from gas cleaning other than those mentioned in 10 01 05, 10 01 07 and 10 01 18	11.6
20 01 10	Clothes	9.9
20 01 02	Glass	9.1

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EWCcode	EWC name	Weight [Mg]
17 08 02	Gypsum-based construction materials other than those mentioned in 17 08 01	7.1
20 01 11	Textiles	5.6
20 02 03	Other non-biodegradable wastes	0.5
01 04 13	Wastes from stone cutting and sawing other than those mentioned in 01 04 07	0.2
02 01 03	Plant-tissue waste	0.1
19 12 08	Textiles	0.0

81 types of waste generated in the project area with a total weight of 3,183 thousand Mg per year were identified (Figure 36).

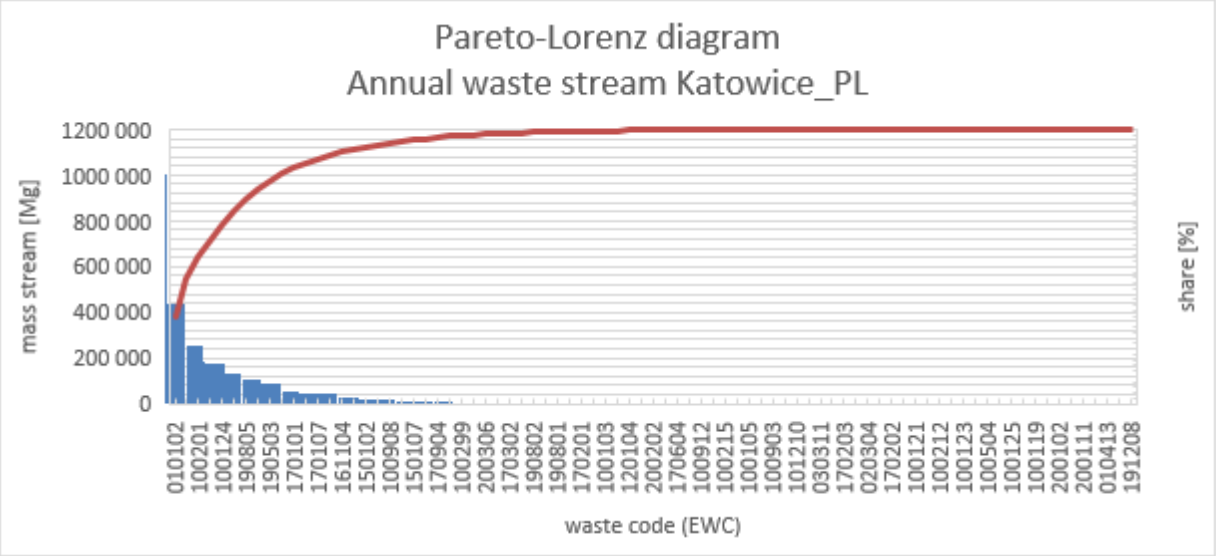

Figure 36 – Pareto-Lorenz Diagram of the annual waste stream in the Katowice case study.

14 waste streams from this list represent 90% of the mass of waste produced (Table 21).

Table 21 – Top waste stream in the Katowice area.

EWC code	EWC name	Percent	Cumulative percent	Material part of the waste
01 01 02	Wastes from mineral non-metalliferous excavation	31.62	31.62	Mining wastes are a mixture of rock debris from layers that accompany coal seams and from layers of these seams. The coal waste consists of clays, clay shales, siltstones, coal shales, sandstones, sporadically conglomerates, and crumbs of coal. They are mainly used for levelling brownfields and open pitches, less frequently used in the construction of foundation layers, shaft cores and slopes. Old mining dumps were often self-igniting and material from a blown up so called "red stone" is willingly used in road and water construction.

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EWC code	EWC name	Percent	Cumulative percent	Material part of the waste
19 12 12	Other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	13.73	45.35	Material with a very diverse composition, unsuitable in construction. By considerable means, it can be used to create artificial soil suitable for the reclamation of landfills and brownfield sites, or to extract fragments of minerals and refuse waste, but their separation from organic contaminants, plastics and paper is difficult.
10 02 01	Wastes from the processing of slag	7.99	53.34	Slag from metallurgical processes is an alloy containing ore impurities, fluxes and some amount of metal oxides, residues from coal combustion, coke, is a mass containing mainly enamel sintered with mineral components. It is used for the construction of leveling and stabilizing layers, mortar and concrete components, less often as a thermal or sound insulation layer.
17 05 04	Soil and stones other than those mentioned in 17 05 03	5.92	59.25	Earth or stones coming from construction works, most often used at the investment site or near surroundings when arranging areas around the investment.
10 01 24	Sands from fluidised beds	5.64	64.89	A fine-grained mixture of silicon sands with the participation of fuel combustion products, eagerly used in the production of building materials.
12 01 01	Ferrous metal filings and turnings	5.56	70.45	Scrap, usually steel with low usefulness for construction purposes. In the case of scrapping construction elements of buildings, it is possible to re-use in less demanding constructions.
19 08 05	Sludges from treatment of urban waste water	4.32	74.76	Such sludges may be an addition to artificial grounds, but on the condition that they meet the standards of cleanliness and they are thoroughly mixed with inert material.
10 01 01	Bottom ash, slag and boiler dust (excluding boiler dust mentioned in 10 01 04)	3.46	78.22	Very finely divided mineral materials, mainly enamel and sintered fuel residues, very often used in the building materials industry - in the production of cement, masonry and plaster mortars and self-leveling masses.
19 05 03	Off-specification compost	2.97	81.19	In the case of the possibility of separating mineral parts - sands and stones, can be used for reclamation mixtures, however, due to the costs of such operations and the availability of other materials rather unsuitable in construction.
19 12 05	Glass	2.83	84.02	Glass granules can be an addition to aggregates and concretes, but they are usually recycled.
17 01 01	Concrete	1.78	85.81	Crushed concrete is a highly sought as replacement for aggregates in road construction and small architecture, it can also be reused in the production of concrete.

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EWC code	EWC name	Percent	Cumulative percent	Material part of the waste
19 12 09	Minerals (for example sand, stones)	1.58	87.39	In the case of unpolluted organic fraction and other municipal waste, such sands and stones can be used for reclamation mixtures but are usually heavily contaminated.
17 01 07	Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06	1.51	88.91	Similarly to crushed concrete, this material may be a substitute for aggregates in construction, however, it requires segregation and cleaning of undesirable components. It can usually be used for levelling.
17 01 02	Bricks	1.51	90.42	Brick aggregate can be a substitute for mineral aggregates in concrete mixes.

In the case of the majority of waste found in the pilot area of Katowice, designated as a source of materials for construction from recovery, it was stated that it could be used. In the case of negatively evaluated waste, the main reason for such an assessment is the content of the organic fraction (biomass) and mixing with undesirable components that are difficult to separate.

5.2.7. Step 7: Waste Composition

For Katowice case study area, from the entry table of waste agreed earlier in the project, all waste produced in the area by the identified actors as part of their activities were selected.

Although the purpose of this step was a more detailed definition of waste material than the EWC was given, due to the lack of information, waste data according to the EWC was uploaded to system, assuming for them in composition a share of 1.

5.2.8. Step 8: Flows and stocks

For case study area of Katowice, based on the data extracted from the document "Voivodeship report on waste management - Silesia voivodeship 2016", data on the amounts of generated waste, specified in step 7, in Mg/year, as stocks data were introduced.

5.2.9. Step 9: Visualization and analysis

The data entered has enabled launching the GDSE visualization module. The results on the diagram of material streams for activity groups as well as resource/material and actor/material maps are shown below (Figure 37 and Figure 38).

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Figure 37 – Stock diagram of the Katowice case study.

Figure 38 shows a geographical distribution of waste resources in the Katowice case area. The image on the left is a screening of waste resources visualization screen for individual actors - for each of actors is displayed a pie chart showing the share of material groups in the generated waste (in practice, this functionality allows use of zoom in the system - on this image, not very visible). The image on the right is a screenshot of the visualization of the geographic location of the actors, where the colours of the points correspond to the dominant material group of the generated waste.

A fairly uniform distribution of stocks in industrial part of case study area is visible - the areas of gaps are mainly forest and recreational areas.

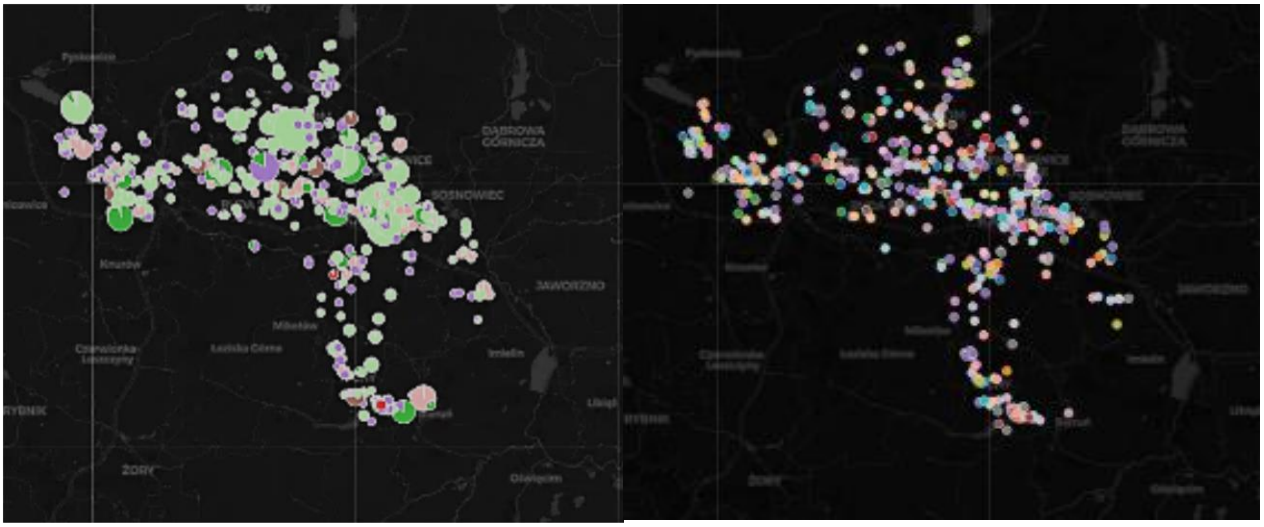

Figure 38 – Visualization of materials by stock and actors for Katowice case study.

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6. MARIBOR (SLOVENIA) CASE STUDY

6.1. Introduction to the case study

The pilot study in Slovenia is carried out in the central area of the Municipality of Maribor and 21 other surrounding municipalities, which, together with the largest municipality (Maribor), comprise the functional urban area of the city of Maribor (Figure 39). This area is in the size of 1,311,33 km^2 and therefore represents a concluded geographical entity, suitable for analysing in the CINDERELA project. The radius of the area selected for analysis is 20–25 km, the number of companies in this area is 1,263 and the number of inhabitants in the area is 259,703. The total amount of officially recorded waste generated in 2016 is 311,328 tonnes or 1,173 kg per capita.

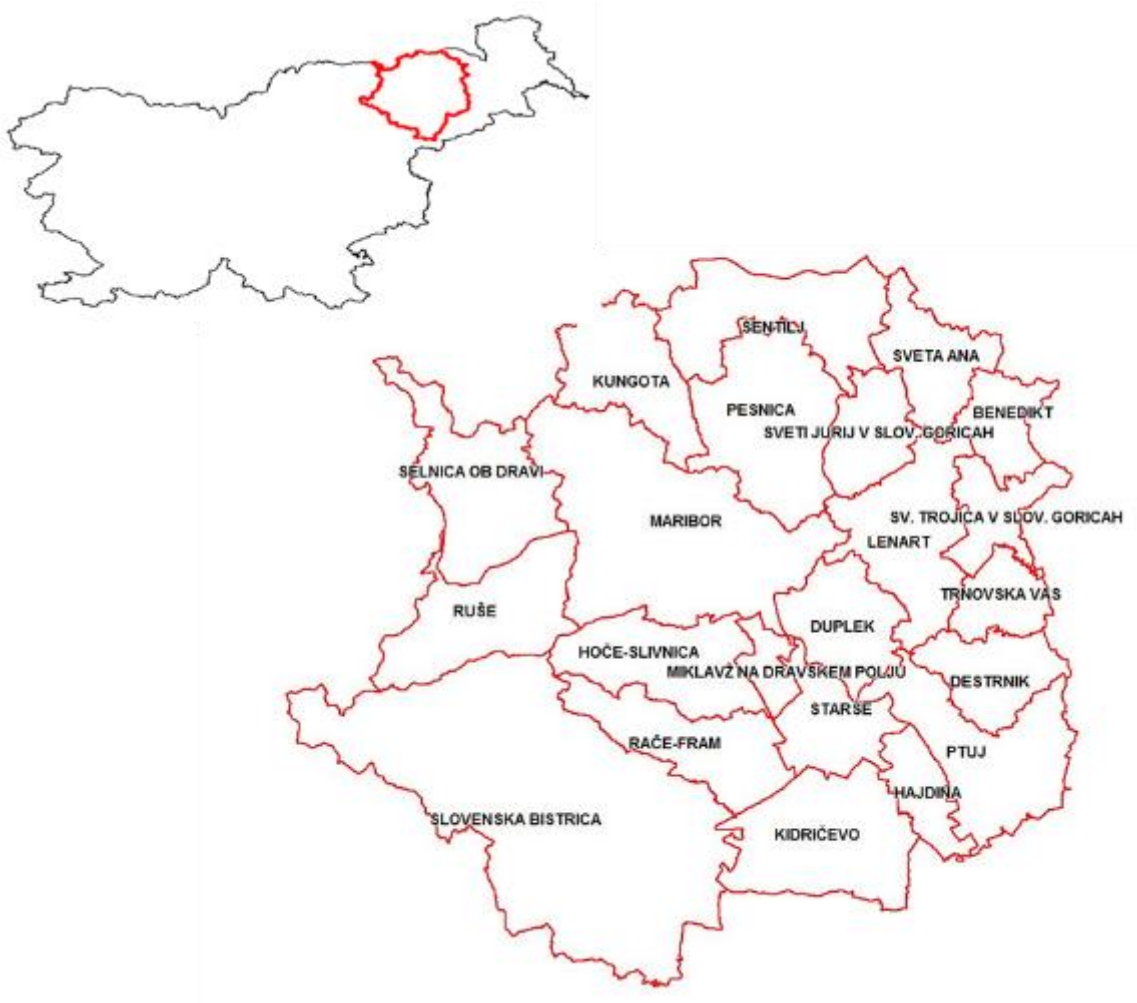

Figure 39 – Area of the Maribor case study.

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The largest group of generated waste in the pilot project area is from the field of construction (demolition of buildings and excavations), followed by industrial waste (from metal forming and metal processing and from thermal metallurgy). There is also a significant part of municipal waste (from cleaning wastewater and physical treatment of mixed municipal waste).

A considerable proportion of waste generated in the area is being processed today, but unfortunately in order to remove them and not to reuse them according to regulations. An important part of the waste, generated in the area, is not officially registered today, especially in the field of construction, and partly for industrial waste.

6.2. Application of the methodology to the case study

6.2.1. Step 1: Collecting data

For the collection of data for year 2016, we have used the state register of the Environmental Agency of the Republic of Slovenia (ARSO) of the Ministry of the Environment and spatial planning. For their classification and sortation, we have also used international, unified databases, described below.

Most of the data we needed to compile the lists, to complete the steps 2-8 and to upload them into the GDSE tool, are publicly available on the ARSO's portal and in the Register of Spatial Units of the Ministry of the Environment and Spatial Planning of the Republic of Slovenia[29].They are not collected, processed and made available in a way that would allow them to be directly inserted into the tool, even though from the large pools collected, it is possible to find out individual types of data, such as code, type of waste, their quantity, producer, address, municipality, etc. Still, the workload needed to process the huge amount of data was considerable and not straight forward.

All data collected, except the transformation of the coordinate system, was processed with Excel (Microsoft Office 365 Business).

The processing of the collected data was carried out in two phases.

6.2.1.1. PHASE 1

In the first phase, the data collected from different databases (dbf, xls, csv) needed to be aggregated. For the baseline, annual reports of waste management producers in 2016 have been assessed. Combination (mappings between masses) was done with Excel Power Query. Prior to aggregation, individual databases were processed accordingly. By combining the bases and taking into account the addresses of waste producers, municipalities could be identified, and the coordinates of business entities and other required information gathered as needed by the methodology. By combining various data bases, a single database has been generated.

More precisely, the necessary data for the processing of the collected data was obtained from different records listed below.

[29] (http://www.e-prostor.gov.si/zbirke-prostorskih-podatkov/nepremicnine/register-prostorskih-enot/).

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- **European waste catalogue (EWC) -** the classification of waste is based on the European List of Waste (Commission Decision 2000/532/EC – consolidated version) and Annex III to Directive 2008/98/EC (consolidated version). The EU List provides an EU-wide common terminology for waste classification to ease waste management, including for hazardous waste. The assignment of LoW codes serves in a broad variety of activities, including the transport of waste, installation permits (which often refer also to specific waste codes), or as a basis for waste statistics;

- **Slovenian Environment Agency (ARSO): Wastes report 2016 in xls -** ARSO publishes every year the waste management data on the basis of the annual waste management reports, received from waste producers (Figure 40);

Registration number	Name and address	SKD	Statistical region	Waste number	Stored waste on 1st of January 2016 (kg)	Quantity of waste produced in 2016 (kg)	Stored waste on 31st of December 2016 (kg)
1786199000	ZAVOD SV. TEREZIJE; VIDEM 033A, 1312 VIDEM - DOBREPOLJE	87.300	08 OSREDNJESLOVENSKA	19 08 09	700	5.600	700
1786199000	ZAVOD SV. TEREZIJE; VIDEM 033A, 1312 VIDEM - DOBREPOLJE	87.300	08 OSREDNJESLOVENSKA	15 01 07	40	1.060	40
1786199000	ZAVOD SV. TEREZIJE; VIDEM 033A, 1312 VIDEM - DOBREPOLJE	87.300	08 OSREDNJESLOVENSKA	15 01 06	50	3.350	50
1786199000	ZAVOD SV. TEREZIJE; VIDEM 033A, 1312 VIDEM - DOBREPOLJE	87.300	08 OSREDNJESLOVENSKA	15 01 01	100	1.750	100
1786199000	ZAVOD SV. TEREZIJE; VIDEM 033A, 1312 VIDEM - DOBREPOLJE	87.300	08 OSREDNJESLOVENSKA	18 01 03*	150	42	150
1786199000	ZAVOD SV. TEREZIJE; VIDEM 033A, 1312 VIDEM - DOBREPOLJE	87.300	08 OSREDNJESLOVENSKA	20 02 01	200	11.300	200
1828410000	ZAVOD SVETEGA CIRILA IN METODA Beltinci; MLADINSKA ULICA 4, 9231 BELTINCI	85.520	01 POMURSKA	20 01 25		420	
1828410000	ZAVOD SVETEGA CIRILA IN METODA Beltinci; MLADINSKA ULICA 4, 9231 BELTINCI	85.520	01 POMURSKA	15 01 01		3.658	
1828410000	ZAVOD SVETEGA CIRILA IN METODA Beltinci; MLADINSKA ULICA 4, 9231 BELTINCI	85.520	01 POMURSKA	20 01 08		7.690	
1828410000	ZAVOD SVETEGA CIRILA IN METODA Beltinci; MLADINSKA ULICA 4, 9231 BELTINCI	85.520	01 POMURSKA	15 01 02		1.450	
1828410000	ZAVOD SVETEGA CIRILA IN METODA Beltinci; MLADINSKA ULICA 4, 9231 BELTINCI	85.520	01 POMURSKA	20 03 01		35.880	

Figure 40 – Example of ARSO data set.

- **The Surveying and Mapping Authority of the Republic of Slovenia (E-Surveying Data) in dbf** - Register of Spatial Units is an integrated database including location and descriptive data on spatial units (spatial districts, settlements, municipalities, postal areas, administrative units, statistical regions, school districts, smaller units within municipalities (local, village and district communities), regional surveying and mapping authorities, national assembly election units (national assembly polling stations, voting districts and voting units) and local elections units (local elections polling stations and voting units)), streets and house numbers;

- **Local administrative units (LAU - NUTS) in xlsx -** The Nomenclature of Territorial Units for Statistics is a geocode standard for referencing the subdivisions of countries for statistical purposes. The standard is developed and regulated by the European Union, and thus only covers the member states of the EU in detail. The Nomenclature of Territorial Units for Statistics is instrumental in the European Union's Structural Fund delivery mechanisms and for locating the

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area where goods and services subject to European public procurement legislation are to be delivered;

- **Coordinate Transformations (Gauss–Krüger coordinate system to WGS84[30] in csv -** The national horizontal coordinate system with the code D48 / GK is a coordinate system that was established in the territory of the former Yugoslavia. The World Geodetic System (WGS) is a standard for use in cartography, geodesy, and satellite navigation including GPS. It comprises a standard coordinate system for the Earth, a standard spheroidal reference surface (the datum or reference ellipsoid) for raw altitude data, and a gravitational equipotential surface (the geoid) that defines the nominal sea level. Conversion of coordinates between WGS84 and Gauss–Krüger projections; the application automatically recognizes input coordinate system. The application supports CSV and GPX file formats. In the CSV file, coordinates must use a decimal point and be separated by a comma. Supported coordinates systems: WGS84, Gauss–Krüger 5th, 6th, and 7th zone, HTRS96/TM.

6.2.1.2. PHASE 2

In the second phase, data have been assessed and refined. Data were divided, into individual parts, accordingly to the Bulk Data Upload Procedure in GDSE. The Excel tool was also used for this part of the data processing. The xls format files were loaded into the GDSE tool. For the last step, namely step 8, which is referring to the identification of waste streams, the data could not be processed from publicly accessible records. Therefore, for the data, which is evident only from the completed individual record sheets for the shift of waste, we had to address a special letter to ARSO and ask them to send us the requested data bases specifically for the purposes of its use in the Cinderella project. This request could be answered positively as ARSO provided the project team with the necessary data for the selected period of waste treatment (calendar year).

6.2.2. Step 2: Selection CINDERELA waste streams

Taking the Slovenian context of waste generation and expert knowledge into account, inputs were collated to CINDERELA EWC List for the purpose of the project. Considering the first step, (a prepared list of waste with EWC codes), the ranking of certain types of waste into the aforementioned list was the first criterion, according to which the Slovenian partners have prepared a list of selected types of waste in the study area. Other types of wastes, not featured in the EWC CINDERELA list, have been removed from the local project data base.

Regarding the quantity, the most part of the generated waste in the selected pilot area, is construction waste from group 17 of EWC (the excavations of the group 17 05 and certain other building inert waste from demolition of facilities). Another major group is waste from the field of industry (metal forming and treatment and thermal metallurgy). Finally another major group of waste emerges from municipal activities (from waste water treatment and physical treatment of mixed municipal waste).

Based on expert knowledge of the project team, it is estimated that most of the mentioned waste, generated in the study area could be reused as inputs for the production of new materials in the

[30] (https://gauss.svemir.co/#uploadfile)

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construction sector, especially in the field of civil engineering, and partly also in the field of high-rise buildings, where there are generally higher security standards. The availability of waste materials with high potential for re-use at local level is very welcome as it is expected this would generate lower environmental impacts due to reduced transport of large quantities of waste on longer distances and may also improve the economic viability perspectives of innovative local circular economy businesses.

6.2.3. Step 3: Selection and delimitation of the geographical area

As described in the beginning, in the third step the area of the case study was defined. Given the existing administrative division of Slovenia by individual municipalities (there are no counties, provinces or similar units in Slovenia) according to NUTS nomenclature. In the case of Slovenia, the case study was distributed according to individual items (the example in Table 22 for the Municipality of Maribor) and entered into the GDSE toolkit based on geometric data (WGS84 EPSG: 4326).

Table 22 – Area of the Maribor case study.

World	
Continent	Europe
Country	Slovenia
NUTS1	
NUTS2	SI03 Eastern Slovenia
NUTS3	SI032 Drava Statistical Region
District	
Municipality	Maribor
City District	/
City Neighbourhood	/
City Block	/
Street Section	/
House	/

6.2.4. Step 4: Activity Group and Activities

On basis of the processed data from ARSO, the types of companies which have generated the selected types of waste were identified (Figure 41). Further, based on the CINDERELA NACE list, the data was uploaded into the GDSE tool.

The activity group was followed by the entry of the activity table defined in the Annex 1 - using the 4-digit NACE codes.

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code*	name
A	AGRICULTURE, FORESTRY AND FISHING
B	MINING AND QUARRYING
C	MANUFACTURING
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES
F	CONSTRUCTION
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES
H	TRANSPORTATION AND STORAGE
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES
J	INFORMATION AND COMMUNICATION
K	FINANCIAL AND INSURANCE ACTIVITIES
L	REAL ESTATE ACTIVITIES
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES
N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES
O	PUBLIC ADMINISTRATION AND DEFENCE; COMPULSORY SOCIAL SECURITY
P	EDUCATION
Q	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES
R	ARTS, ENTERTAINMENT AND RECREATION
S	OTHER SERVICE ACTIVITIES

Figure 41 – Activity groups added in the Maribor case study.

6.2.5. Step 5: Actors

The input of the data concerning waste producers and their locations into GDSE tool, was entered on the basis of the data obtained from official records (without the use of ORBIS!), and according to the use of NACE codes. From the processing of the CINDERELA NACE list, a list of companies with identified activities and their locations was generated.

The connection of the generated waste with the waste producers according to their activity group is appropriately and fairly presented for most waste categories. An exception is the waste group 17 of EWC, i.e. construction waste. This is a consequence of a specificity of the Slovenian national legislation. Indeed, under Slovenian legislation, construction waste is generated by an investor as a contracting authority for construction works. Hence, construction companies as such (i.e. companies carrying out construction work for its contracting authority - construction contractor) are not considered as generator of construction waste. However, as it happens, the collection of construction waste data in Slovenia does not strictly comply with the legal framework in force. Indeed, many construction companies report waste generated by their investors (i.e. companies from very different sectors: economy, industry, public organizations, banks, hospitals, municipalities, state, etc.) as their own generated waste from production and service activities. Consequently, in the Slovenian context the available data on construction waste cannot be considered as accurate or realistic. The probability of double counting or data gaps is high.

6.2.6. Step 6: Detail description of the materials

In Figure 42, a section of the material table is displayed. Although this table does not provide more detailed information on waste than the information provided by EWC code, this list was uploaded to the GDSE tool as the Slovenian context and waste data situation does not provide the necessary level of details on waste data. In the Slovenian context, ARSO collects data at the basic level of their information by the waste producers. Hence, in the case of Slovenia the level of detail for material

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description could only reach LEVEL II. LEVEL III and LEVEL IV details could not be obtained and uploaded to the GDSE tool.

parent	name*
	0103 - wastes from physical and chemical processing of metalliferous minerals
	0104 - wastes from physical and chemical processing of non-metalliferous minerals
	0201 - wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing
0103 - wastes from physical and chemical processing of metalliferous minerals	010308 - dusty and powdery wastes other than those mentioned in 01 03 07
0104 - wastes from physical and chemical processing of non-metalliferous minerals	010413 - wastes from stone cutting and sawing other than those mentioned in 01 04 07
0201 - wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing	020101 - sludges from washing and cleaning

Figure 42 – Example of Material table for the Maribor case study.

6.2.7. Step 7: Waste Composition

In step 7, which is regarding the composition of waste, the situation in Slovenia is similar to that in step 6. The data obtained from Slovenian official records are not sufficient for further processing.

The reason is also, and above all, the construction waste characteristic, which, as a rule, is not assembled or packaged (bulk!). Therefore, their composition by source cannot be divided into several different assemblies. For this reason, all the information in our wastes table for the fraction section is indicated by 1 (see Figure 43).

name	nace	material	fraction	hazardous	avoidable	source
P-8520 - 200301	P-8520	200301 - mixed municipal waste	1			SlovenianEnvironmentAgency2018
P-8520 - 200201	P-8520	200201 - biodegradable waste	1			SlovenianEnvironmentAgency2018
P-8520 - 200101	P-8520	200101 - paper and cardboard	1			SlovenianEnvironmentAgency2018
P-8520 - 150106	P-8520	150106 - mixed packaging	1			SlovenianEnvironmentAgency2018

Figure 43 – Example of the waste composition table for the Maribor case study.

6.2.8. Step 8: Flows and stocks

The new business model CinderCEBM, which is being developed in the project, is the first step based on the analysis of existing waste streams in urban and peri-urban areas. To perform data modelling and test processing of the masses of waste streams of selected companies in 2016 in Maribor and neighbouring municipalities, information of companies and producers of waste is needed. This information is provided through companies when signing the electronic record sheets. These are then entered in the electronic system IS-waste, which is led by ARSO.

The ARSO`s users website offers access to annual reports on waste management of individual companies in PDF format. However, this information does not include information on waste flows (i.e. from company to individual waste collectors – waste processors – or waste disposal facilities).

The Slovenian case study area is covering 22 municipalities; access to electronic records from the electronic system of IS-Waste has been requested to ARSO. The information provided by ARSO

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contained the data from all the signed electronic record sheets for the handling of waste in the country in all possible routes (approximately 658,000 documents):

- Original producer/ collector, processor, waste disposal;
- Collector / Collector, processor, waste disposal;
- Processor / Collector, processor, remover.

These data have been processed according to the methodology instructions and then entered successfully into the GDSE, including those waste flows reaching beyond the geographical limits of the case study area.

6.2.9. Step 9: Visualization and analysis

An overview of all registered waste streams for identified EWC codes of generated waste at the waste producers in the urban area of Maribor is geographically visually depicted in the Sankey diagram below, which shows the quantities and types of waste streams between different groups of activities (Figure 44and Figure 45).

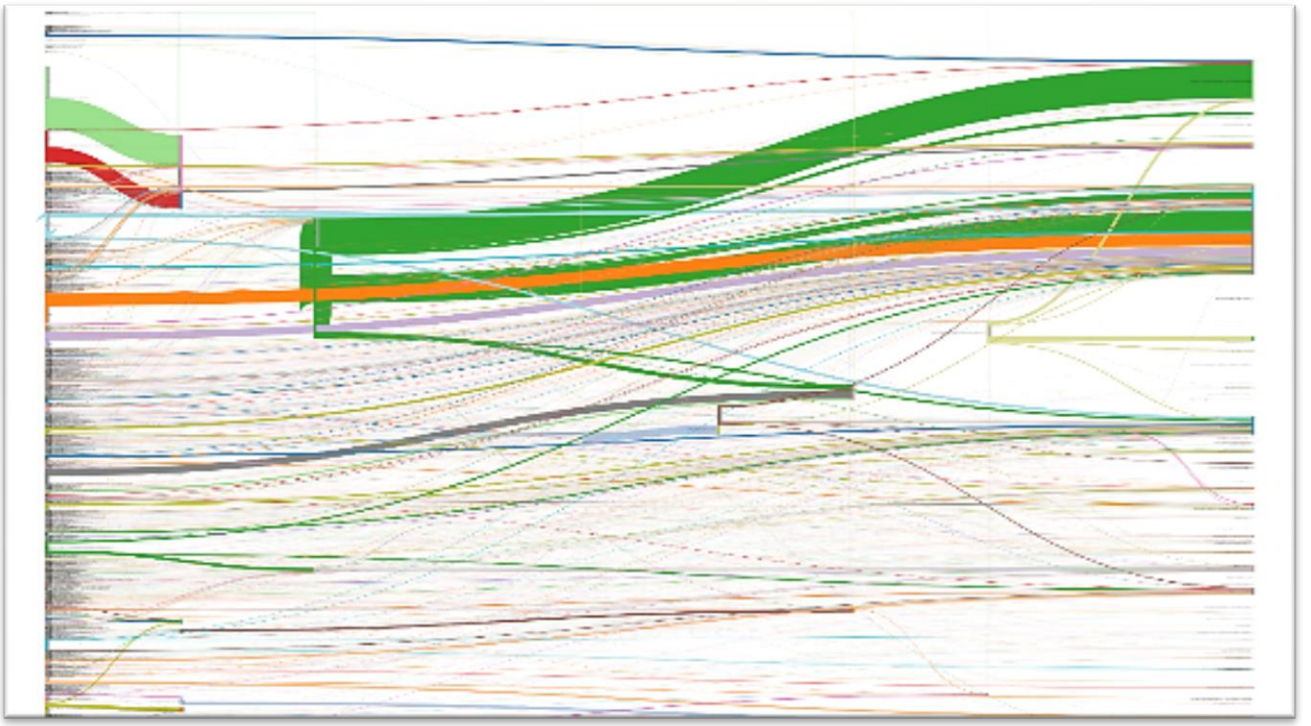

Figure 44 – Sankey diagram of Maribor case study.

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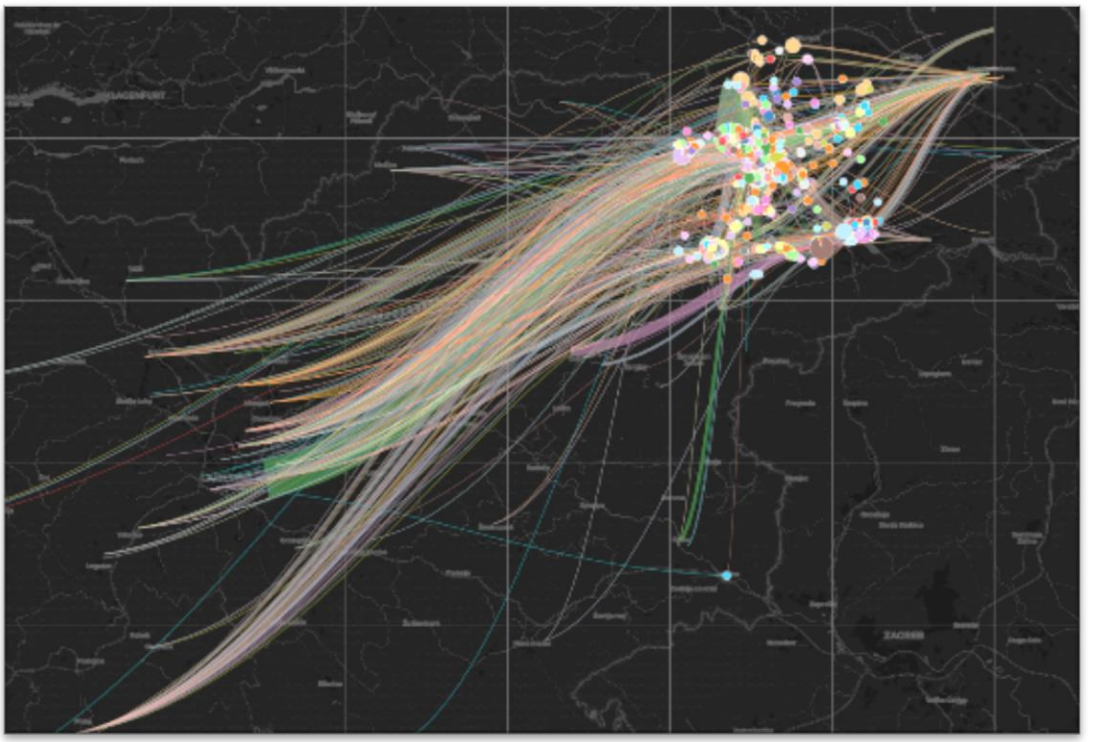

Figure 45 – Flows visualization of the Maribor case study.

The following images (Figure 46 and Figure 47) show the flows for two important groups of waste with a significant potential for secondary raw materials:

Figure 46 – Visualization for the 17 01: concrete, bricks, tiles and ceramics waste stream in the GDSE.

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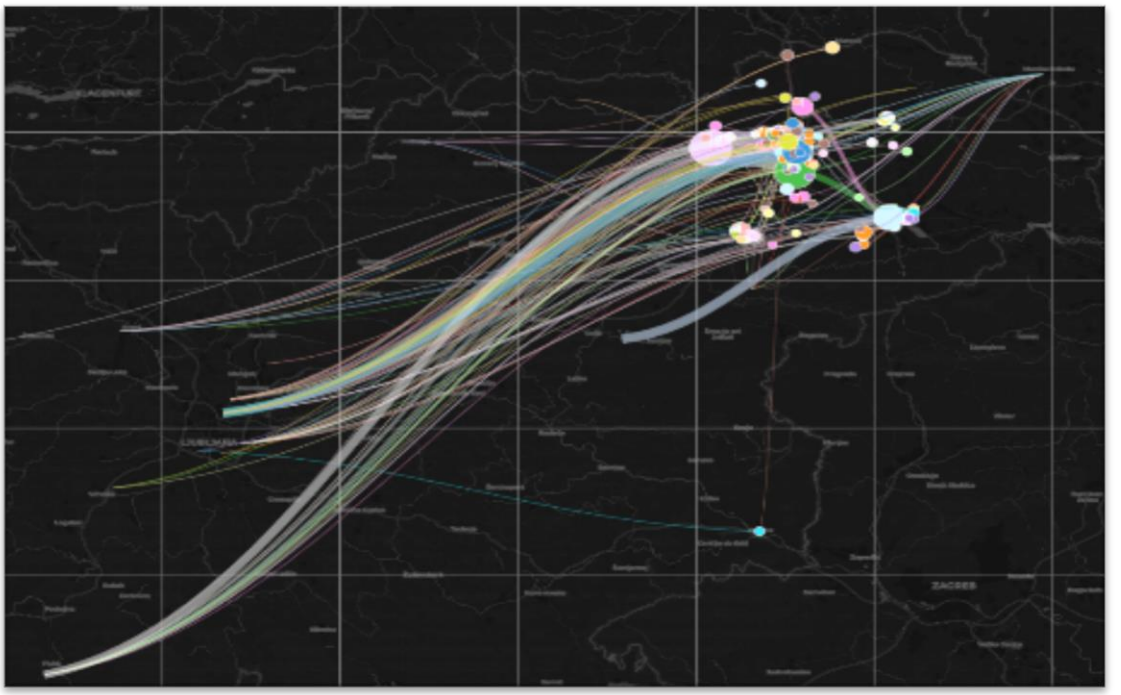

Figure 47 – Visualization for the 12 01: waste from physical treatment of metals waste stream in the GDSE.

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7. TRENTO (ITALY) CASE STUDY

7.1. Introduction to the case study

Trento is an autonomous province of north-eastern Italy. It is one of the two provinces that belong to Trentino-Alto Adige/Südtirol region (Figure 48). Its capital is the town of Trento. The province has an area of 6,208 km² (2396.54 sq. miles) and a total population of 538,604 (Eurostat, 2018).

Figure 48 – Trento case study area.

The regional innovation system is well developed and interconnected. It is characterised by strong public components (universities, research institutes and foundations), while business R&D investments are still relatively low compared to other sources of funding (i.e. government). Trento is a relatively wealthy autonomous province, both in comparison with other Italian regions, and with the EU28 average: the GDP per capita PPS was €35,600 in 2016, corresponding to 122% of the EU28 average and to 126% of the national average (Eurostat, 2018). In 2015, services account for 73.5% of the gross value added, followed by industry (22.9%) and agriculture (3.6%). Tourism is vital, and mostly related to the exploitation of natural amenities, sky resorts etc. Agro-food is also a strategic sector. The share of agriculture is also higher than average, while the importance of industry is lower than in the rest of Italy. The most important manufacturing sectors include textiles, materials for construction, mechanics, food processing, paper and wood making. The fragmentation of the productive fabric and the prevalence of micro-enterprises in all sectors is a key feature of the economy (as well as of many Italian regions) which implies a lack of critical mass for carrying out innovation activities.

Nevertheless, the Trentino innovation system is well developed and interconnected. During the last decade or so, Trento has specialised increasingly in ICT as well as related pervasive applications, which

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has become a very important competitive advantage and prompted the development of lead markets in the region (e.g. eHealth and sustainable construction). More recently, and on the way of the new programming period 2014-2020, Trento has also pushed forward the specialisation in a number of manufacturing sectors related to advanced manufacturing and Industry 4.0. The relatively low level of private R&D investments represents the main weakness of the system. The new specialisations in sectors such as mechatronics and smart systems, led also by private research centres of multinationals established in Trentino, could partly offset this tendency in the future[31].

The per capita collection in Trentino Alto Adige remains second at national level for 2015, with 6.8 kg per inhabitant (Figure 49). There are in total 215 waste collection facilities in the region in a ratio of 20 disposals per 100,000 inhabitants, the highest number in Italy.

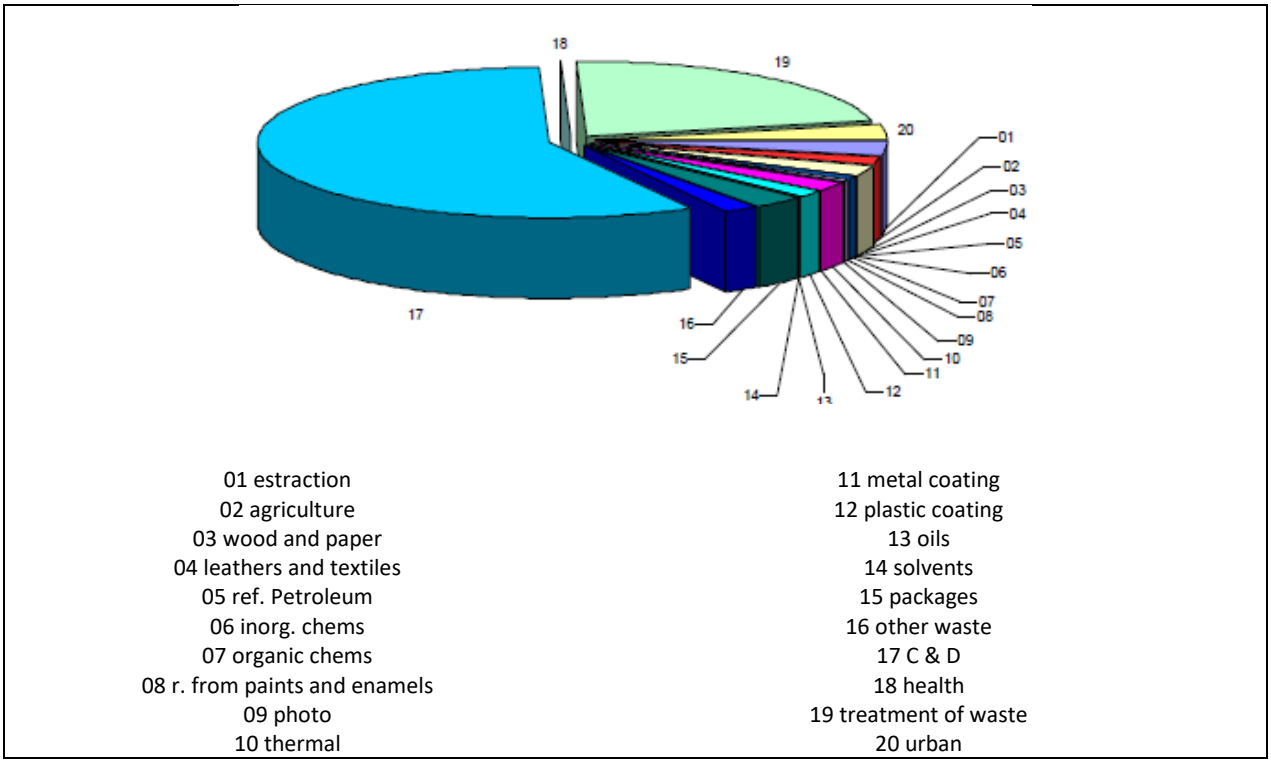

Figure 49 – Data on waste collection (2015).

As part of provincial policies to promote waste recycling culture in economic activities, the provincial government has approved the provincial Waste Disposal Plan[32] for the management of non-hazardous inert waste produced by construction and demolition activities.

The need of this plan stems from the fact that C&D sector represent a group of very significant waste in quantitative terms, corresponding to little less than 50% of non-hazardous waste produced at the provincial level. The Extract Plan outlines an integrated waste management system from construction and demolition (C&D) activities, giving priority to policies for the recovery and requalification of inert

[31] DG-Growth: https://ec.europa.eu/growth/tools-databases/regional-innovation-monitor/base-profile/trento

[32] Piano stralcio per la gestione dei rifiuti speciali inerti non pericolosi provenienti dalle attività di costruzione e demolizione – Download from Provincial Agency for Environment website

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materials and reducing landfill disposal activities. Two thirds of the total C&D waste consists of essentially mixed main waste and demolition mixtures, followed by the material coming from the excavations, treated as waste, and the bituminous conglomerate coming from the demolition flooring, while homogeneous waste such as metals, plastics, wood and glass are produced and managed in small quantities. As in Figure 49[33], the main part is represented by construction waste and demolition (C&D - EWC 17) for a percentage that is around 57%. This is explicable due to the effect of both their weight, but also because a single average building site is of interest considerable volumes. Afterwards, an important part is represented by the chapter of EWC-19 (waste from plants of waste treatment, wastewater treatment, and water purification and from its preparation for industrial use) for a percentage that is around 22% of the total.

The overall figure of the management is positive and in line with the community programs, however the careful examination of the categories highlights the substantial component of the mixtures of waste. Although they are included in the typological classification provided by the current law, the presence of mixed waste means that the processes of de-construction of the works, in general, do not follow the rules of selective demolition.

7.2. Application of the methodology to the case study

7.2.1. Step 1: Collecting data

Data regarding environmental issue are collected by the Provincial Agency for Environmental Protection (APPA). APPA is an organizational Provincial structure which has organizational, administrative, technical and accounting autonomy. Function of APPA regards air, water and soil protection, waste management and noise pollution prevention. The APPA, as other regional Agencies, has been established in order to assure, overall national territory, the presence of technical and autonomous bodies and to make the collection and elaboration of environmental data easier and more homogeneous.

Of relevance to CINDERELA, APPA manages the database of disposal of industrial waste. Since data are not publicly available, APPA was engaged by the project team by means of a formal letter including a presentation of CINDERELA project followed by a vis-à-vis meeting in order to ask for their collaboration. APPA's database collects data about transfers of wastes from private companies to waste disposals, included EWC and quantity. They mostly collect data by means of a specific environmental declaration called MUD (Modello Unico Dichiarazione Ambientale), which each company is obliged to produce whenever delivers waste to the disposal. Data are then shared at national level with the Ministry of Environment. APPA database provides therefore a complete picture of the waste movements in the province. Nevertheless, data are still collected manually and for this reason, they are subject to human errors especially with what concerns company names (e.g. misspelling, abbreviations). Furthermore, the query of the APPA database can be done by company name, therefore we had to ask for the data concerning specific companies. Access to the Database for the whole province could not be achieved; instead, the project team focused on specific companies in the case study area for which information was available. In fact, APPA provided rough data for about more than

[33] Data referring to year 2015 included in the official provincial decree nr.2076/2018: Download from Provincial Agency for Environment website:

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1400 companies. Due to the abovementioned issues (i.e. no guaranty of company exact name giving rise to errors), data was cleaned and as a result a remaining 158 companies could be selected to conduct the analysis.

7.2.2. Step 2: Selection CINDERELA waste streams to be studied

Likewise to other study areas of the project, inputs to the proposed CINDERELA waste list according to the EWC were provided. See the CINDERELA EWC LIST in Table 2.

7.2.3. Step 3: Selection and delimitation of the geographical area

The case study area is composed of 7 municipalities in the province of Trento (Table 23). They were chosen based on presence of relevant companies in construction and building sector. Trento is the capital city of the province with 539,898 inhabitants (ISTAT2018). Trento covers the most productive area/valley of the province. The other areas are geographically connected with Trento area and it is where other industries have their location.

Table 23 – Area of the Trento Case study.

Code	Name	WKT	Level	Parent	Inhabitants
IT	Italy		2		
ITH2	Trentino Province		3	IT	539,898
ITH20	Trento		4	ITH2	117,997
ITH20	Pergine Valsugana		4	ITH2	21,384
ITH20	Dro		4	ITH2	4,986
ITH20	Lavis		4	ITH2	8,969
ITH20	Mezzocorona		4	ITH2	5,477
ITH20	Mezzolombardo		4	ITH2	7,156
ITH20	Faedo		4	ITH2	648

7.2.4. Step 4: Activity Group and Activities

We kept and uploaded the original set provided by the consortium listed in chapter 2.2.4.

7.2.5. Step 5: Actors

List of actors is based on the Orbis query, which retrieved a list of 3,333 actors. They were chosen from the municipalities constituting the study area. Actors belong to different NACE codes representing all the economic sectors in the area. 1524 of them belong to construction sector. 712 have only one employee. These actors were compared with those provided by APPA.

7.2.6. Step 6: Detail description of the materials part of the waste

Original set provided by the consortium as described in chapter 2.2.6 was uploaded to GDSE tool.

7.2.7. Step 7: Waste Composition

Original set provided by the consortium as described in chapter 2.2.7 was uploaded to GDSE tool.

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7.2.8. Step 8: Flows and stocks

As described above, data were asked to the APPA. They provided the project team with the list of 1,400 companies. For each of them one or more waste flows were identified (almost 8,000 totally). Flows represent the transport of waste from a specific construction site to the collector. For each flow the following information is provided: Company name; Construction site address; Collector address; Type of waste and Quantity. For the purpose of the exercise, the focus was put on the flows of the 158 companies that were listed both in the APPA and Orbis queries and it has been decided to map only one waste flow for each company.

7.2.9. Step 9: Visualization and analysis

An overview of all the waste flows for the identified EWC-codes in the Trento area are visualized both on a Sankey diagram (Figure 50) and geographically (Figure 51) below, illustrating the amounts and types of wastes between the different activity groups.

Figure 50 and Figure 51 show the Sankey diagram and flows related to the actors identified in the area.

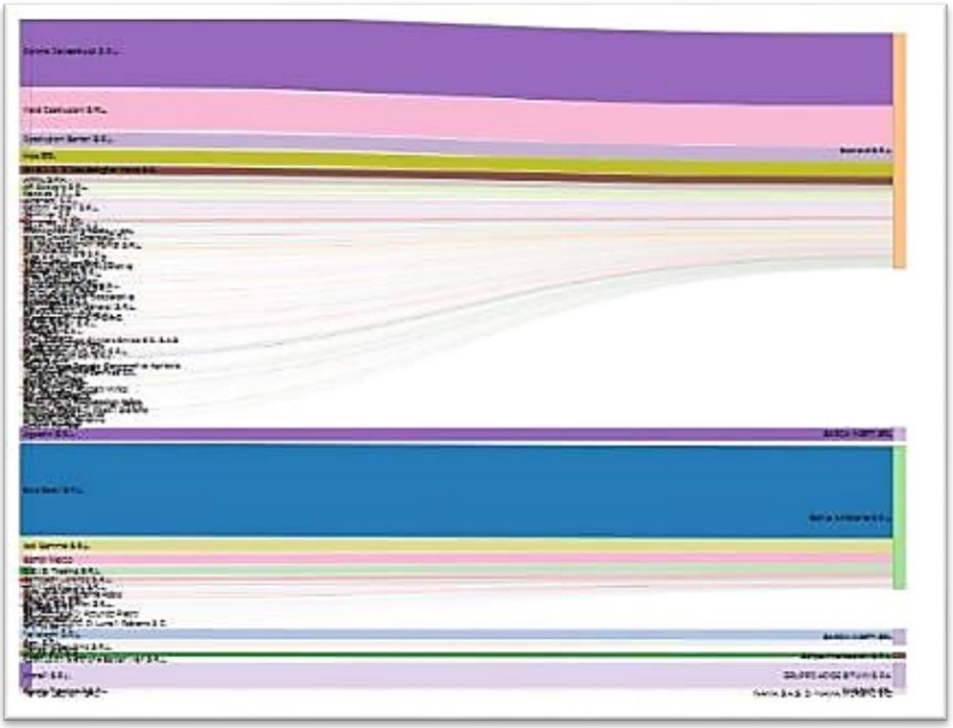

Figure 50 – Sankey diagram of the Trento case study.

As in Figure 50 there are 4 to 5 big waste collectors (right side of the picture) in the area where majority of actors deliver their material. This is also depicted in the Figure 51 where thickness of lines shows quantity of material delivered.

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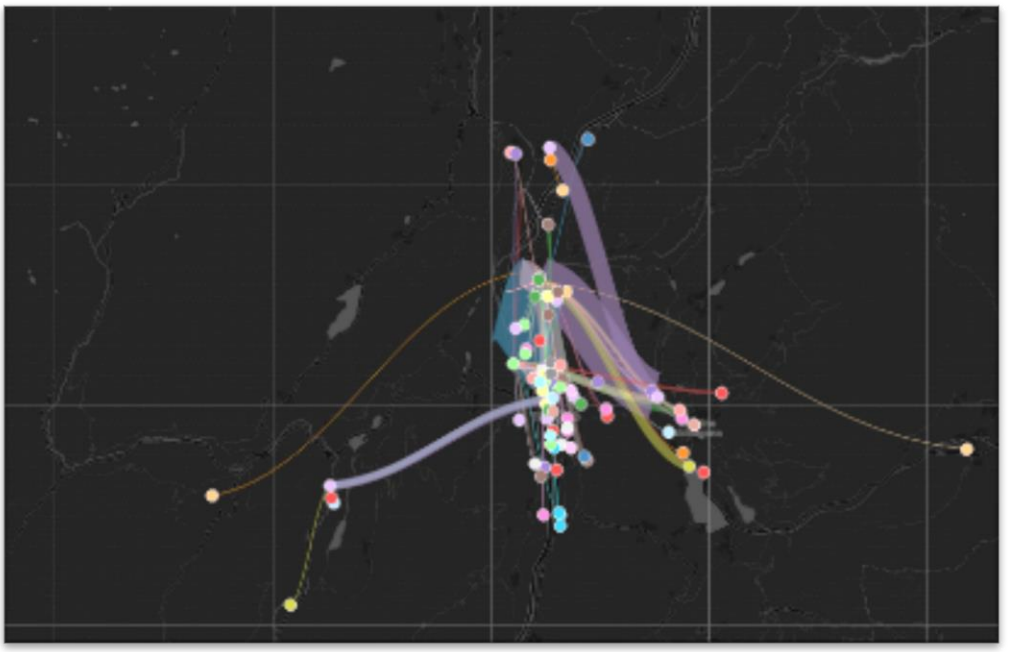

Figure 51 – Flows visualization of the Trento case study (Actors).

The Sankey diagram in Figure 52 depicts the flows among the Activity Groups identified in the area. In Figure 53 a filter on Construction Activity Group was applied and displayed based on Activity. Both the pictures provide evidence that a big amount of material produced in construction goes to waste management collectors.

Figure 52 – Sankey diagram of the Trento case study general situation per Activity Group.

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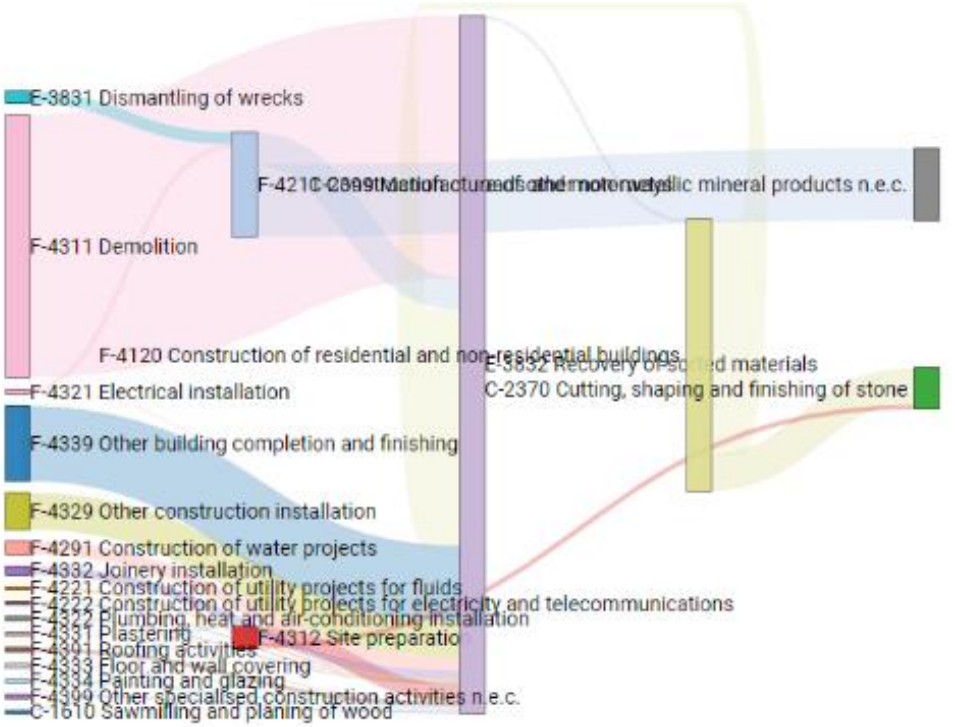

Figure 53 – Sankey diagram of the Trento case study Construction Activity Group.

Figure 54 shows the Sankey diagram related to the Activity Group: Construction identified in the area. Most of the Actors are located around the Trento area as indicated by the flows that go from peripheral to more central areas.

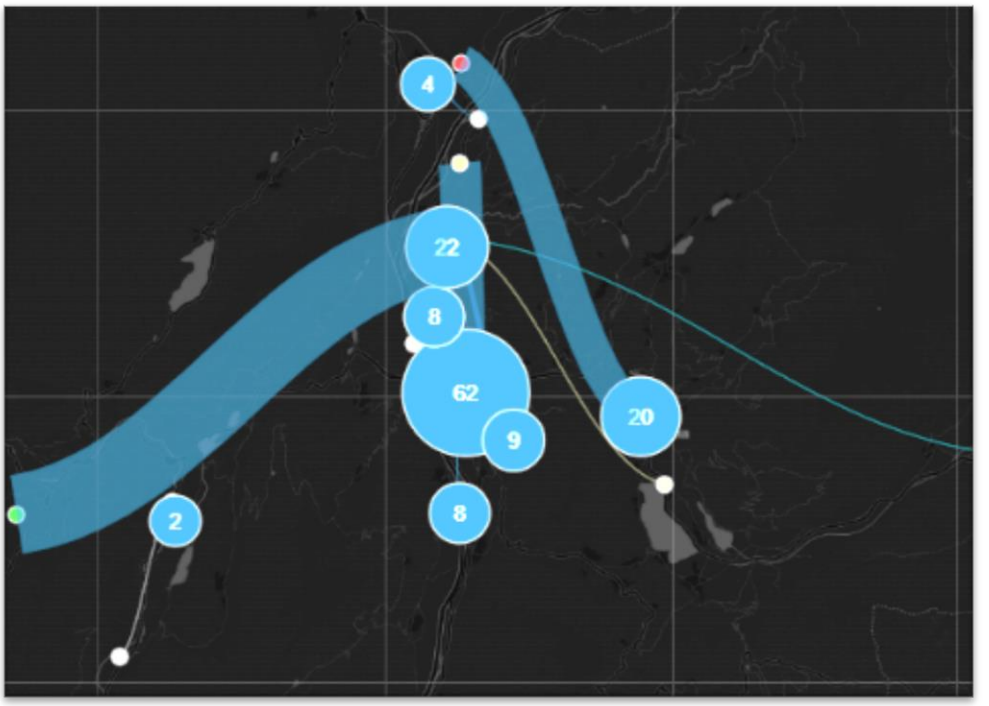

Figure 54 – Cluster visualization of the Trento case study (Activity Group: Construction).

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8. UMAG (CROATIA) CASE STUDY

8.1. Introduction to the case study

The pilot study is carried out in Croatia in the base area of the Municipality of Umag and in 5 other neighbouring municipalities (Figure 55) in its eastern and southern part (Buje, Bartonigla, Novigrad, Grožnjan, Oprtalj). Together they represent a functional urban area of 376.67 km^2 with 26,206 inhabitants of the population. There are 749 business entities in the area, in which 5,770 tons of generated waste from production and service activities (excluding mixed municipal waste from households) were officially recorded in 2017 (220 kg per capita).

Figure 55 – The Umag case study area.

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The largest group of generated waste in the pilot region concerned is coming from the field of packaging waste, followed by biodegradable waste, including sewage sludge from municipal wastewater treatment, industrial waste and construction waste.

Given the number of business entities and residents in the pilot region concerned, it is undeniable that a very large proportion of waste generated from production and service activities is not officially registered at all, which is especially true for generated construction waste. Officially there are only 722 tonnes recorded, which is only 28 kg per capita. In practice, however, bigger existence of construction waste is proven by many illegal landfills of such types of waste throughout the entire area under consideration.

8.2. Application of the methodology to the case study

8.2.1. Step 1: Collecting data

The data was collected and processed in accordance with the instructions for their input into the GDSE tool. All data except the coordinate system transformation has been processed with Excel. Data collecting took place in two phases.

8.2.1.1. PHASE 1

In the first phase, data on business entities that are registered and potentially operating in the area under consideration from the ORBIS DATABADE database for selected 6 Croatian municipalities were obtained. Further, data on the generated waste for registered businesses in the selected area in 2017 from the Croatian pollution register[34] were obtained and processed. From this register all necessary data on the producer, the type and amount of officially recorded waste generated were collected. However, data on waste collectors or waste sent for further process could not be obtained.

The necessary data for the processing of the collected data was obtained from the records listed below.

- **European waste catalogue (EWC) -** The classification of waste is based on the European List of Waste (Commission Decision 2000/532/EC – consolidated version) and Annex III to Directive 2008/98/EC (consolidated version). The List of Waste (EWC) provides an EU-wide common terminology for waste classification to ease waste management, including for hazardous waste. The assignment of EWC codes serves in a broad variety of activities, including the transport of waste, installation permits (which often refer also to specific waste codes), or as a basis for waste statistics;

- **Croatian Agency for Environment and Nature (HAOP) -** The Croatian Agency (HAOP) publishes data from the environmental pollution register every year on its websites. Data export is possible for the following data sums:

  - Year;
  - Company registration number (OIB);

[34] http://roo.azo.hr/rpt.html?rpt=pi2&pbl=roo#

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- Identification number of the subject (MBS) or registration number of trades (MBO);
- Operator;
- Name of the organizational unit at the location;
- Street and house number of the organizational unit;
- The postal code of the organizational unit;
- City / settlement of the organizational unit;
- Organizational unit county;
- HTRS 96 TM Organizational Unit Coordinates (E);
- HTRS 96 TM Organizational Unit Coordinates (N);
- NKD activity (code);
- NKD activity (description);
- Activity according to Annex 1 (code);
- Activity according to Annex 1 (name);
- Key Waste Number;
- Waste name;
- Dangerous / jeopardous waste;
- The amount of waste generated (t).

- **Local administrative units (LAU - NUTS) in xlsx -** The Nomenclature of Territorial Units for Statistics is **a geocode standard for referencing the subdivisions of countries for statistical purposes. The standard is developed and** regulated by the European Union, and thus only covers the member states of the EU in detail. The Nomenclature of Territorial Units for Statistics is instrumental in the European Union's Structural Fund delivery mechanisms and for locating the area, where goods and services subject to European public procurement legislation.

- **Coordinate Transformations (Gauss–Krüger coordinate system to WGS84) in csv -** The national horizontal coordinate system with the code D48 / GK is a coordinate system that was established in the territory of the former Yugoslavia. The World Geodetic System (WGS) is a standard for use in cartography, geodesy, and satellite navigation including GPS. It comprises a standard coordinate system for the Earth, a standard spheroidal reference surface (the datum or reference ellipsoid) for raw altitude data, and a gravitational equipotential surface (the geoid) that defines the nominal sea level. Conversion of coordinates between WGS84 and Gauss–Krüger projections[35]; the application automatically recognizes input coordinate system. The application supports CSV and GPX file formats. In the CSV file, coordinates have to use a decimal point and be separated by a comma. Supported coordinates systems: WGS84, Gauss–Krüger 5th, 6th, and 7th zone, HTRS96/TM.

[35] https://gauss.svemir.co/#uploadfil

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8.2.1.2. PHASE 2

In the second phase, data have been assessed and refined. Data were divided, into individual parts, accordingly to the Bulk Data Upload Procedure in GDSE. The Excel tool was also used for this part of the data processing. The xls format files were loaded into the GDSE tool. For the last step, namely step 8, which is referring to the identification of waste streams, the data could not be processed from publicly accessible records.

8.2.2. Step 2: Selection CINDERELA waste streams

This step is common for all the case studies. See the CINDERELA EWC LIST in Table 2. On the basis of collected and processed data on waste generated in 2017, a list of wastes according to EWC codes and annually non-hazardous waste generated by producers, which together account for 80% of all annual waste generated, was created for the selected case study area (Table 24).

Table 24 – Quantities of waste generated in the Umag case study.

Labels	Quantity (kg)	Share of total mass	% total mass
15 01 05	826,580	0.16	15.86
20 02 01	579,530	0.11	11.12
19 08 05	518,980	0.10	9.96
12 01 03	386,011	0.07	7.41
15 01 01	382,350	0.07	7.33
17 09 04	377,400	0.07	7.24
15 01 02	320,079	0.06	6.14
15 01 06	264,930	0.05	5.08
19 08 09	183,050	0.,04	3.51
17 04 05	168,432	0.03	3.23
02 03 04	114,652	0.02	2.20
20 03 07	114,031	0.02	2.19
17 05 04	105,200	0.02	2.02
15 01 07	94,139	0.02	1.81
20 01 08	80,388	0.02	1.54
17 03 02	72,280	0.01	1.39

The largest group of officially recorded generated waste in the pilot region concerned (excluding mixed municipal waste from households) is coming from the field of packaging waste, followed by biodegradable waste, including sewage from urban wastewater treatment, industrial waste and construction waste.

From the list drawn up, it is obvious that the official records of the waste generated in the selected area do not cover the majority in the area generated construction waste. Since it is a predominantly tourist area with an intense construction activity and that many illegal landfills for construction waste can be found, construction waste is certainly created, but is not covered by official records. It is a very special feature of the area under consideration, which should be considered in further project activities.

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8.2.3. Step 3. Selection and delimitation of the geographical area

In the third step, the geographical area of the case study area was defined. Given the existing administrative division of Croatia by individual municipalities and counties and taking into account internationally accepted NUTS units, the territory of case study is appropriately divided (example below Table 25 - for the Municipality of Umag) and then entered into the GDSE tool based on geometric data (WGS84 EPSG: 4326).

Table 25 – Area of the Umag case study.

World	
Continent	Europe
Country	Croatia
NUTS1	
NUTS2	HR03 Jadranska Hrvatska (Adriatic Croatia)
NUTS3	HR036 Istarska županija (County of Istria)
District	
Municipality	Umag
City District	
City Neighbourhood	
City Block	
Street Section	
House	

8.2.4. Step 4. Activity Group and Activities

On basis of HOPA data processed, activity groups generating the wastes listed in the CINDERELA EWC list was identified (Figure 56). The list was then successfully entered into the GDSE tool.

code*	name
A	AGRICULTURE, FORESTRY AND FISHING
B	MINING AND QUARRYING
C	MANUFACTURING
D	ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES
F	CONSTRUCTION
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES
H	TRANSPORTATION AND STORAGE
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES
J	INFORMATION AND COMMUNICATION
K	FINANCIAL AND INSURANCE ACTIVITIES
L	REAL ESTATE ACTIVITIES
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES
N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES
O	PUBLIC ADMINISTRATION AND DEFENCE; COMPULSORY SOCIAL SECURITY
P	EDUCATION
Q	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES
R	ARTS, ENTERTAINMENT AND RECREATION
S	OTHER SERVICE ACTIVITIES

Figure 56 – Activity groups added in the Umag case study.

The activity group was followed by the entry of the activity table defined in the Annex 1 - where the 4-digit NACE codes were used.

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8.2.5. Step 5: Actors

The input of the data concerning waste producers and their locations into GDSE tool, was entered on the basis of the data obtained from official records first ORBIS DATABASE (records of business subjects in selected municipalities), and then for selected business entities from the HAOP database, and according to the use of NACE codes. From the processing of the CINDERELA NACE list, a list of companies with identified activities and their locations was generated.

The connection of the generated waste of the selected pilot area with the producers of waste according to their group of business activities is appropriately and fairly presented for practically all other groups of generated waste, except for the generated construction waste from group 17. The building waste producers are legal investors of construction works, and not construction companies, which implements construction work for their customers. However, since the generated building waste is usually reported by the contractors of construction works and not by the construction contractors themselves, the generated data on construction waste EWC Group 17, is inaccurate and does not represent the reality of the local C&D waste market.

8.2.6. Step 6: Detail description of the materials part of the waste

In Figure 57 is a section of the table that we successfully uploaded to the GDSE tool in accordance with the instructions for step 6. Although this table does not provide more detailed information on waste than the information provided by EWC code, this list was uploaded to the GDSE tool as the Croatian context and waste data situation does not provide the necessary level of details on waste data. In the Croatian context, the Agency for Environment and Nature (HAOP) collects data at the basic level of their information by the waste producers. Hence, in the case of Croatia the level of detail for material description could only reach LEVEL II. LEVEL III and LEVEL IV details could not be obtained and uploaded to the GDSE tool

parent	name*
	0203 - wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee, tea and tobacco preparation and processing; conserve production; yeast and yeast extract production, molasses preparation and fermentation
	0206 - wastes from the baking and confectionery industry
	0402 - wastes from the textile industry
0203 - wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee, tea and tobacco preparation and processing; conserve production; yeast and yeast extract production, molasses preparation and fermentation	020304 - materials unsuitable for consumption or processing
0206 - wastes from the baking and confectionery industry	020601 - materials unsuitable for consumption or processing
0402 - wastes from the textile industry	040222 - wastes from processed textile fibres

Figure 57 – Example of the Material table for the Umag case study.

8.2.7. Step 7: Waste Composition

In step 7, which regards to the composition of waste, the situation in Croatia is similar to that in step 6. The data obtained from the Croatian official records are not sufficient for this kind of further processing.

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The reason is also and above all in the construction waste specification, which are usually not assembled or packaged (bulk!), so their composition by source cannot be divided into several different assemblies. For this reason, all the information in our wastes table for the fraction section is indicated by 1 (Figure 58).

name	nace	material	fraction	hazardous	avoidable	source
C-1039 - 02 03 04	C-1039	020304 - materials unsuitable for consumption or processing	1			CroatianAgencyforEnvironmentandNatureCAEN2018
G-4711 - 02 03 04	G-4711	020304 - materials unsuitable for consumption or processing	1			CroatianAgencyforEnvironmentandNatureCAEN2018
G-4711 - 02 06 01	G-4711	020601 - materials unsuitable for consumption or processing	1			CroatianAgencyforEnvironmentandNatureCAEN2018
I-5510 - 04 02 22	I-5510	040222 - wastes from processed textile fibres	1			CroatianAgencyforEnvironmentandNatureCAEN2018
C-2229 - 07 02 04*	C-2229	070204* - other organic solvents, washing liquids and mother liquors	1			CroatianAgencyforEnvironmentandNatureCAEN2018
C-1813 - 07 02 08*	C-1813	070208* - other still bottoms and reaction residues	1			CroatianAgencyforEnvironmentandNatureCAEN2018

Figure 58 – Example of the Waste composition table for the Umag case study.

8.2.8. Step 8: Flows and stocks

The business model CinderCEBM, which we are developing in the project, is the first step based on the analysis of existing waste streams in urban and peri- urban areas. In order to be able to carry out data modelling and test processing of waste masses of selected business entities in 2017 in the Municipality of Umag and five neighbouring municipalities, we would need the data that companies / waste generators record on the record sheets during the transfer of waste. On the website of the Croatian Environment Agency (HAOP) there is public access to the annual reports on the management of waste of individual waste producers (pdf), but it does not include data on further flows of waste thus generated (for example, from company to individual collector / processor / waste disposal).

Since we do not have the necessary data on relocating the generated waste, the last step of 8, which refers to the identification of waste flows, could not be executed fully, but we have managed to do the visualization regarding the stocks in this area.

8.2.9. Step 9: Visualization and analysis

Sankey diagram and geographical visualisation (Figure 59 and Figure 60) have been created based on the data from official data bases, as mentioned in step 8.

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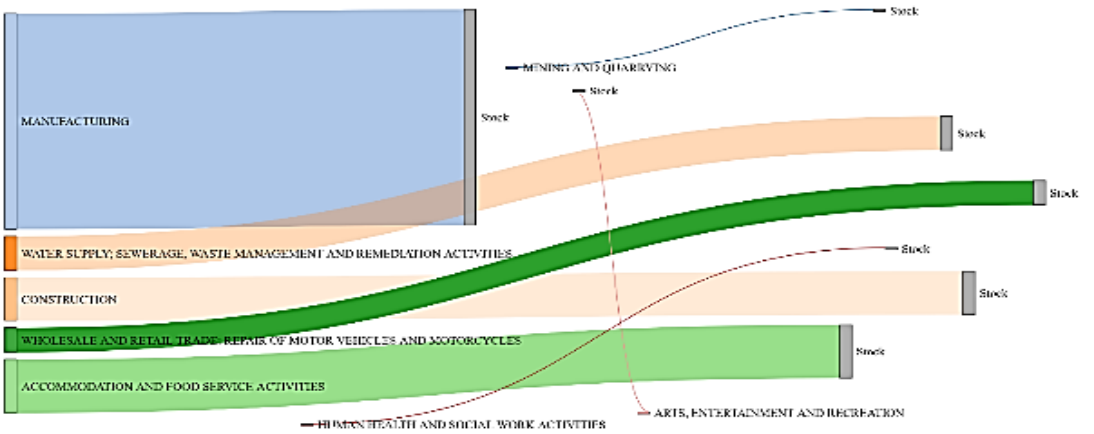

Figure 59 – Sankey diagram of the Umag case study.

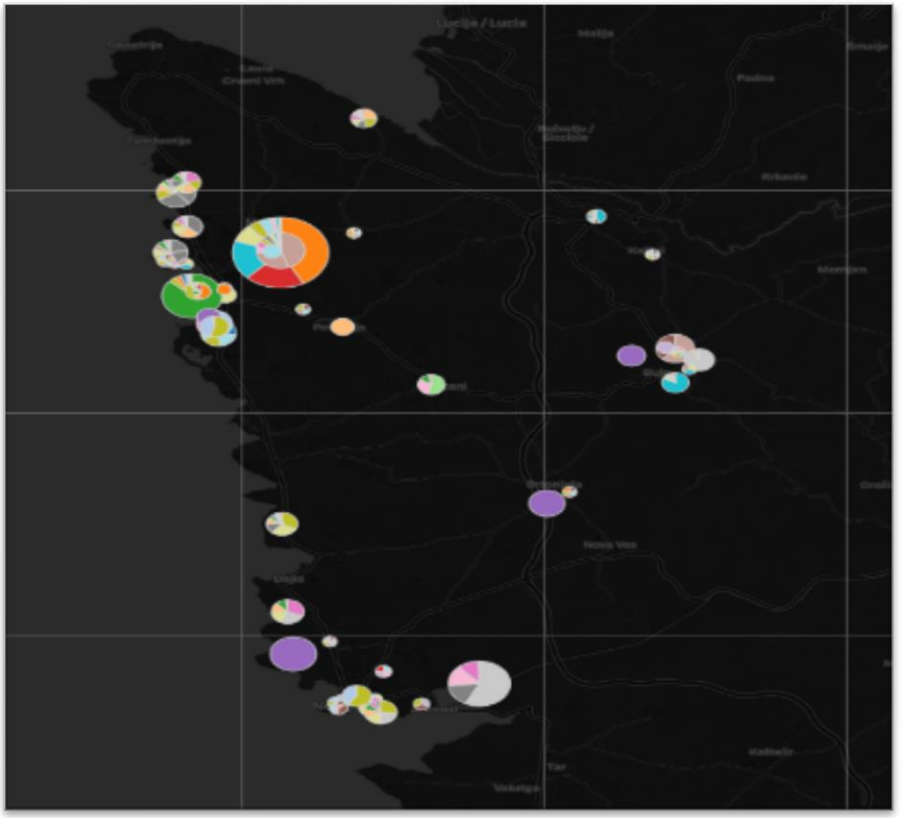

Figure 60 – Visualisation of materials by stock of the Umag case study.

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9. CONCLUSIONS

The analysis of waste in certain urban/regional area is important for the establishment of CinderCEBM and assessment of business model viability. The CinderCEBM end-users need to have initial information about the waste in the selected area and appropriate methodology to funnel down the most viable waste streams. Proper data on available resources and their current and projected flows is a critical enabler of the CINDERELA business model.

First observations show that there are great differences in the waste data obtained from the six European regions studied in CINDERELA. Even though the EU Member States are obliged to carry out appropriate registers, only some countries have data resources available and accessible in formats enabling an easy and correct quantification and classification of wastes from different streams. Others, however, either refuse to provide access to the data for other than reporting purposes or do not have the data available in structured formats. Even if waste flow data is not necessary for the assessment of technical feasibility and setting up of the pilots, to be able to assess the full business potential of a solution, ***accessible and accurate data on waste generation and current flows in a specific region are crucial for the analysis and assessment of the waste stream suitability as a source of SRM.***

One of the key issues is that getting data on the types, locations and the actors behind the specific waste streams is challenging. Even if it is a formal EU requirement for countries to collect and store the data on waste generation and treatment methods, data formats differ per country and data accessibility for other than reporting purposes is not formalised.

On basis of the observations made during the implementation of the AS-MFA and especially in relation to the access to quality data on waste, it seems that the waste data has not reached the same level of maturity in all countries. Indeed, the experience gained in some CINDERELA case studies indicates (as it could be expected, given the very diverse policy, legal contexts, governance models, cultural contexts in the EU-27) that the administrations in charge of the management of waste data are yet not all at the same level of readiness to provide on demand tailored waste data sets as needed by the market. At least, such procedures are not yet formalized neither legally, nor technically or procedurally. In a context of European economies switching towards more circular business models in which the recirculation of wasted materials will become more important, demands for waste data are anticipated to become more frequent. Hence, it could be estimated that waste related governmental datasets will need to become more mature and data access tools will need to be developed to enable rapid, secure and reliable deployment of governmental data to support societal and environmental needs. Until such data infrastructures become reality, we estimate key areas of improvement may be found in:

- Governance of waste data management (i.e. moving from scattered, decentralized databases towards unified and centralized systems);
- Technical issues, i.e. data formats, electronic access, security issues;
- Legal issues around waste data registering obligations (see Slovenian and Croatian case studies and the ways of registering C&D waste).

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Concerning the observed challenges of data access in the CINDERELA case studies described above, these can be summarized in the following lines.

In the Basque Country, Italy, Slovenia and Katowice region, specific written and formal requests needed to be handed over to local administrations in order to obtain the data on waste streams of interest for the project. In the Basque Country data on municipal solid waste were available from public data sources while those related to industrial waste were only available aggregated by industrial sector, therefore flows from company to company could only be obtained after official written request to local authorities. Taking this into account, data could be provided but with some delay, not allowing to integrate these in the deliverable D3.1. As no demonstration plant for valorization of SRM will be implemented in the Basque Country, the absence of such data for the continuation of the project has no major impact. In the case of the Basque Country, the completion of task 3.1 has been reached for municipal solid waste and has allowed the project team to learn about the overall process of generating flow maps via the GDSE tool as well as experience the challenges of data collection necessary for the future business model evaluations in the local context.

The case of Slovenia was similar to the Basque Country. Although CINDERELA's Slovenian partners NIGRAD and ZAG had public access to aggregated data, they encountered a major difficulty because the waste data format was not readily exploitable for the purpose of CINDERELA. This problem could be solved after some data processing measures implemented by NIGRAD. Regarding the flows from company to company, ZAG obtained the needed information after a formal request to the responsible public authorities.

In the case of Katowice, and Poland in general, access to waste data from regional databases system is formally reserved for local and state administration units, not allowing CINDERELA's contact point (IETU) direct access to these data despite requesting them to the local authorities.

To overcome this barrier, polish partner IETU used publicly available reports on waste data regularly delivered by the local administration. As data contained in these reports were:

- Not systematically available in a digital exploitable form (yearly regional waste reports in pdf files were available in July of next year); and
- Only little tailored for the purpose of the project (i.e. level of disaggregation not systematically sufficient, no information on waste's fate etc.).

IETU had to invest special efforts to trace back waste amounts, (i.e. by crossing information from different sources) and link these with their respective producers or recipients. The information provided to CINDERELA's polish partner IETU by the local authorities and the data available through other means, did not allow estimating waste flows between actors in the study area. Hence, in the case of Katowice study area, information provided and uploaded to GDSE tool only enabled to geo-localize waste stocks. However, even though the objective of the exercise was not fully reached (i.e. representation of waste flows), we estimate that the information provided through CINDERELA's tools, represents already a step forward for supporting local stakeholders to identify opportunities for valorizing wastes into secondary raw materials for the construction sector.

In the Italian region of Trento, data on waste could be obtained from the Provincial Agency for Environmental Protection (APPA) despite some issues as mentioned in earlier sections. Although some

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minor data processing was required before uploading these on the GDSE tool (i.e. checking data validity of companies within APPA's database), waste flows could be obtained for the study region.

In the case of Umag in Croatia, visualization of waste flows could not be generated as, despite the availability of data on the quantities of waste produced by individual waste producers, there were no information available on further fate of wastes. Hence, similarly to the polish case of Katowice (see above), only waste stocks could be represented via GDSE tool. Again, we estimate this outcome represents already a significant step forward for supporting decision making at local level for increasing waste revalorization in the construction sector.

In consideration of possible problems of data collection that may occur in real business implementation processes, CINDERELA considers that data could be further completed by complementary means, i.e. i) consulting with local business associations (this has been done in the area of Madrid-Henares), ii) through interviews of stakeholders. Although these processes might be more time intensive, they have the advantage of mobilizing key stakeholders (i.e. waste owners) in early stages of designing new collaborative schemes for the implementation of circular economy business models for SRM in the construction sector.

Policy makers in regions and cities are key players in enabling circular economy business models. Without their support to make the proper data available, setting up business models and assessing their viability based on regionally/locally available potentials may represent challenging uncertainties and therefore pose increased risks. Nevertheless, although the information may not be optimal at the beginning, further in pilot development local stakeholders may be included to make use of their expert knowledge on local contexts of waste generation and markets.

The visualization of waste flows in Sankey diagrams and flow maps available in the GDSE tool can give important information to the CinderCEBM end-users on geographic distribution and existing value chains of selected waste streams.

The analysis of flows and stocks have allowed to investigate different opportunities of handling waste generated in the region with regards to material recovery for construction applications. If fed with the appropriate and extensive data, the tool can help selecting the most appropriate SRMs produced in the region and to make an in-depth analysis of their adequacy to serve as inputs for manufacturing new products and establishing new value chains for the needs of the circular economy business model for urban construction.

From the findings and observations during this analysis it becomes evident, that current waste data related processes and policies do not support the assessment of circular business models. Encouraging all stakeholders at regional and city level to become active players in building the necessary data infrastructures and valorising already existing data for the societal, environmental and economic benefits is necessary to overcome those mentioned difficulties. This will also facilitate their implication as end users of CinderCEBM and CinderOSS. Hence, it is expected actors would facilitate data and ensure the business model become viable and the regions would accelerate their transitions towards more circularity.

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Lessons learned from the implementation of CINDERELA stocks and flows analysis show that *the assessment and knowledge base for industrial symbiosis in Europe can be greatly enhanced through different means. Among these are the following:*

- *"Utilizing current information (related mainly to IPPC activities) to create a knowledge data-base of waste and material flows using a GIS supported downloadable software"*
- "*Introduce IS principles in strategic planning and economic development plans at the local and regional level to mapping resource flows to understand opportunities to recover material, energy, water and heat, using the "accounting" standards from the knowledge base*"

These solutions are in line with the ***key policy recommendations*** listed in the report "Cooperation fostering industrial symbiosis market potential, good practice and policy actions[36]" issued by the Commission in 2018.

Taking stock of the observations and conclusions learned so far, we estimate that AS-MFA and GDSE tools represent key elements to be introduced in the future CinderCEBM and CinderOSS. We estimate that its impact on accelerating the implementation of wider Industrial Symbiosis projects in Europe would be considerable.

In practical terms, we estimate that the outcomes of Task 3.1 are important also for the following tasks and WPs within CINDERELA:

- Task 3.2, 3.3 and 3.4: information for selection of top wastes on the case of which valorization approach (technological valorization), value chain study and other characteristics of use cases will be applied;
- WP4: Methodology and GDSE tool for the initial development of CinderCEBM and CinderOSS;
- WP5: Information on wastes for testing and development of SRM based construction products for large scale demonstrations;
- WP6: Information on local environment and selection of materials for large scale demonstrations;
- WP7: Information for the LCA and ETV assessments.

[36] Cooperation fostering industrial symbiosis: market potential, good practice and policy. https://publications.europa.eu/en/publication-detail/-/publication/174996c9-3947-11e8-b5fe-01aa75ed71a1/language-en

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10. ANNEXES

Annex 1 - List of common activities to upload into the GDSE tool.

Annex 2 - Template of Letter to Environmental agencies requesting data.

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10.1. Annex 1 - List of common activities to upload into the GDSE tool.

NACE	Name	AG
A-0111	A-0111 Growing of cereals (except rice), leguminous crops and oil seeds	A
A-0112	A-0112 Growing of rice	A
A-0113	A-0113 Growing of vegetables and melons, roots and tubers	A
A-0114	A-0114 Growing of sugar cane	A
A-0115	A-0115 Growing of tobacco	A
A-0116	A-0116 Growing of fibre crops	A
A-0119	A-0119 Growing of other non-perennial crops	A
A-0121	A-0121 Growing of grapes	A
A-0122	A-0122 Growing of tropical and subtropical fruits	A
A-0123	A-0123 Growing of citrus fruits	A
A-0124	A-0124 Growing of pome fruits and stone fruits	A
A-0125	A-0125 Growing of other tree and bush fruits and nuts	A
A-0126	A-0126 Growing of oleaginous fruits	A
A-0127	A-0127 Growing of beverage crops	A
A-0128	A-0128 Growing of spices, aromatic, drug and pharmaceutical crops	A
A-0129	A-0129 Growing of other perennial crops	A
A-0130	A-0130 Plant propagation	A
A-0141	A-0141 Raising of dairy cattle	A
A-0142	A-0142 Raising of other cattle and buffaloes	A
A-0143	A-0143 Raising of horses and other equines	A
A-0144	A-0144 Raising of camels and camelids	A
A-0145	A-0145 Raising of sheep and goats	A
A-0146	A-0146 Raising of swine/pigs	A
A-0147	A-0147 Raising of poultry	A
A-0149	A-0149 Raising of other animals	A
A-0150	A-0150 Mixed farming	A
A-0161	A-0161 Support activities for crop production	A
A-0162	A-0162 Support activities for animal production	A
A-0163	A-0163 Post-harvest crop activities	A
A-0164	A-0164 Seed processing for propagation	A
A-0170	A-0170 Hunting, trapping and related service activities	A
A-0210	A-0210 Silviculture and other forestry activities	A
A-0220	A-0220 Logging	A
A-0230	A-0230 Gathering of wild growing non-wood products	A
A-0240	A-0240 Support services to forestry	A
A-0311	A-0311 Marine fishing	A
A-0312	A-0312 Freshwater fishing	A
A-0321	A-0321 Marine aquaculture	A
A-0322	A-0322 Freshwater aquaculture	A
B-0510	B-0510 Mining of hard coal	B
B-0520	B-0520 Mining of lignite	B
B-0610	B-0610 Extraction of crude petroleum	B

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NACE	Name	AG
B-0620	B-0620 Extraction of natural gas	B
B-0710	B-0710 Mining of iron ores	B
B-0721	B-0721 Mining of uranium and thorium ores	B
B-0729	B-0729 Mining of other non-ferrous metal ores	B
B-0811	B-0811 Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate	B
B-0812	B-0812 Operation of gravel and sand pits; mining of clays and kaolin	B
B-0891	B-0891 Mining of chemical and fertiliser minerals	B
B-0892	B-0892 Extraction of peat	B
B-0893	B-0893 Extraction of salt	B
B-0899	B-0899 Other mining and quarrying n.e.c.	B
B-0910	B-0910 Support activities for petroleum and natural gas extraction	B
B-0990	B-0990 Support activities for other mining and quarrying	B
C-1011	C-1011 Processing and preserving of meat	C
C-1012	C-1012 Processing and preserving of poultry meat	C
C-1013	C-1013 Production of meat and poultry meat products	C
C-1020	C-1020 Processing and preserving of fish, crustaceans and molluscs	C
C-1031	C-1031 Processing and preserving of potatoes	C
C-1032	C-1032 Manufacture of fruit and vegetable juice	C
C-1039	C-1039 Other processing and preserving of fruit and vegetables	C
C-1041	C-1041 Manufacture of oils and fats	C
C-1042	C-1042 Manufacture of margarine and similar edible fats	C
C-1051	C-1051 Operation of dairies and cheese making	C
C-1052	C-1052 Manufacture of ice cream	C
C-1061	C-1061 Manufacture of grain mill products	C
C-1062	C-1062 Manufacture of starches and starch products	C
C-1071	C-1071 Manufacture of bread; manufacture of fresh pastry goods and cakes	C
C-1072	C-1072 Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes	C
C-1073	C-1073 Manufacture of macaroni, noodles, couscous and similar farinaceous products	C
C-1081	C-1081 Manufacture of sugar	C
C-1082	C-1082 Manufacture of cocoa, chocolate and sugar confectionery	C
C-1083	C-1083 Processing of tea and coffee	C
C-1084	C-1084 Manufacture of condiments and seasonings	C
C-1085	C-1085 Manufacture of prepared meals and dishes	C
C-1086	C-1086 Manufacture of homogenised food preparations and dietetic food	C
C-1089	C-1089 Manufacture of other food products n.e.c.	C
C-1101	C-1101 Distilling, rectifying and blending of spirits	C
C-1102	C-1102 Manufacture of wine from grape	C
C-1103	C-1103 Manufacture of cider and other fruit wines	C
C-1104	C-1104 Manufacture of other non-distilled fermented beverages	C
C-1105	C-1105 Manufacture of beer	C
C-1106	C-1106 Manufacture of malt	C
C-1107	C-1107 Manufacture of soft drinks; production of mineral waters and other bottled waters	C
C-1200	C-1200 Manufacture of tobacco products	C

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NACE	Name	AG
C-1310	C-1310 Preparation and spinning of textile fibres	C
C-1320	C-1320 Weaving of textiles	C
C-1330	C-1330 Finishing of textiles	C
C-1391	C-1391 Manufacture of knitted and crocheted fabrics	C
C-1392	C-1392 Manufacture of made-up textile articles, except apparel	C
C-1393	C-1393 Manufacture of carpets and rugs	C
C-1394	C-1394 Manufacture of cordage, rope, twine and netting	C
C-1395	C-1395 Manufacture of non-wovens and articles made from non-wovens, except apparel	C
C-1396	C-1396 Manufacture of other technical and industrial textiles	C
C-1399	C-1399 Manufacture of other textiles n.e.c.	C
C-1411	C-1411 Manufacture of leather clothes	C
C-1511	C-1511 Tanning and dressing of leather; dressing and dyeing of fur	C
C-1512	C-1512 Manufacture of luggage, handbags and the like, saddlery and harness	C
C-1520	C-1520 Manufacture of footwear	C
C-1610	C-1610 Sawmilling and planing of wood	C
C-1621	C-1621 Manufacture of veneer sheets and wood-based panels	C
C-1622	C-1622 Manufacture of assembled parquet floors	C
C-1623	C-1623 Manufacture of other builders' carpentry and joinery	C
C-1624	C-1624 Manufacture of wooden containers	C
C-1629	C-1629 Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials	C
C-1711	C-1711 Manufacture of pulp	C
C-1712	C-1712 Manufacture of paper and paperboard	C
C-1811	C-1811 Printing of newspapers	C
C-1812	C-1812 Other printing	C
C-1813	C-1813 Pre-press and pre-media services	C
C-1814	C-1814 Binding and related services	C
C-1910	C-1910 Manufacture of coke oven products	C
C-1920	C-1920 Manufacture of refined petroleum products	C
C-2011	C-2011 Manufacture of industrial gases	C
C-2012	C-2012 Manufacture of dyes and pigments	C
C-2013	C-2013 Manufacture of other inorganic basic chemicals	C
C-2014	C-2014 Manufacture of other organic basic chemicals	C
C-2015	C-2015 Manufacture of fertilisers and nitrogen compounds	C
C-2016	C-2016 Manufacture of plastics in primary forms	C
C-2017	C-2017 Manufacture of synthetic rubber in primary forms	C
C-2020	C-2020 Manufacture of pesticides and other agrochemical products	C
C-2030	C-2030 Manufacture of paints, varnishes and similar coatings, printing ink and mastics	C
C-2041	C-2041 Manufacture of soap and detergents, cleaning and polishing preparations	C
C-2042	C-2042 Manufacture of perfumes and toilet preparations	C
C-2051	C-2051 Manufacture of explosives	C
C-2052	C-2052 Manufacture of glues	C
C-2053	C-2053 Manufacture of essential oils	C
C-2059	C-2059 Manufacture of other chemical products n.e.c.	C

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NACE	Name	AG
C-2060	C-2060 Manufacture of man-made fibres	C
C-2110	C-2110 Manufacture of basic pharmaceutical products	C
C-2120	C-2120 Manufacture of pharmaceutical preparations	C
C-2211	C-2211 Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres	C
C-2219	C-2219 Manufacture of other rubber products	C
C-2221	C-2221 Manufacture of plastic plates, sheets, tubes and profiles	C
C-2222	C-2222 Manufacture of plastic packing goods	C
C-2223	C-2223 Manufacture of builders ware of plastic	C
C-2229	C-2229 Manufacture of other plastic products	C
C-2311	C-2311 Manufacture of flat glass	C
C-2312	C-2312 Shaping and processing of flat glass	C
C-2313	C-2313 Manufacture of hollow glass	C
C-2314	C-2314 Manufacture of glass fibres	C
C-2319	C-2319 Manufacture and processing of other glass, including technical glassware	C
C-2320	C-2320 Manufacture of refractory products	C
C-2331	C-2331 Manufacture of ceramic tiles and flags	C
C-2332	C-2332 Manufacture of bricks, tiles and construction products, in baked clay	C
C-2341	C-2341 Manufacture of ceramic household and ornamental articles	C
C-2342	C-2342 Manufacture of ceramic sanitary fixtures	C
C-2343	C-2343 Manufacture of ceramic insulators and insulating fittings	C
C-2344	C-2344 Manufacture of other technical ceramic products	C
C-2349	C-2349 Manufacture of other ceramic products	C
C-2351	C-2351 Manufacture of cement	C
C-2352	C-2352 Manufacture of lime and plaster	C
C-2361	C-2361 Manufacture of concrete products for construction purposes	C
C-2362	C-2362 Manufacture of plaster products for construction purposes	C
C-2363	C-2363 Manufacture of ready-mixed concrete	C
C-2364	C-2364 Manufacture of mortars	C
C-2365	C-2365 Manufacture of fibre cement	C
C-2369	C-2369 Manufacture of other articles of concrete, plaster and cement	C
C-2410	C-2410 Manufacture of basic iron and steel and of ferro-alloys	C
C-2442	C-2442 Aluminium production	C
C-2443	C-2443 Lead, zinc and tin production	C
C-2444	C-2444 Copper production	C
C-2445	C-2445 Other non-ferrous metal production	C
C-2451	C-2451 Casting of iron	C
C-2452	C-2452 Casting of steel	C
C-2453	C-2453 Casting of light metals	C
C-2454	C-2454 Casting of other non-ferrous metals	C
C-2540	C-2540 Manufacture of weapons and ammunition	C
C-2561	C-2561 Treatment and coating of metals	C
C-2562	C-2562 Machining	C
C-3101	C-3101 Manufacture of office and shop furniture	C

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NACE	Name	AG
C-3102	C-3102 Manufacture of kitchen furniture	C
C-3103	C-3103 Manufacture of mattresses	C
C-3109	C-3109 Manufacture of other furniture	C
C-3312	C-3312 Repair of machinery	C
D-3511	D-3511 Production of electricity	D
D-3530	D-3530 Steam and air conditioning supply	D
E-3600	E-3600 Water collection, treatment and supply	E
E-3700	E-3700 Sewerage	E
E-3811	E-3811 Collection of non-hazardous waste	E
E-3812	E-3812 Collection of hazardous waste	E
E-3821	E-3821 Treatment and disposal of non-hazardous waste	E
E-3822	E-3822 Treatment and disposal of hazardous waste	E
E-3831	E-3831 Dismantling of wrecks	E
E-3832	E-3832 Recovery of sorted materials	E
E-3900	E-3900 Remediation activities and other waste management services	E
F-4110	F-4110 Development of building projects	F
F-4120	F-4120 Construction of residential and non-residential buildings	F
F-4211	F-4211 Construction of roads and motorways	F
F-4212	F-4212 Construction of railways and underground railways	F
F-4213	F-4213 Construction of bridges and tunnels	F
F-4221	F-4221 Construction of utility projects for fluids	F
F-4222	F-4222 Construction of utility projects for electricity and telecommunications	F
F-4291	F-4291 Construction of water projects	F
F-4299	F-4299 Construction of other civil engineering projects n.e.c.	F
F-4311	F-4311 Demolition	F
F-4312	F-4312 Site preparation	F
F-4313	F-4313 Test drilling and boring	F
F-4321	F-4321 Electrical installation	F
F-4322	F-4322 Plumbing, heat and air-conditioning installation	F
F-4329	F-4329 Other construction installation	F
F-4331	F-4331 Plastering	F
F-4332	F-4332 Joinery installation	F
F-4333	F-4333 Floor and wall covering	F
F-4334	F-4334 Painting and glazing	F
F-4339	F-4339 Other building completion and finishing	F
F-4391	F-4391 Roofing activities	F
F-4399	F-4399 Other specialised construction activities n.e.c.	F
G-4520	G-4520 Maintenance and repair of motor vehicles	G
G-4675	G-4675 Wholesale of chemical products	G
G-4677	G-4677 Wholesale of waste and scrap	G
G-4730	G-4730 Retail sale of automotive fuel in specialised stores	G
H-5010	H-5010 Sea and coastal passenger water transport	H
H-5020	H-5020 Sea and coastal freight water transport	H
H-5030	H-5030 Inland passenger water transport	H

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NACE	Name	AG
H-5040	H-5040 Inland freight water transport	H
M-7420	M-7420 Photographic activities	M
M-7500	M-7500 Veterinary activities	M
Q-8610	Q-8610 Hospital activities	Q
Q-8621	Q-8621 General medical practice activities	Q
Q-8622	Q-8622 Specialist medical practice activities	Q
Q-8623	Q-8623 Dental practice activities	Q
Q-8690	Q-8690 Other human health activities	Q
Q-8710	Q-8710 Residential nursing care activities	Q
Q-8720	Q-8720 Residential care activities for mental retardation, mental health and substance abuse	Q
Q-8730	Q-8730 Residential care activities for the elderly and disabled	Q
Q-8790	Q-8790 Other residential care activities	Q
S-9524	S-9524 Repair of furniture and home furnishings	S
S-9603	S-9603 Funeral and related activities	S
T-9700	T-9700 Activities of households as employers of domestic personnel	T
T-9810	T-9810 Undifferentiated goods-producing activities of private households for own use	T
T-9820	T-9820 Undifferentiated service-producing activities of private households for own use	T

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10.2. Annex 2 - Template of Letter to Environmental agencies requesting data.

Slovenian National Building and Civil Engineering Institute - ZAG
Dimičeva ulica 12
SI-1000 Ljubljana

Slovenian Environmental Agency
Vojkova 1b
SI-1000 Ljubljana

Ljubljana, 29.01.2019

Subject: Request to access electronic record sheets in "IS-Odpadki" system

Slovenian National Building and Civil Engineering Institute – ZAG is coordinator of an innovative project funded by Horizon 2020 EU financial instrument, entitled **CINDERELA - New Circular Economy Business Models for More Sustainable Urban Construction**. The main objective of the CINDERELA project is to establish a circular business model and one stop shop service for resource-efficient urban construction with use of secondary raw materials (SRM), which are produced from different waste in the same urban and peri-urban area. With construction products, based on secondary raw materials, such as recycled aggregates, recycled soil and innovative building composites, the project consortium will carry out 11 pilot demonstrations in three European cities: Maribor (Slovenia), Umag (Croatia) and Madrid (Spain). These pilot demonstrations are: establishment of SRM based construction products pilot production, extraction of phosphorous from waste water, construction of roads, facilities and revitalization of degraded areas. Beside ZAG, 12 other partners from across Europe (Spain, Italy, The Netherlands, Poland, Serbia, Croatia and Slovenia) are included in the project (Annex1).

The new business model called CinderCEBM, which is developed in the project, is in its initial phase based on waste flow analysis carried out in urban areas. In order to carry such modelling in one of the seven use-cases of the project, i.e. Maribor and surrounding municipalities, we would need data for year 2016 as annually reported by companies to Slovenian Environmental Agency. There are already available annual data on waste management by individual polluters on the web pages of the Agency (in pdf), never the less this data does not include waste flows (e.g. from company to company or from company to landfill). Therefore, we would like to ask you to grant us access to electronic record sheets from "IS-Odpadki" for 22 municipalities around Maribor (Annex 2).

By granting access to electronic record sheets in selected area we would be able to finish modelling in stated area. Maribor use-case is one of 7 European use-cases with waste flow modelling.

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Others are: Basque county (Spain), Trento (Italy), Pordenone (Italy), Umag (Croatia), Katowice (Poland) and Amsterdam (The Netherlands). The waste flow modelling is made with GDSE tool (Annex 3), which is dedicated mass flow modelling tool developed by TuDelft, partner in the project. We think that methodology itself and tool (which is open accessed) as well as results of modelling and stakeholder interaction around Europe would be interesting inputs for the Environmental Agency of Slovenia. On the other hand with your valuable input we would be able to successfully finish the modelling of waste flow in selected Slovenian use-case and by this achieve one of the objectives of the project.

For any additional information please don't hesitate to contact us.

With kind regards

Assist. Prof. Dr. Ana Mladenovič

CINDERELA Project Coordinator

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