Interreg North-West Europe
RAWFILL
European Regional Development Fund
Co-funded by the Walloon region

WP T3 – Deliverable 1.2. – ELIF Performance report

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1. Introduction

The ELIF [1] (Enhanced Landfill Inventory Framework) is a landfill inventory structure focused on information regarding resources that can be extracted from a landfill (materials, energy carriers and land) and information useful for a landfill mining (LFM) project developer at technical, economical, environmental and social point of view. ELIF is used to describe landfills not only in terms of environmental and risk issues, but focuses on the quality and the quantity of dormant materials lying on them, in order to supply relevant data for stakeholders involved in enhanced landfill mining (ELFM)[2] projects. It supplies a first set of quantified information allowing to evaluate at first sight the pre-feasibility and feasibility of a LFM project. This approach is innovative, as no known landfill inventory among the 34 inventories[3] analyzed contains such ELFM-driven information (*for more information, see Deliverable WP T1.1.1 - Current Inventories Structure Report*).

There are finally three main drivers related to a decision to launch an ELFM project:

- An **economic driver** related to material valorization and land reclaiming;
- A **territorial strategy driver** related to the planned local/regional land development;
- An **environmental driver** related to environmental and human health issues.

ELIF structure took these drivers into account, although its structure will be proposed in four sections: landfill ID Card, surroundings, landfill geometry and waste.

ELIF is the base of the Decision Support Tool (DST) *(Deliverable WP T2.3.1 - DST software tool)* and so a prerequisite to assess feasibility, business plans & business cases *(Deliverable WP T3.2.2 - Business cases)* for launching profitable projects. DST is a ranking tool that will allow ELFM projects prioritization based on a set of suitable physical, chemical, environmental, technical and social information. It integrates multiple aspects involved in ELFM projects, i.e. economic, technical, environmental & social factors in order to compare and classify landfills regarding their ELFM interest. The main source of information for DST will be extracted from an ELIF-compatible database.

2. ELIF improvement steps

[1] In the RAWFILL's application form, the term EIF (Enhanced inventory framework) was employed. For a better understanding, we have decided to transform this term into ELIF (Enhanced Landfill Inventory Framework).
[2] A complete definition of ELFM can be found here: https://eurelco.org/definition/.
[3] From Belgium, France, United Kingdom, Denmark, Germany, Sweden and Greece. These inventories mostly contained environmental information.

The ELIF structure has been defined after:

- a deep analysis of the existing inventories structures (*see Deliverable WP T1.1.1 - Current Inventories Structure Report*) within NWE Europe, gathered through a questionnaire sent by the RAWFILL project partners (PPs) in their own region/country, with the support of some organizations such as EURELCO;
- a benchmark of existing LFM initiatives (*see Deliverable WP T1.1.2 – Benchmark of landfill mining initiatives*) and an analysis of success and failure factors regarding landfill surveys and material valorizations;
- a benchmark of existing survey methods, in order to define relevant indicators regarding waste quantities and qualities.

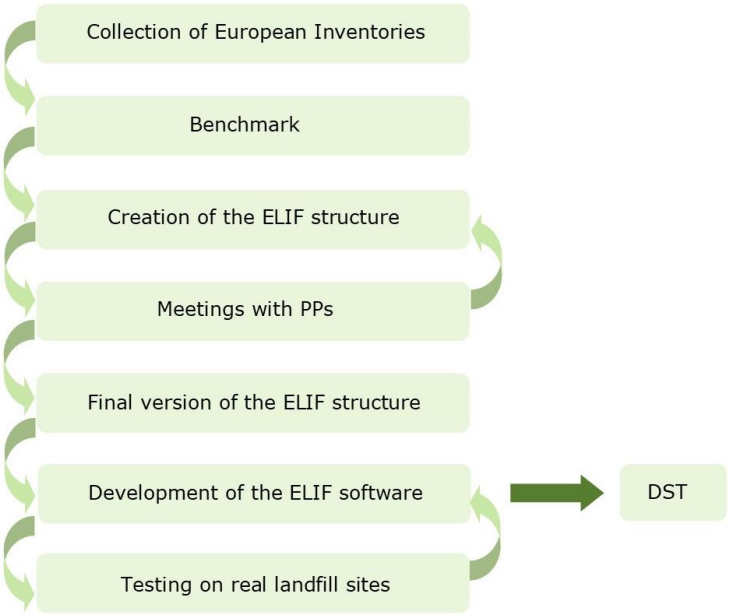


Figure 1 – Scheme illustrating the different steps to create the ELIF structure and the ELIF software.

Deep interactions between PPs were necessary to define and fine-tune the list of indicators that will be used by the DST-1 "Cedalion" and DST-2 "Orion" (**Fig. 1**). Several spreadsheets were developed in order to allow landfill inventories managers to fill a first database and import/export data to their own existing systems.

3. Review of ELIF fields

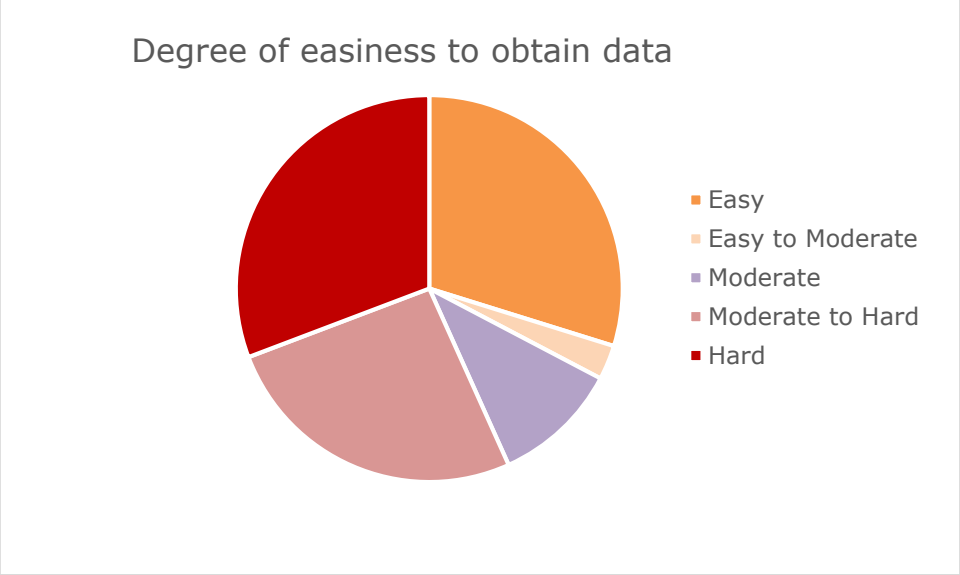
The **Table 1** (see below) shows all the indicators included in the ELIF. The definition of each field can be found in the *Deliverable T1.4.1. - List of Enhanced Landfill Inventory Framework Indicators*. The easiness to complete the field and their integration in the DSTs were reviewed. In order to determine the degree of easiness to obtain the information, a relatively simple scale (i.e. easy – moderate – hard) was used. It was defined as follows:

- *Easy:* the information is available for everybody without specific requests. For instance, the landfill coordinates can be found directly on Google Earth or the average level of ground permeability based on geological maps that are available on line.
- *Moderate:* the information is available for everybody but requires extra effort with moderate costs to have it. For example, a site visit is needed to assess the surface state of the landfill.
- *Hard:* the information is not available for everybody, only specialist/expert working in the field can have access to it. It requires a lot of effort to obtain it (ex: waste sampling, geophysics survey, laboratory waste analysis, etc.).

The results are presented in **Figure 2** and can be summarized as follows:

- 33% of the fields contained in the ELIF are relatively easy to moderate to fill;
- 36% are moderate to hard to fill;
- 31% of the hard to fill.

Figure 2 – Graph showing the degree of easiness to fill the fields defined in the ELIF.



The development of the DSTs is based on the ELIF fields. 32% of the ELIF fields were selected to be directly used in the DST 1 - Cedalion[4] and 28 % of the ELIF fields are employed in the DST 2 - Orion and/or in the associated tools (e.g., ONTOL, Hombre - Opportunity matrix)[4]. All the other fields that were not directly used in the DSTs, so not used to rank landfills, are however necessary, as they will supply useful information for a project developer when the landfill will be selected for further steps (e.g., interim use, creation of a business case).

[4] The fields from the RDM (resource distribution model) that can be only filled after investigation surveys (i.e. geophysics and waste sampling) and the additional not-ranked information were not taken into account in the computation.

	Fields	ELIF section	Easiness to obtain the information	Presence in the DST	Fields equivalence in the DSTs
1	Name & Other name 1	Landfill description	Easy	DST 1, DST 2	Landfill name
2	Site reference	Landfill description	Easy	DST 1	
3	Address (Street, Postal Code, City, Country)	Landfill description	Easy	DST 1	
4	Coordinates (X,Y)	Landfill description	Easy	DST 1	X coordinate Y coordinate
5	Site area	Landfill description/Waste description	Easy	DST 1	Surface area
6	Administration in charge	Landfill description	Easy		
7	Land plot codes	Landfill description	Easy	DST 1	Cadastral codes
8	Name of the site Owner	Landfill description	Moderate		
9	Surface occupied by waste	Waste description	Moderate to Hard	DST 1, DST 2	Surface area (DST 1) Landfill area (DST 2 -OnTol)
10	Total Waste Volume	Waste description	Hard	DST 1, DST 2	Volume (DST 1), V (DST 2) Landfill size (DST 2 -OnTol)
11	Type of Waste : • Ferrous metals • Non-ferrous metals • Cardboard/paper • Plastics • Glass/ceramic	Waste description	Hard	DST 2 (OnTol)	• Fe metals • Al, Cu • Paper • Plastics

	• Stone/concrete • Rubber • Textile • Wood • Organic • Hazardous waste • Fine matrix				• Stones & inerts • Textiles • Wood • Organic matter • Hazadous
12	Waste characterization (Volume, Density, Weight, Recovery factor, Tons recovered, Price (€)/Tonne recovered, Evacuation cost (€)/Tonne, Cost or Benefit /Tonne)	Waste description	Hard	DST 2 (OnTol)	Price (steel scrap, aluminum scrap, copper scrap, plastics, aggregates) (DST 2 – OnTol)
13	Void space value	Waste description	Hard	DST 2 (OnTol)	Recovered landfill volume value (DST 2 – OnTol)
14	Main waste type	Waste description/Economical form	Moderate to Hard	DST 1	Criteria 1 - Type
15	Monolandfill	Waste description	Moderate to Hard	DST 1, DST 2	Monolandfill
16	Specific waste stream • Dredging sludge • Construction waste • Water purification sludge • Gypsum • Fly ash • Asbestos • Slags • Mining waste • Lime • Contaminated soils • Other	Waste description/Economical form	Moderate to Hard	DST 1	• Dredging materials • Inert • WWT sludge • Fly ash • Asbestos • Metal slags • Mining waste • Other

17	Radioactive waste	Waste description/Economical form	Hard	DST 1, DST 2	Harmful waste spotted?/Hazardous waste
18	Hazardous hospital waste	Waste description/Economical form	Moderate to Hard	DST 1, DST 2	Harmful waste spotted? /Hazardous waste
19	Hazardous military waste	Waste description/Economical form	Hard	DST 1, DST 2	Military waste/Hazardous waste
20	Main physical state	Waste description/Economical form	Moderate to Hard		
21	Use of daily cover	Waste description/Economical form	Hard		
22	Cover Type	Waste description/Economical form	Moderate	DST 1	• Type of cover (DST 1)
23	% of the waste volume occupied by the cover	Waste description/Economical form	Moderate to Hard		
24	Origin of cover product	Waste description/Economical form	Moderate to Hard		
25	Waste homogeneity	Waste description/Economical form	Hard	DST 1	Nature of mixed landfill
26	Flood	Environmental form	Easy	DST 1	Flooding risk
27	Fire	Environmental form	Hard		
28	Risk of landfill's collapse	Environmental form	Moderate to Hard		
29	Person accident	Environmental form	Moderate	DST 1	Harmful waste spotted? (DST 1)
30	Direct exposition to waste, (bio)gas and/or leachate	Environmental form	Moderate	DST 1	Harmful waste spotted? (DST 1)

31	Environmental Issue	Environmental form	Moderate to Hard	DST 2 (Risk assessment model)	
32	Impact of the LFM project *(not related to water or soil issues)*	Environmental form	Moderate to Hard		
33	Surface Water (contamination)	Environmental form	Hard	DST 2 (Risk assessment model)	
34	Permeability (based on the geological context)	Environmental form	Easy	DST 2 (Risk assessment model)	
35	Groundwater type (exploited or not)	Environmental form	Moderate	DST 2 (Hombre tool)	Water Resource Efficiency and Quality (DST 2 - Hombre tool)
36	Groundwater contamination	Environmental form	Hard	DST 2 (Hombre tool)	Risk Mitigation of Contaminated Land and Groundwater (DST 2 - Hombre tool)
37	Landfill included in a catchment protection zone	Environmental form	Easy	DST 1	Drinking water protection zone
38	Average level of upper groundwater table	Environmental form	Hard	DST 2	
39	Landfill producing leachates	Environmental form/Economical form	Moderate to Hard	DST 2 (Risk assessment model, OnToL)	
40	Air emission	Environmental form	Hard	DST 2 (Risk assessment model)	
41	Valuable biodiversity on site	Environmental form	Easy		

42	Site in Natura 2000 zone	Environmental form	Easy	DST 1	Nature area
43	Contamination of the soil surrounding the landfill	Environmental form	Hard	DST 2 (Hombre tool)	Risk Mitigation of Contaminated Land and Groundwater (DST 2 - Hombre tool)
44	Erosion	Environmental form	Easy	DST 1	Erosion
45	Severe risks for human health caused by the landfill	Social form	Hard	DST 2 (Hombre tool)	Biosphere (including human health) (DST 2 - Hombre tool)
46	Olfactory pollution	Social form	Moderate		
47	Distance from nearest housing	Social form	Easy		
48	Land planning	Social form	Easy	DST 1	Criterion 6 – Surroundings
49	Current use	Social form	Easy to Moderate		
50	Presence of a touristic area nearby	Social form	Easy	DST 1	Recreational /touristic
51	Territorial strategy aspects	Social form/Economical form	Moderate to Hard	DST 2 (Hombre tool)	Strategic Planning of land use over time (DST 2 - Hombre tool)
52	Surroundings • Natural • Agricultural • Forest • Residential • Recreational/touristic • Economical/services	Social form	Easy	DST 1	Criterion 6 - Surroundings • Natural • Agricultural • Residential • Recreational/touristic

	• Industrial				• Industrial
53	Social support	Social form	Hard		
54	Age of the Landfill	Technical form	Moderate to Hard	DST 1, DST 2	Period of main activities (DST 1) Start of waste disposal/End of waste disposal (DST 2 – OnTol)
55	Rehabilitation status	Technical form	Hard		
56	Sampling	Technical form	Easy		
57	Leachates treatment plant on site	Technical form/Economical form	Moderate to Hard	DST 2 (OnTol)	Leachate collection in place (DST 2 – OnTol)
58	Leachates treatment plant nearby	Technical form/Economical form	Moderate to Hard		
59	Biogas aerial collection system	Technical form	Hard	DST 2 (OnTol)	Landfill gas collection in place (DST 2 – OnTol)
60	Landfill Morphology	Technical form	Moderate		
61	Surface state	Technical form	Moderate	DST 1	Surface conditions
62	Average thickness of the waste deposit	Technical form	Hard		
63	Maximal height of the waste deposit *(above ground level)*	Technical form	Hard	DST 1	Height above ground level
64	Maximal depth of the waste deposit *(below ground level)*	Technical form	Hard	DST 1	Depth below ground level

65	General slope	Technical form	Easy to Moderate	DST 1	Slope angle
66	Water table *(within the landfill)*	Technical form	Hard		
67	Risk of collapse during future excavation works	Technical form	Hard	DST 2	Complex excavation
68	Top layer • Watertightness layer • Rainwater drainage • Gas drainage • Type of cover	Technical form	Moderate to Hard	DST 1	• Type of cover (DST 1)
69	Bottom layer • Watertightness • Leachate drainage layer	Technical form	Moderate to Hard		
70	Regional incentives encouraging LFM	Economical form	Easy		
71	Site-specific LFM facilitation procedures	Economical form	Easy		
72	Regional authorization for in-situ relandfilling	Economical form	Easy		
73	Regional authorization for relandfilling at another landfill	Economical form	Easy		
74	Ownership	Economical form	Moderate		
75	Legal status of the landfill	Economical form	Moderate to Hard		
76	Fence/site protection	Economical form	Moderate		

77	Buried volume	Economical form	Hard	DST 2 (OnTol)	Landfill size
78	Remaining volume before LFM	Economical form	Hard		
79	New available volume	Economical form	Hard		
80	LFM costs (waste excavation and remediation costs)	Economical form	Hard	DST 2 (OnTol)	• Excavation, sorting, upgrading – Economy (DST 2 – OnTol) • Costs for final landfill cover (& potential waste stabilization) (DST 2 – OnTol) • Initial costs for landfill mining project (DST 2 – OnTol) • Final costs for landfill mining project (DST 2 – OnTol)
81	Annual aftercare costs	Economical form	Hard	DST 2 (OnTol)	• Remaining aftercare duration (DST 2 – OnTol) • Costs for maintenance and monitoring (after final closure) (DST 2 – OnTol)
82	Land pressure	Economical form	Easy	DST 2 (OnTol)	Land value (DST 2 – OnTol)
83	Access for landfill mining operations • Paved roads • Heavy truck access (> 30T) • Distance to main road • Distance to the nearest harbor • Distance to waterways	Economical form	Easy to Moderate	DST 1	Criterion 5 –Accessibility • Paved roads? • Accessible heavy equipment? • CEMT canals • Stations

	• Distance to the nearest rail station				
84	Facilities for landfill mining operations • Incineration plant • Cement factories • Waste treatment plant *(in general)* • Landfill for hazardous waste • Landfill for non-hazardous waste • MBT plant	Economical form	Moderate to Hard	DST 2 (OnTol)	• Transport distance: combustibles (CCM) to thermal utilization (DST 2 – OnTol) • Transport distance: aggregates (ACM) to recycling facility/construction site (DST 2 – OnTol) • Transport distance of excavated waste (EW1) to sorting Transport distance: plastics (Ro) to recycling facility (DST 2 – OnTol) • Transport distance: fine material (FMr) to landfill new (DST 2 – OnTol)
85	Fragmentation	Economical form	Moderate to Hard		
86	Resource Distribution Model (per zone) • Thickness • Volume • Density • Tonnes buried • Physical State	RDM	Hard		

	• Homogeneity (macro) • Homogeneity (micro) • % Fines • Main type • Gas content • Water content • T° • Presence of a water table • Begin landfilling • End landfilling • Composition				
87	ELIF datasheet responsible	Additional information	Easy		
88	Creation date	Additional information	Easy		
89	Date of updating	Additional information	Easy		
90	Regional policy encouraging ELFM	Additional information	Easy		
91	Regional incentives encouraging ELFM	Additional information	Easy		
92	Dates of landfill ban • Name of the stream • Regional code of the restricted stream *(when it exists)* • Date of applicability of the restriction • Type of restriction	Additional information	Moderate to Hard		
93	Site-specific ELFM facilitation procedures:	Additional information	Moderate to Hard		

	• Reference • Signature date • Expiration date • Summary				
94	Regional authorization for in-situ relandfilling	Additional information	Easy		
95	Regional authorization for relandfilling at another landfill	Additional information	Easy		
96	Permits • Reference • Date of authorization • Expiration date • Nature of permit • Permit Holder	Additional information	Moderate to Hard		
97	Landfill operator(s): • Name • Start date • End date	Additional information	Moderate to Hard		
100	Landfill type (EU Directive)	Additional information	Easy		
101	Landfill status and dates • Usage status • Landfill operation (Start date – End date) • Rehabilitation (Start date – End date) • Aftercare period (Start date – End date)	Additional information	Moderate to Hard		
102	Landfill monitoring	Additional information	Moderate		

	• Monitored at the data sheet date • Company in charge of the monitoring				
103	Warranties given	Additional information	Hard		
104	Studies • Reference • Title • Date • Main author(s) • Confidentiality	Additional information	Moderate to Hard		
105	Sampling • Reference • Date • Author(s) • Sampling method • Analysis	Additional information	Hard		
106	Historical Information • Date • Historical activities/Description/Historical data	Additional information	Hard		

Table 1 – List of the fields included in the ELIF.

4. Testing of the ELIF software

4.1. Selection of the sites

First, seven RAWFILL pilot sites were tested (*see Deliverable WP T1.3.2. – Additional pilot sites*). The results of the RAWFILL pilot sites are summarized in **Table 3** (section 4.2.). Then, to improve the quality of the testing, we decided to broader the testing phase to 62 sites from Walsols (Walloon database managed by SPAQuE). We limited the number of sites to 62 because we had to fill the ELIF for each site manually. As some data such as the description of boreholes can still only be found in reports, extra time was spent to research the necessary information. In the near future, the coupling between the ELIF software and Walsols will be done in order to demonstrate that the ELIF structure can be easily implemented on existing landfill database (*Deliverable T1.4.2*). This coupling will allow to complete semi-automatically the ELIF for all the landfill present in Walsols (1,031 landfills in total).

The landfill sites were selected in Walsols based on several criteria: (i) their economic potential (e.g., land value/pressure, interest to develop new building projects, valuable potential waste content) or (ii) the environmental issues related to the presence of a landfill (groundwater contamination, polluted soil, etc.). A few monolandfill sites were also included in the testing as they are (i) easy to characterize and to mine and (ii) they potentially represent important economic interests/benefits. In addition to these selected sites, the ELIF model was applied on several landfill sites that were chosen randomly to test the pertinence of the model and the relevance of the fields. Most of the time, these random sites did not present any interest for LFM. Due to the confidentially of certain data, we decided to hide the name and the location of the landfills. In this report, the landfill sites are referred by a number and by the name of the municipality where the landfill is located. In total, the selected landfill sites are owned by at least 88 entities, the repartition into the different types of landfill site owners is shown in **Table 2**. It is important to note that most of the time, the landfill site is divided into several land plots which do not always belong to the same owner. This explained why the number of site owners is higher than the 62 landfill sites. The results of the testing phase will be uploaded in Walsols and will be available for the landfill site owners (on demand).

Type of LF site owners	Number
Enterprise	7
Infrastructure and (public) service provider	4
Local public authority	21
National public authority	1
Private individual	42
Other	1
SME	10
Sectoral agency	2

Table 2 – Distribution of the owners of the 62 selected landfill sites.

4.2. Results

4.2.1. General comments

As mentioned above, the ELIF software is divided in several sections: Landfill description; Waste description; Environmental form; Social form; Technical form; Economical form; RDM; Additional information. These sections contain a series of relevant fields, which can be filled at different steps of the RAWFILL methodology (see **Fig. 3**). The degree of completion of the fields present in the ELIF software is expressed by a completeness rate, which is automatically calculated. The completeness rate is only calculated for the environmental, social, technical and economical sections. An average completeness rate is also calculated for each landfill in order to compare landfill sites (in the DSTs) having similar quality information.
In the following sections, we will present first the results obtained for the 62 sites selected from Walsols. Then, we will compare these results with the result of the RAWFILL pilot sites.

4.2.1. Sites selected from Walsols

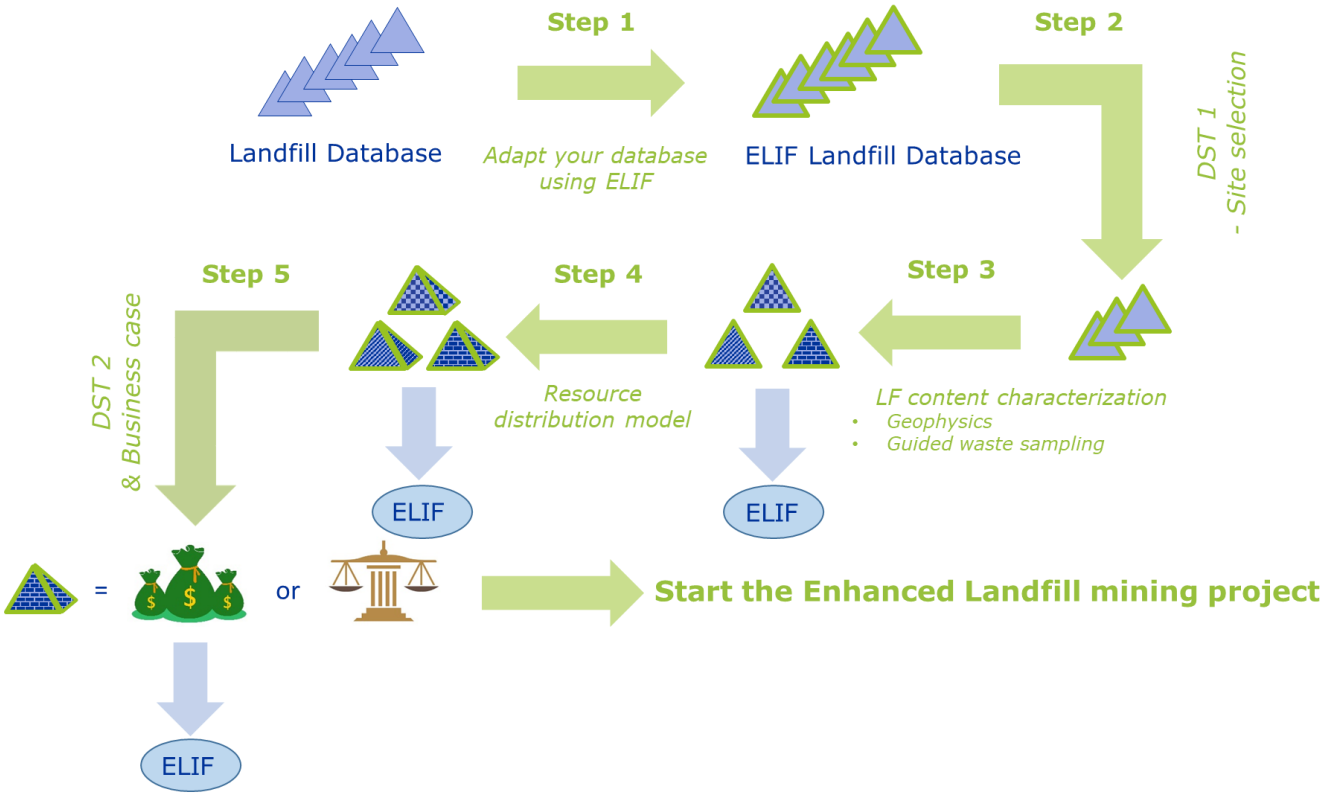


Figure 3 – RAWFILL Methodology scheme. *The first step of the RAWFILL methodology is to use the ELIF Structure to enhance the initial database. Once the database is adapted, the DST 1 - Cedalion can be applied to the database to select a few landfills that can potentially fulfill the criteria to launch an ELFM project but requires further investigations. After each step (i.e., LF content characterization and building of a resource distribution model), the ELIF can be fed with new information. After the completion of the RDM, the DST 2 - Orion can be applied on few sites to select the most promising one and the business model of the project can be calculated. These economic data can also be inserted in the ELIF. If the business model shows potential economic benefits or if the balance between costs, environmental and social benefits is reached, the ELFM project can start.*

In this section, we will present and discuss the results obtained for the 62 landfill sites selected from Walsols. The completeness rate of each landfill site is presented in detail in the Appendix 1. An overview of the results obtained for the different ELIF sections is described below.

- *Landfill description*

The landfill description is the easiest form to fill. Most of the fields were already present in the Walsols database. The form contains all the classic information required to identify the site (e.g., name, address, coordinates). Only the identification of the site owner requires performing further investigations and cannot be obtained straightforward.

- *Waste description*

With the economical form, this form is quite difficult to fill if no sampling investigations (e.g., trenches, boreholes) have been performed on site. Historical documents can help to fill some fields but it generally remains vague and provides no quantitative and qualitative information. A correct estimation of the waste composition and volume is most of the time impossible to do for the landfill sites from Walsols. During the last twenty-five years, landfills were considered internally as black boxes where only the production and the analyses of leachates and biogas were studied and monitored explaining the lack of data concerning the waste content in Walsols. For a few landfill sites, boreholes and/or trenches were performed on site but the waste description was often quite cursory and non-exhaustive. For instance, municipal solid waste was considered as one waste facies without taking into account the change in proportion of the plastics, metals, paper and organic matter content.
For this form, no completeness rate can be computed. The waste description form partly consists of text, and therefore a relevant calculation for the completeness rate was impossible to achieve. However, some indicators present in this form are taken into account in the economical form and thus in the computation of the completeness rate (e.g. presence of hazardous waste deposits, type of waste stream).

- *Environmental form*

On average, the environmental form had a degree of completeness of 79%. For the 62 landfill sites, the minimum completeness rate obtained was 58% (**Fig. 4**). The reason is that a few fields of the environmental form requires investigations on site (e.g. water, soil and gas sampling collection and analysis) to be filled such as the presence of biogas and the potential surface and groundwater contamination.

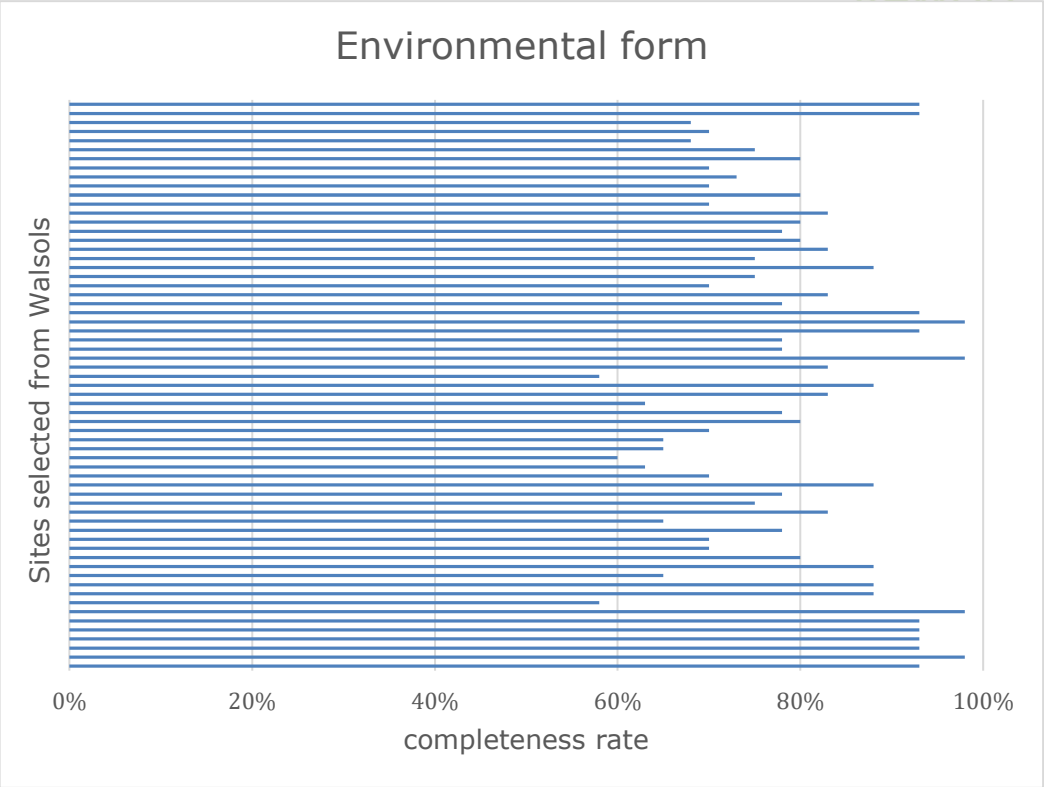


Figure 4 - Completeness rate of the Environmental form for 62 landfill sites selected from Walsols.

- *Social form*

Out of 62 landfill sites, 30 landfill sites obtained a completeness rate below or equal to 50 % (in red in Fig. 5). This high proportion of the landfill sites having a low rate of completion for the social form is mainly due to the relative difficulty to get the data. For instance, the precise evaluation of health issues should be performed by a consortium of physicians and therefore requires times and advanced site investigations (e.g., waste, air, soil and water sampling collection and analysis). Site visits are also required to assess the presence of an olfactory pollution related to the landfill. Moreover, they help to identify the presence of a touristic area nearby, which is also sometimes difficult to know when the person in charge of completing the ELIF is not familiar with the area. Regarding the social support of the inhabitants living nearby the site to remove the landfill and rehabilitate it, a door-to-door survey is often necessary to assess it. Additionally to the door to door, talking with the local authorities might help to identify the presence of a strategic territorial redevelopment project nearby the site or on site. Due to the large number of tested sites and the objectives of the RAWFILL project, we decided to limit the on-site visits explaining the low completeness rate for this form (59%).

Figure 5 – Completeness rate of the social form for 62 landfill sites selected from Walsols. *The landfill sites having a completeness rate below or equal to 50% are indicated in red.*

- *Technical form*

The analysis of the completeness rate for technical form showed a huge gap between the sites. 22 landfill sites (out of 62) got a score below or equal to 50 % (in red in **Fig. 6**) whereas 16 landfill sites obtained a score above or equal to 90 % (cf. **Fig. 6**). The reason behind this huge gap between the landfill sites is that a series of fields requires either site investigation (e.g. geophysics, waste sampling) or historical research to identify the landfilling activities on site and to identify the potential presence and characteristics of the top and bottom layers. Without these data, most of the technical form cannot be completed explaining the discrepancy in the completeness rate between the landfill sites.

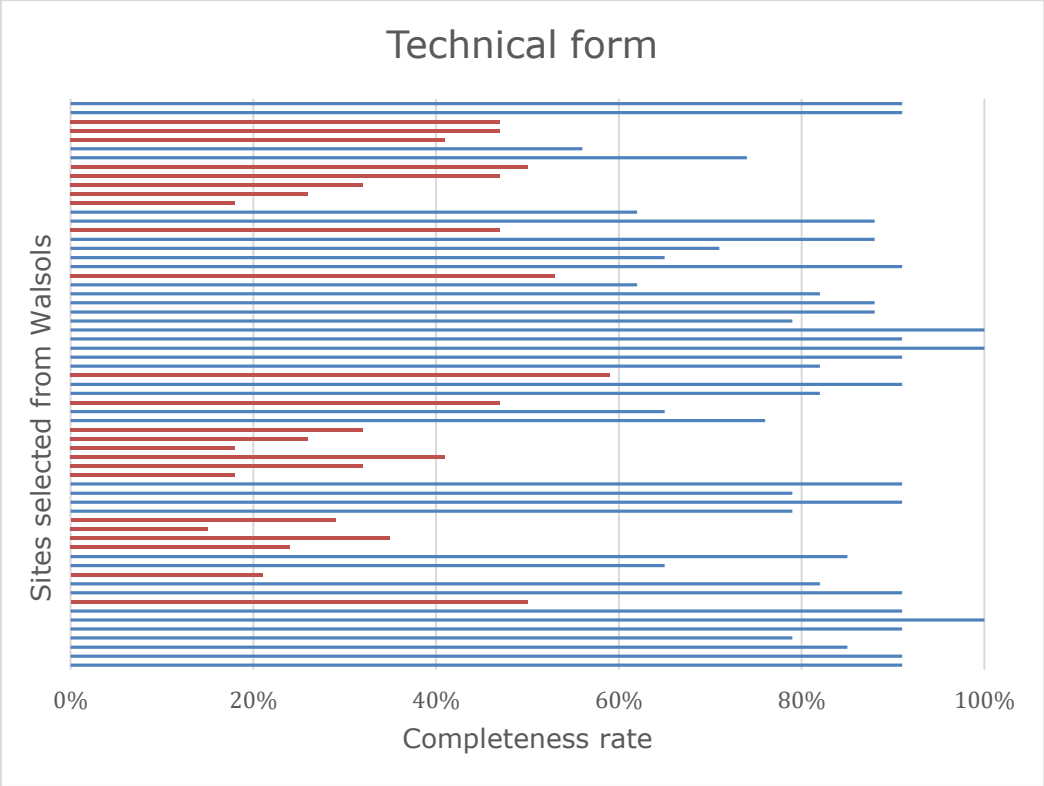


Figure 6 – Completeness rate of the technical form for 62 landfill sites selected from Walsols. *The landfill sites having a completeness rate below or equal to 50% are indicated in red.*

- *Economical form*

As expected, the economical form is the most difficult form to fill due to its innovative character. The analysis of the EU current landfill inventories showed that the fields contained in this section are generally not included. Therefore, only a few data are available to complete the fields of this section. The average rate for this form is 56%, which is the lowest average completeness rate (**Fig. 7**). Moreover, 17 landfill sites obtained a completeness rate below or equal to 50% (in red in **Fig. 7**). The difficulty to fill this form lies in assessing the waste content, the volume of materials (linked with the waste description) as well as the costs of the landfill mining project and of aftercare[5]. The calculation of these data requires to investigate the landfill site with geophysics and waste sampling in order to fully characterize the landfill content and its economic potential (step 5), which was not done for the landfill sites present in the Walsols database. As mentioned above, the filling of the ELIF is a constant process and the economic form is the last step of it. This weakness of the economical information is a good justification of the RAWFILL approach and the need for inventory managers to receive a ready-to-use ELIF structure.

[5] There are only few examples where landfill mining project total costs are available.

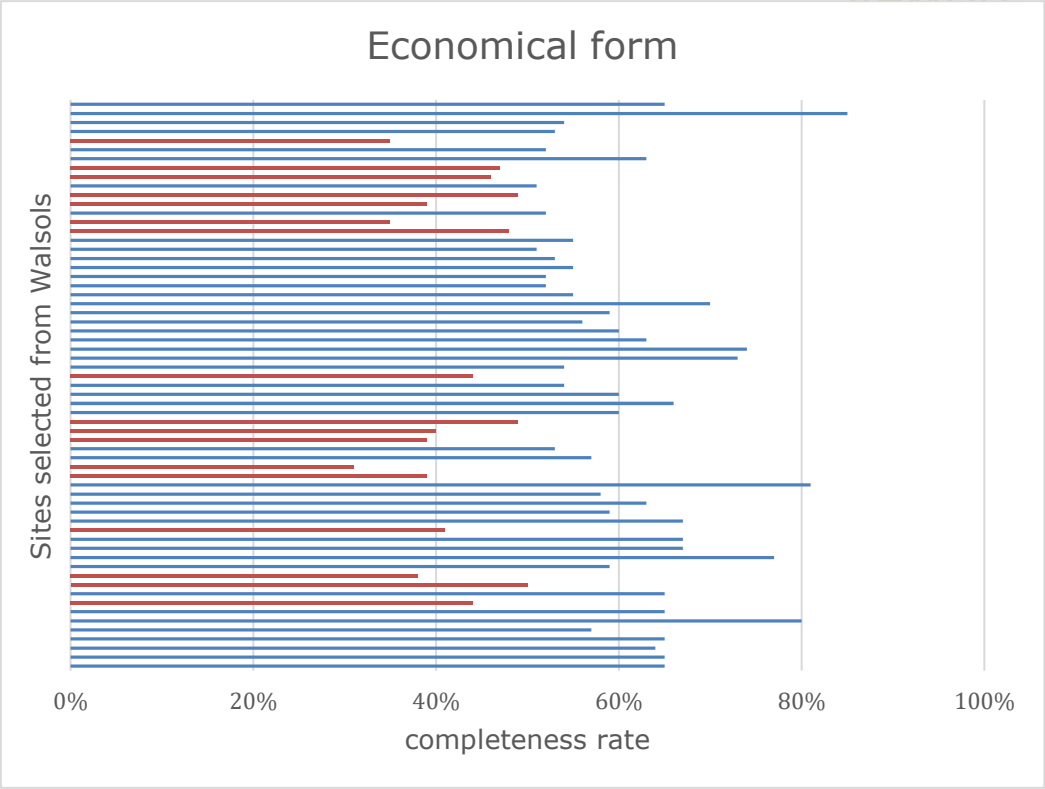


Figure 7 – Completeness rate of the economical form for 62 landfill sites selected from Walsols. *The landfill sites having a completeness rate below or equal to 50% are indicated in red.*

- *RDM*

Resource distribution models (RDMs) were only performed for the RAWFILL pilot sites. Therefore, this section was not completed for the 62 landfill sites selected from Walsols. More information regarding this form can be found in the section 4.2.3. RAWFILL pilot sites.

- *Additional information*

This form contains fields that are not directly used by the DST 1 - Cedalion, DST 2 - Orion, and the other tools associated with the DST 2. Nevertheless, these fields are important to ensure the follow-up of the investigations on site, the landfill mining operations and the landfill site remediation. Moreover, this form provides valuable information for the dynamic landfill management[6] of the site.

4.2.3. RAWFILL pilot sites

As shown in **Table 3**, the ELIF is not entirely completed for most of the RAWFILL pilot sites. On average, the completeness rate ranges from 80% up to 98% which is quite pretty good to ensure data relevance. The economical form and the social form present the lowest completeness rate. However, the completeness rates for the RAWFILL pilot sites are higher than the one obtained for the 62 landfill sites selected from Walsols. The explanation of these discrepancies in the results is that more site investigations (geophysics, waste sampling) have been carried on the RAWFILL pilot sites. It is important to keep in mind that the feeding of the ELIF is a constant process. For most of the RAWFILL

[6] A complete definition of this concept can be found here: https://eurelco.org/definition/.

pilot sites, the steps 3, 4 and 5 of the RAWFILL methodology have been achieved (see Fig. 3) whereas only the step 1 has been performed for most of the landfill sites from Walsols.

	Completeness rate				
Landfill site	**Env. form**	**Social form**	**Technical form**	**Economical form**	**Average**
Meerhout	83%	100%	88%	*64%*	84%
Les Champs Jouault	*88%*	*100%*	*97%*	*82%*	92%
Emerson's green	*75%*	*96%*	*79%*	*43%*	*73%*
Stockley Park	*78%*	*100%*	*76%*	*67%*	*80%*
Leppe	*98%*	*100%*	*100%*	*94%*	98%
La Samaritaine (Lingreville)	*98%*	*100%*	*97%*	*82%*	94%
Onoz	*93%*	*100%*	*91%*	*85%*	92%

Table 3 – Summary of the completeness rate for the RAWFILL pilot sites.

- *RDM*

The RDM is the acronym for "resource distribution model". This RDM is a 3D map built based on geophysics and guided samples. More information regarding the RDM can be found in *the Deliverable WP T3.1.1. – Resource Distribution Model*. In the ELIF, the landfill can be described, based on the RDM, as five different layers having similar geophysical properties, which are directly related to waste composition. The testing on the RAWFILL pilot sites where a RDM was available[7] showed that some fields are difficult to complete :

- Waste density;
- Weight;
- Percentage of fine fraction;
- Water content;
- Gas content;
- Temperature;
- Composition.

These fields must be filled with average properties so that it can provide guidelines for civil engineering and separation processes during the landfill mining project. These fields have a great interest but their filling will come only during a detailed design LFM study.

Moreover, the testing demonstrated the necessity to adapt the RDM section of the ELIF structure by adding additional information such as the spatial location of the layer (e.g. coordinates of the zone boundary or a 3D map with cross sections) as the landfilled waste composition may vary laterally and its depth.

[7] RDM is currently available for the following RAWFILL pilot sites : Meerhout, Leppe, Lingreville, Onoz, Emersons green.

Fields such as the volume, the homogeneity, the waste composition of each layer as well as its valorization potential are key parameters to calculate the economic potential of the landfill and should be included in the DST 2 - Orion and/or associated tools.

5. Conclusions

The ELIF is a very complete inventory structure, which helps to fully characterize the landfill sites by taking into account the administrative, environmental, social, technical, economical aspects. The completion of the ELIF is an important step to facilitate the application of the DST 1 - Cedalion and DST 2 - Orion. It is a constant iterative process. The ELIF needs to be fed at each step of the RAWFILL methodology. The completeness rate of the ELIF can only reach 100 % when all the steps of the RAWFILL methodology are achieved, for the landfills identified and selected as valuable for a mining project.

The completion of the RDM section based on the data retrieved from the RDMs of Meerhout, Leppe, Onoz, Lingreville and Emersons green (RAWFILL pilot sites) showed the necessity to fine-tune it by adding new fields such as the spatial coverage and the depth of the layers defined by the RDM. It also highlights the importance to describe the landfill in terms of layers/zone instead of one single block. For each layer/zone, fields such as the volume, the homogeneity, the waste composition, are key parameters to calculate the economic potential of the landfill and will be included in the DST 2 - Orion and/or associated tools.

6. Appendix

Appendix 1 – List of the 62 selected landfill sites and their completeness rate.

Landfill site		Completeness rate				
		Env. form	Social form	Technical form	Economical form	Average
N°	Municipality					
1	Wavre	93%	73%	91%	65%	80%
2	Tournai	98%	96%	91%	65%	87%
3	Peronnes-Lez-Binche	93%	73%	85%	64%	79%
4	Loyers	93%	73%	79%	65%	77%
5	Châtelet	93%	100%	91%	57%	85%
6	Flobecq	93%	73%	100%	80%	86%
7	Dalhem	98%	77%	91%	65%	83%
8	Montigny-le-Tilleul	58%	46%	50%	44%	49%
9	Liège	88%	73%	91%	65%	79%
10	Ottignies	88%	73%	82%	50%	73%
11	Kelmis	65%	50%	21%	38%	38%
12	Chaudfontaine	88%	73%	65%	59%	71%
13	Gemmenich	80%	96%	85%	77%	85%
14	Kelmis	70%	73%	24%	67%	51%
15	Kelmis	70%	35%	35%	67%	52%
16	Kelmis	78%	35%	15%	41%	42%
17	Kelmis	65%	35%	29%	67%	49%
18	Perwez	83%	58%	79%	59%	70%
19	Couvin	75%	50%	91%	63%	70%
20	Bertrix	78%	73%	79%	58%	72%
21	Beauvechain	88%	73%	91%	81%	83%
22	Louvain-La-Neuve	70%	31%	18%	39%	39%
23	Tournai	63%	31%	32%	31%	39%
24	Morlanwez	60%	54%	41%	57%	53%
25	Ittre	65%	35%	18%	53%	42%
26	Huy	65%	31%	26%	39%	40%
27	Ramillies	70%	35%	32%	40%	44%
28	Hannut	80%	35%	76%	49%	60%
29	Namur	78%	35%	65%	60%	59%
30	Anderlues	63%	58%	47%	66%	58%
31	Dalhem	83%	35%	82%	60%	65%
32	Jalhay	88%	54%	91%	54%	72%
33	Liège	58%	35%	59%	44%	49%
34	Fleurus	83%	73%	82%	54%	73%
35	Sambreville	98%	73%	91%	73%	84%
36	Auvelais	78%	73%	100%	74%	81%

37	Ciney	*78%*	*73%*	*91%*	*63%*	76%
38	Bastogne	93%	73%	100%	60%	81%
39	Oupeye	*98%*	*50%*	*79%*	*56%*	71%
40	Hamoir	*93%*	*50%*	*88%*	*59%*	73%
41	Courcelles	*78%*	*50%*	*88%*	*70%*	72%
42	Tournai	*83%*	*50%*	*82%*	*55%*	67%
43	Tournai	*70%*	*73%*	*62%*	*52%*	64%
44	Lasnes	*75%*	*50%*	*53%*	*52%*	58%
45	Chaumont-Gistoux	*88%*	*73%*	*91%*	*55%*	77%
46	Chaumont-Gistoux	*75%*	*69%*	*65%*	*53%*	66%
47	Chaumont-Gistoux	*83%*	*73%*	*71%*	*51%*	69%
48	Gosselies	*80%*	*50%*	*88%*	*55%*	68%
49	Dinant	*78%*	*50%*	*47%*	*48%*	56%
50	Arlon	*80%*	*73%*	*88%*	*35%*	69%
51	Fléron	*83%*	*50%*	*62%*	*52%*	62%
52	Ottignies	*70%*	*31%*	*18%*	*39%*	39%
53	Braine l'alleud	*80%*	*46%*	*26%*	*49%*	50%
54	Kelmis	*70%*	*50%*	*32%*	*51%*	51%
55	Antoing	*73%*	*46%*	*47%*	*46%*	53%
56	Beaumont	*70%*	*69%*	*50%*	*47%*	59%
57	Soignies	*80%*	*46%*	*74%*	*63%*	66%
58	Soignies	*75%*	*50%*	*56%*	*52%*	58%
59	Farciennes	*68%*	*69%*	*41%*	*35%*	53%
60	Namur	*70%*	*46%*	*47%*	*53%*	54%
61	Grace – Hollogne	*68%*	*92%*	*47%*	*54%*	65%
62	Jemeppe-Sur-Sambre	*93%*	*100%*	*91%*	*85%*	92%
63	Boussu	*93%*	*73%*	*91%*	*65%*	80%
Average		*79%*	*59%*	*65%*	*56%*	*65%*

Contact

Feel free to contact us.

Local contact details:

BELGIUM	ATRASOL	renaud.derijdt@atrasol.eu
	Cleantech Flanders / VITO	alain.ducheyne@vito.be
	OVAM	ewille@ovam.be
	SPAQuE	l.lamair@spaque.be
	Université de Liège	f.nguyen@ulg.ac.be
FRANCE	SAS Les Champs Jouault	champsjouault@gmail.com
GERMANY	BAV	pbv@bavmail.de
THE UK	NERC	jecha@bgs.ac.uk

Coordination office:

BELGIUM	SPAQuE Boulevard Maurice Destenay, 13 4000 Liège	c.neculau@spaque.be