Report on End-User Requirement Specification
Deliverable 5.1

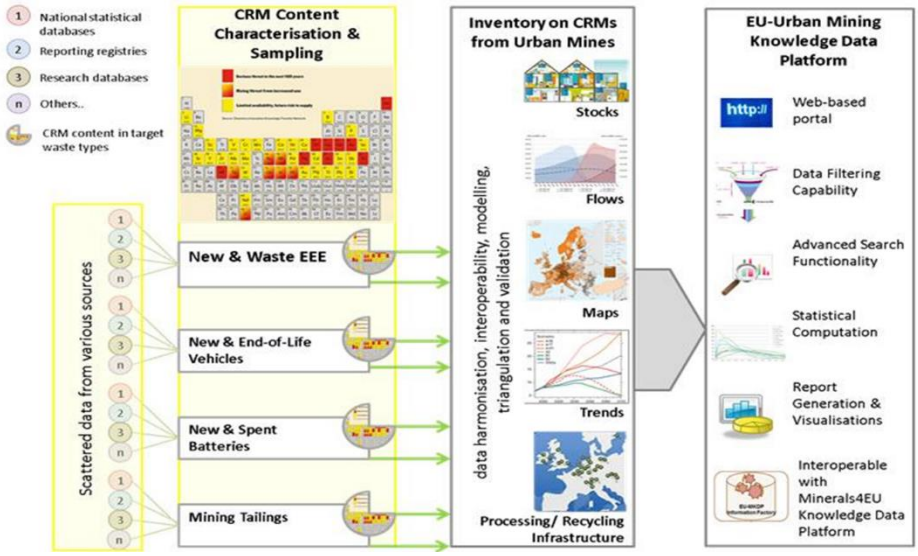

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TABLE OF CONTENTS

Contents

PURPOSE

Task 5.1.1 aims to identify the requirements of users of the EU Urban Mine Knowledge Data Platform (EU-UMKDP). This task is closely linked with Work Package 3 and other tasks within Work Package 5. Activities that are specifically relevant are the development of the understanding of the stocks and flows, and the subsequent mapping of material as it flows through the economy (in WP3), and the development of a clear taxonomy for the naming of various elements of products as they are handled as they move from the use stage to the end-of-life. During the development of the end-user requirements the taxonomy had not been developed. Therefore, the generic term "item" is used extensively throughout this report. This term should be viewed as a non-exclusive method of representing all types of materials, products, and components.

EXECUTIVE SUMMARY

The Integration Definition (IDEF) methodology has been adopted and adapted to set out a mechanism for eliciting information from the potential end-users of the EU Urban Mine Knowledge Data Platform. An initial workshop was held at the first meeting of the ProSUM Information Network (23rd April 2015) at which end-users were invited to participate in a "brainstorming" session to test initial conclusions, and to provide input towards the development of the questionnaire used to gather further views.. The questionnaire that was developed was made available via both a document and an on-line version, and was sent to all members of the Information Network and also forwarded to associated groups. A total of 27 responses were received by September 18th 2015 with 17 of these being submitted on-line. Access to the questionnaire remains available via the ProSUM website, and further updates for the end-user requirements will be possible as the Knowledge Platform is developed. The questionnaire was sent to the 136 Members of the Information Network. The questionnaire and the link to the on-line survey was subsequently circulated to other contacts by the IN Members.

The questionnaire was split into the following sections:

1. Questions for which the respondent wished to get answers;
2. Prioritising the importance of data gathered on:
    a. The flow of secondary raw materials;
    b. Waste or material stock;
    c. Supporting data (for example population of a country, GDP);
3. Representation of the data gathered.

The questions that were posed by the respondents were grouped by key words. The average priority assigned to the data sets was calculated, and the range of responses also noted. Finally, the questions were matched against the data that is most likely to be available, and thus identifying any gaps that may occur whilst gathering data, and developing the models for stocks of flows of materials.

It is clear that the total quantity of materials flowing through the EU economy, and the stocks of products and materials is the primary interest for most. However, respondents are also keen to understand the location of these flows and stocks, as this scored highly for both, and this is also supported by the fact that the geographic representation of information was thought to be the most valuable method for representing the data that could be extracted from the knowledge platform. It also became clear that there was interest in understanding the nature of the waste as given by the level of "purity" of the stream, for example the percentage of a key material that was present in a waste flow, or stock of material.

As a result of views expressed at the workshop, it was decided that highly variable data, such as the financial value of a stream, would not be included directly in the list of options for data to be

gathered, although the ability to add this was included by allowing respondents to provide a "user-input" option. Only one respondent added the preference to have "price" as an additional set of data points.

A comparison has been made between the questions that the stakeholders wish to have answered when using the EU-UMKDP and the data that may be held in the platform. An assessment is made as to the ability to answer the questions with available data, and also whether the questions are within scope of the current project objectives. Whilst the majority of questions suggested by those answering the survey can be answered and are within scope, there were a group of questions based on the drivers for understanding the stocks and flows of materials that are unlikely to be answered by the data gathered in this project. Some respondents identified the need to understand the potentially least environmentally harmful or cheapest route for producing the raw materials for manufacturing. For example, in some circumstances, would it be more environmentally beneficial to actually source the raw materials for manufacture from virgin sources, or is it better to recycle? It is unlikely that the data provided from this project would be able to provide a solution to this question. However, access to the information gathered in the EU UMKP will make it significantly easier to answer this type of question when used alongside other research findings.

The information from the end-user survey will be used in tasks 2.1, 3.1 and 4.1 to prioritise actions, and to help formulate the knowledge platform to gather and present information in the most beneficial way in the other tasks in Work Package 5.

DELIVERABLE REPORT

1. Introduction

As a material flows through the market it undergoes a series of transformations, both physically and chemically to produce new materials that are then used to manufacture products. For many systems this can be conveniently represented by the following diagram:

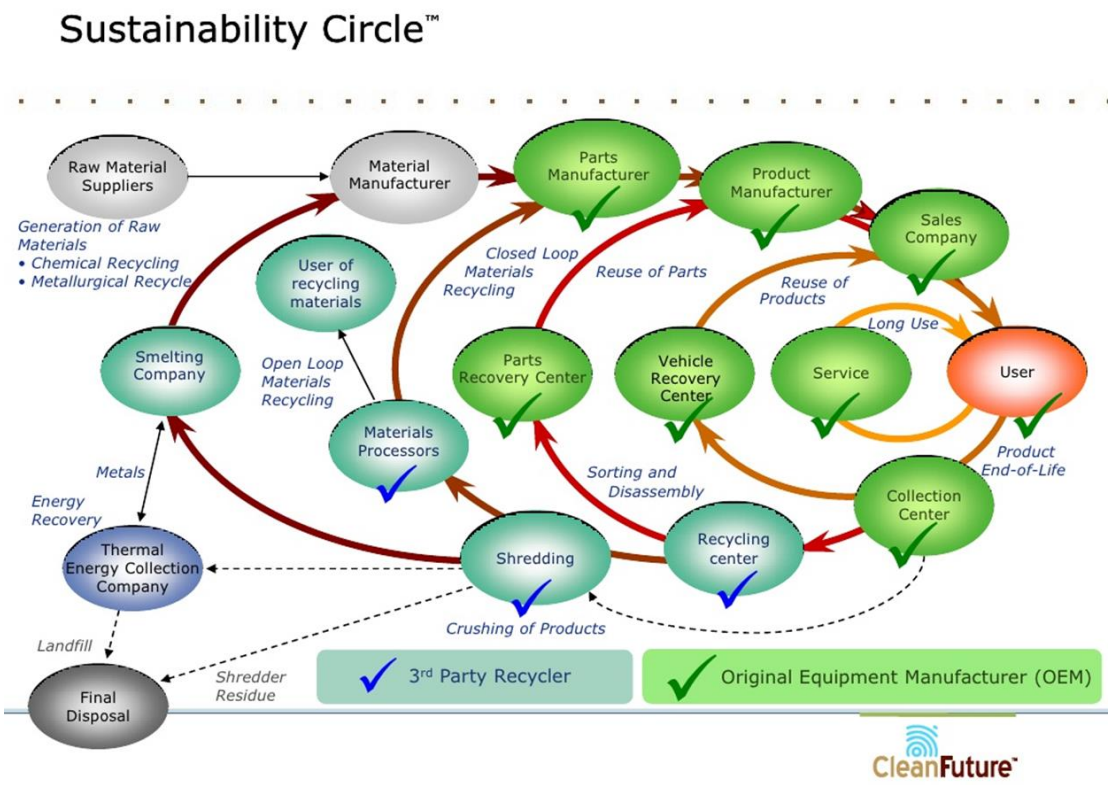


Figure 1 The flow of materials and products from extraction to disposal

Some Governmental Environment Departments have also produced their own maps of the flow of materials and products through the supply chain to identify the potential future needs to meet targets for recycling and recovery of products. For example, in the UK, The Department for Environment and Rural Affairs (Defra), analysed the material flows to enable the assessment of the Waste Prevention Programme, and generated a materials flow map that enabled the representation of business models and design sub-models.[1]

A common function for all of the flow maps is to show the journey of a material from its first use to its fate at the end of its useful life. One key reason for producing this information is to support the move from an essentially linear to a more circular economy.

The base materials will be combined with other materials at certain points in its life to produce a range of products, components, sub-assemblies etc. To make the process of monitoring the flow of materials through the production, use and recycle stages, a number of product lists have been produced by a range of organisations worldwide. Although it is not absolutely necessary, it is convenient to group certain items together (for example, in the figure above as raw materials, materials, components, and products). The grouping allows for easier identification of the flow of materials through the supply chain. The flow of material can then be seen as a series of transfers from one manufacturing or processing facility to another until the material is eventually recycled

[1] Defra Waste Prevention Programme for England Waste Prevention Model – Materials Flows map and Business Models and Design sub- model (December 2013)

or becomes a waste stream. Figure 1 shows the most important flows, but it is possible to connect almost any of the bubbles in the figure to any another. There may also be the opportunity to recover and recycle materials within a facility, but this information is unlikely to be public, and materials will not be available for external use.

This widely understood model of flows was used as a tool to engage with end users in the absence of an agreed ProSUM classification model. It is the task of 5.2.1 to review and harmonise these data sets and create a classification system and common, harmonised language (see Deliverable Report 5.3 for more information).

2. Description of the deliverable

The deliverable is a report that outlines the process to develop a questionnaire to elicit information from a range of end-users on their needs and expectations from the EU Urban Mine Knowledge Data Platform. The report presents the results from the input received up to and including the 18th September 2015. The on-line questionnaire will remain available so that updates to the findings can be generated if required.

The information is to be provided to the developers of the EU-UMKDP to help prioritise the process for the development of the stocks and flow model as well as the outputs that should be made available from the platform.

3. Approach to Defining the End-User Requirements

3.1 Mechanisms to elicit information

The process of identifying end-user requirements is relatively common in the manufacturing and IT sectors, where the process is often called requirements elicitation or requirements engineering. The earliest developments were undertaken by the US Air Force Program when Integrated Computer Aided Manufacturing (ICAM) was in its infancy. The concepts developed in the 1970s resulted in a family of modelling languages that have been used for developing information models and database design issues. The IDEF (Integration DEFinition) suite of methods provides a mechanism for supporting the development of data modelling, object-oriented analysis and design and knowledge acquisition. Different sections cover the ontology (IDEF5), process description capture (IDEF3), auditing (IDEF7) etc. of the final system[2]. The aspect that is of interest to this stage of the user-definition is the function modelling and is set out in IDEF0. Although this process is normally used to model the functionality of automated and non-automated systems, it can be adapted to provide a framework to define a knowledge base. This process was used in the elicitation of information for the Factories of the Future "Plant Cockpit" project, in which they defined the process as given in figure 2. This process was adapted for ProSUM.

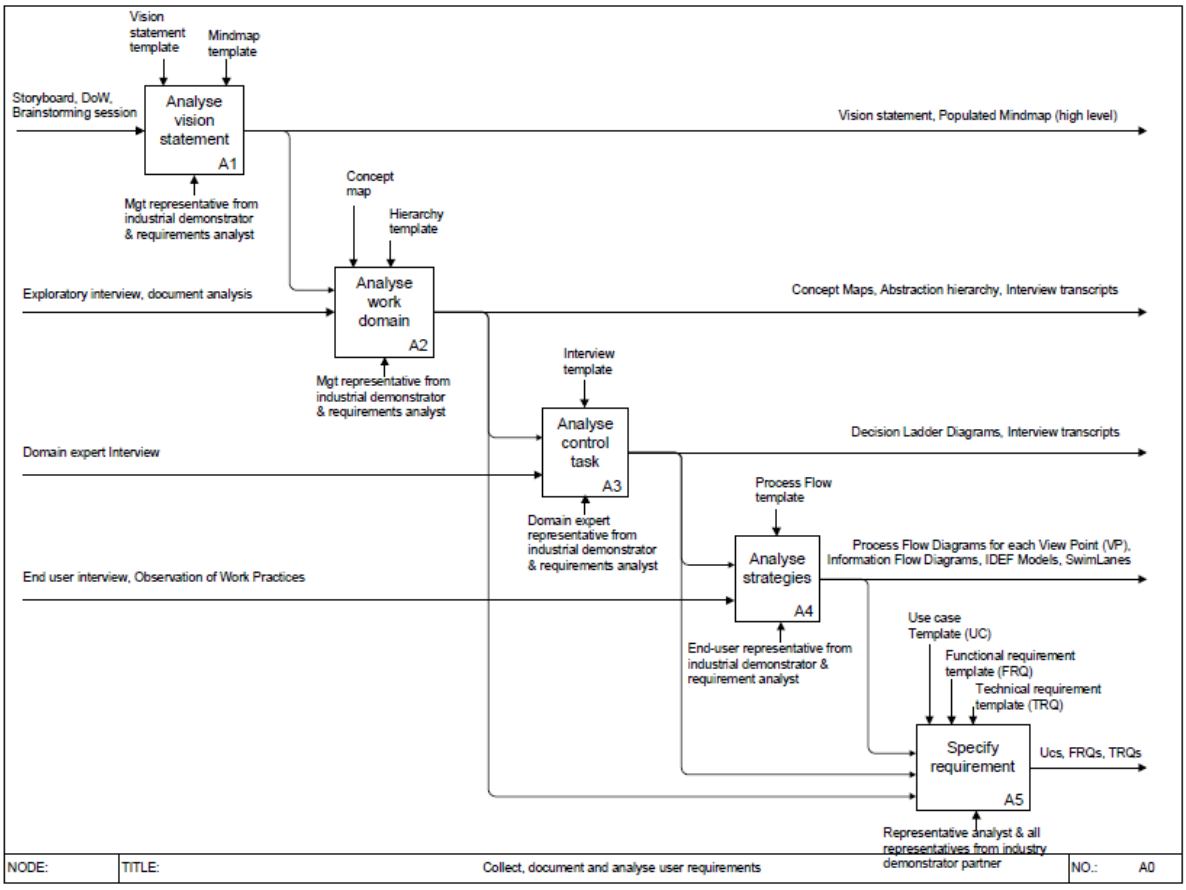


Figure 2 IDEF0 diagram of the requirement elicitation process for the FoF project Plant Cockpit

At each of the stages within IDEF0, there is the requirement to identify key users and mechanisms to engage with them to obtain information. There are a number of mechanisms to engage with the end-user community, and it is important to choose an appropriate mechanism depending on the level of knowledge of the end-users. Hickey and Davis proposed a simple method to help identify

[2] EEE Standard for Functional Modeling Language—Syntax and Semantics for IDEF0, Software Engineering Standards Committee of the IEEE Computer Society, IEEE-SA Standards Board, The Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street, New York, NY 10017-2394, USA, IEEE Std 1320.1-1998, 25 June 1998

the appropriate engagement method depending on the level of experience of the database developers and the end-users[3].

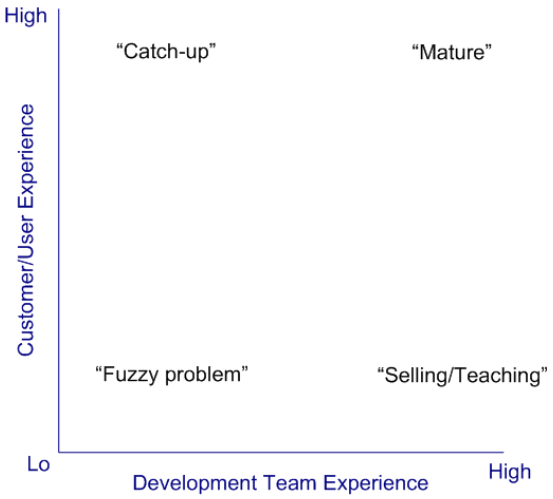


Figure 3: Choosing engagement mechanisms with end-users
Figure based on: Hickey A., Davis, A.

There is no "right answer", but the guidelines below were used to decide which method to use:

- Catch-up: Interviews, work in target environment
- Fuzzy: Brainstorming, workshops
- Mature: Questionnaires, workshops, prototypes
- Selling/Teaching: prototypes

As this is an entirely new knowledge data platform, it is likely that both the development team and the customer /user experience is still at a relatively low level of development, which makes the workshop / brainstorming session the most profitable technique to use in the first instance, followed by the prototype approach for the development team to propose a format for the knowledge base and then seek input from the end-user community.

3.2 Analysis of the Vision Statement

ProSUM has the clear objective to create an Information Network (IN) that allows partners in the network to provide to, and use data in, an inventory for waste streams with a high potential to serve as a source of CRMs. One part of the IN is the provision of the EU Urban Mine Knowledge Data Platform (EU-UMKDP), which will give access to this inventory. The end-user requirements must therefore satisfy the vision that there is a clear and open method to access data that provides a range of stakeholders with information that will enable them the use of different streams as a source of CRMs. Objective 5 (sub-action 1) summarises the overarching vision for the current work: ***Construct an inventory and a portal providing state of the art data on CRMs in ELVs, WEEE, batteries, and mining waste. Enable access to the inventory via a multi-user portal allowing for the presentation of data and information on primary and secondary materials with the potential for yearly updates and reports.***

3.3 Analyse work domain

For ProSUM, the work domain comprises the flow of material through the various value chains. Generic representations of this have already been given in figures 1 and 2. However, it is also important to define the boundary of the information that will be gathered for the EU-UMKDP. Figure 1 represents the flow of all materials, including virgin material, as it moves through the global

[3] *Hickey A., Davis, A. Elicitation Technique Selection: How Do the Experts Do It?, International Conference on Requirements Engineering (RE03), Los Alamitos, California: IEEE Computer Society Press, Sep. 2003*

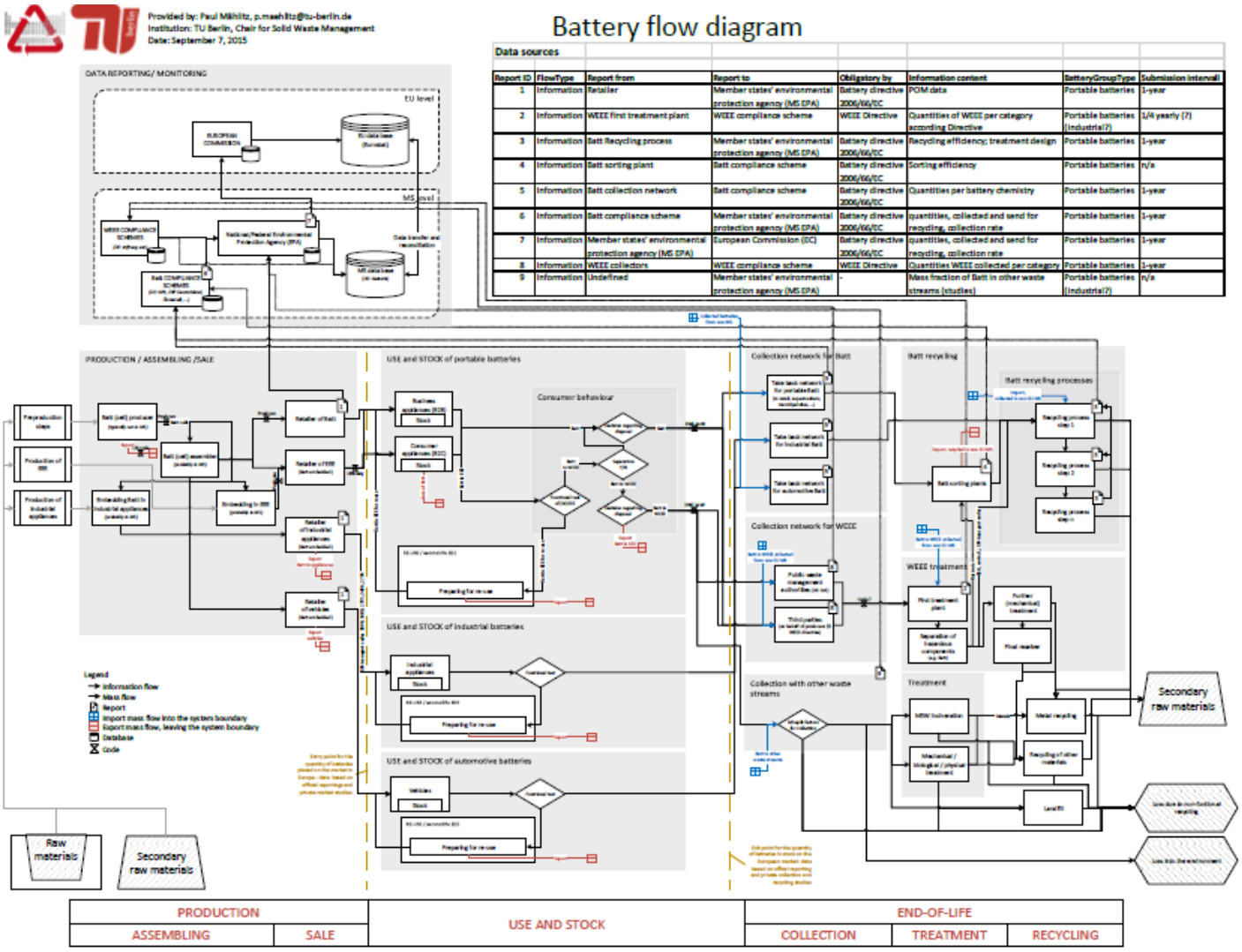
economy, whilst figure 2 introduces the concept of material flow into and out of certain geographic regions. The EU-UMKDP is primarily investigating the flow of material once it leaves the user (or has reached the end-of-life with the user but is still held by them and represents a stock of material that will enter the recycling loop at some future time). However, there is still the need to link the recycled flows back into the manufacturing flow, if that is already taking place.

Data mapping has been undertaken within the project, and initial flow diagrams have been produced. The one for the flow of batteries is presented in figure 4.

Figure 5 shows a simplified presentation of the flow of material between the different types of activity, and what data may be available at specific stages, and how this can be collected and stored in the knowledge platform . This simplified diagram was used in the questionnaire. There are six activities identified that are grouped into three overarching categories:

- Production
    - Assembling
    - Sale
- Use and stock
- End-of-life
    - Collection
    - Recycling
    - Treatment

The flow of materials are shown within each activity group, as well as the potential routes for the transfer of materials back up the supply chain.



Report ID	FlowType	Report from	Report to	Obligatory by	Information content	BatteryGroupType	Submission interval
1	Information	Retailer	Member states' environmental protection agency (MS EPA)	Battery directive 2006/66/EC	POM data	Portable batteries	1-year
2	Information	WEEE first treatment plant	WEEE compliance scheme	WEEE Directive	Quantities of WEEE per category according Directive	Portable batteries (industrial?)	1/4 yearly (?)
3	Information	Batt Recycling process	Member states' environmental protection agency (MS EPA)	Battery directive 2006/66/EC	Recycling efficiency; treatment design	Portable batteries	1-year
4	Information	Batt sorting plant	Batt compliance scheme	Battery directive 2006/66/EC	Sorting efficiency	Portable batteries	n/a
5	Information	Batt collection network	Batt compliance scheme	Battery directive 2006/66/EC	Quantities per battery chemistry	Portable batteries	1-year
6	Information	Batt compliance scheme	Member states' environmental protection agency (MS EPA)	Battery directive 2006/66/EC	quantities, collected and send for recycling, collection rate	Portable batteries	1-year
7	Information	Member states' environmental protection agency (MS EPA)	European Commission (EC)	Battery directive 2006/66/EC	quantities, collected and send for recycling, collection rate	Portable batteries	1-year
8	Information	WEEE collectors	WEEE compliance scheme	WEEE Directive	Quantities WEEE collected per category	Portable batteries	1-year
9	Information	Undefined	Member states' environmental protection agency (MS EPA)	-	Mass fraction of Batt in other waste streams (studies)	Portable batteries (industrial?)	n/a

Figure 4 Data map for the flow of batteries from production to end-of-life

3.4 Analyse Control Task

The term "control task" is used in this report to mean the transfer of a material. This transfer can be from one physical location to another, or from one process to another. Looking at figure 4, this can be any of the connecting lines between the boxes. However, as indicated in figure 4, data is only available at certain points within this complex flow of materials. The analysis of the control task is to understand what data may be available to provide the end-user with key information. The datasets associated with the facilities and the material flows are investigated in more detail below. Detail can potentially be gathered at different levels of granularity for the geographic location. However, data may not always be available and therefore a decision needs to be made whether assumptions should be employed to provide estimates for "missing" data. Any assumptions used will need to be stated as part of the knowledge platform. Figure 5 shows a representation of the control task and how the data being gathered can be linked to information at different points in the flow of a material through the economy. For example, information on the quantity, purity, presence of critical raw materials is gathered and can be associated with either the origin or destination locations of the material, as well as the material flow itself. In addition, extra information can be linked to the data that will enable the end-user to interrogate the data platform.

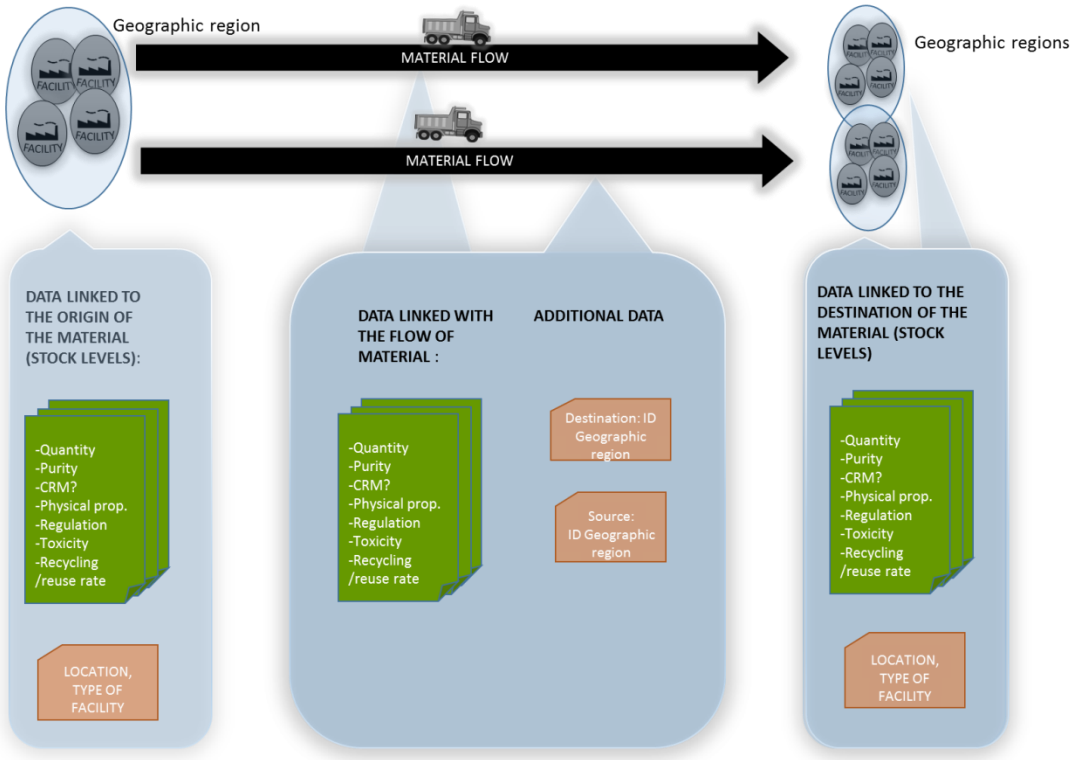


Figure 5 Representation of Data Requirements linked to Material Flows

End-user requirements are defined in three stages:

1. The type of data that should be included;
2. The level of detail of that data (either geographically based or time based), and how these data groups can be linked to each other;
3. The representation of the data,

Stages 1 and 2 are covered in this section 3.4, and stage 3 is covered in section 3.6.

3.4.1 Formulation of the survey of end-user needs

A workshop was held during the first public meeting of ProSUM on 23rd April 2015. The workshop took the form of a brainstorming session to identify the key datasets that would be required by typical stakeholders.

Key requirements identified by the workshop members were noted, as were the views that certain information should not be collected and presented via the Data Platform.

The findings from the workshop resulted in the generation of the survey questionnaire, which is shown in full in the annex.

3.5 Analyse Strategies

The analysis of strategies in this context means the investigation of the likely questions asked and insights sought by a range of stakeholders, and the subsequent analysis of the data gathered to ensure that the questions can be answered. The process already outlined has followed the principles of the IDEF0 process and can be summarised below.

1. The first stage is the setting of the domain to be considered, and the definition of items and facilities.
2. Stage two looks at the different data sets, and identifies how these may be combined to give further insights into the likely availability of waste materials
3. The penultimate stage tries to outline the nature of the questions that may be posed for specific reasons. In developing these questions, it is possible to review the first two stages to ensure that key data is available, and at the level of detail necessary to answer the questions.
4. The final stage then looks at the outputs following an interrogation of the data platform, and how the information should be presented, either by the generation of exportable datasets or in graphical form.

The analysis of strategies is equivalent to step 3 given above, and this would then be followed by a re-evaluation of the data gathered during steps 1 and 2.

The range of questions that may be posed by end-users can conveniently be grouped into a number of overarching categories. These are discussed below.

3.5.1 Questions by nature of information sought

The range data that can be gathered, which is associated with a material as it flows through the economy, has been outlined above. This data is gathered so that it can be used to answer questions posed by the potential end-users of the EU UMKDP. The types of questions that may be asked can conveniently by grouped into a number of categories:

- Current material flows;
- Available stocks;
- Forward projection of likely flows;
- Existing capacity for treatment of materials
- Lifetime of a material
- Drivers for recovery and recycling of materials

These are discussed in more detail below.

Current material flows

The core function of the data platform is to be able to understand and map the stocks and flows of a range of materials, and particularly to map the fate of materials as they reach their current end of life and so become part of the “urban mine”. However, it is also required to collate information that is associated with the stocks and flows that will enable stakeholders to make informed business decisions and policy recommendations. Examples of additional information that will enable these decisions to be made include:

- The composition of the stream with which a material of interest is associated;

- The main constituent that is of importance to the user, whether this be economic or strategic;
- Any materials or items present that are regulated.

Available stocks

This is the equivalent to the reserves of a virgin material. Information will have to be gathered from historical data to understand how much material is likely to be still within the economy (either within businesses or households). Information on what may also be available from waste landfill sites.

Forward projection of likely flow of materials

Each of the material flow data sets should have the ability to run forward in time. This information will be generated in Work Package 2 for products and Work Package 3 for waste. This needs to show any significant changes in the amount of an item likely to be available, its location, and the presence of other items. The time frame will be consistent across all data sets. The current level of information will limit the number of time intervals. It is proposed that short, and medium time frames will be used in the future projections. Short term includes 2 to 3 years from the current date, and medium term is 2020 and beyond.

Existing capacity for treatment of materials

Comparison between the flow of materials and the capacity for treating the materials would be needed to answer questions on the overall capability to handle materials from the urban mine. Information on the flows will be provided..

Information on the lifetime of an item

By identifying the residence times of products it may be possible to answer questions on opportunities for improved product design, and in particular with a view to improve overall recovery and recyclability.

Drivers for the recovery and recycling of material

There will be a number of reasons for implementing recovery and recycling programmes. Different end-users will have very different reasons for developing or supporting the construction and operation of either new recycling facilities or the instigation of new business models. These will vary from purely economic reasons, to issues over environmental concern or improvements in the local society.

3.5.2 Information sought by stakeholders

Different stakeholders who are likely to use the Knowledge Data Platform have been identified as follows:

1. **Data Providers** have access to data which is necessary to map the urban mine for CRMs
2. **Future Changers** can radically alter the way CRMs are used and generated
3. **Implementers** will use the outputs of the project to increase CRM collection, recycling and recovery rates, for example through changes in collection and dismantling techniques, or investment in CRM end-processing capacity.
4. **Policy Makers** also have the ability to be Future Changers but through changes in policies and legislation.
5. **Knowledge Improvers** can influence the market through knowledge exchange.

For the questionnaire the respondents were asked to identify the description that best represented their organisation's activity:

- manufacturers and retailers;
- collection; dismantling, preprocessing / pretreatment;
- processing / recycling facilities / smelting;
- environmental bodies;
- policy and strategy;
- and researcher.

The views of different groups can then be compared to see whether there are any significant variations in their requirements and the potential outputs and services from the EU-UMKDP.

3.6 Specifying the Requirements

This is the final step in the IDEF0 process and is interpreted here as the stage that specifies the nature of the outputs that can be provided by the EU UMKDP. This will take the form of a number of different graphical and tabular outputs that can be used to view the information gathered when analysing the data, but it will also include access to the raw data itself, so that additional plots can be generated by those seeking the information.

Examples of the type of output that may be of interest were provided in the questionnaire, and can be seen in the annex.

4. Development of the End-User Questionnaire

The information gathered prior to the workshop was combined with the brainstorming session and discussions with Work Package Leaders to develop the questionnaire that was then circulated to all of the Information Network members. The questionnaire was also made available on-line so that this could be completed by a wide range of respondents. The tables developed above were adapted, and a scoring system adopted to allow the respondents to provide their view of the aspects that were of high and low importance to them. One of the most important aspects was to allow respondents to set out the questions that they would expect to be answered by accessing the EU-UMKDP. The questionnaire is given in the annex.

4.1 Responses to the Questionnaire

A mixture of on-line and completed questionnaire documents were received. A total of 10 written responses were received, and 17 on-line responses received. A number of respondents started the on-line survey, but these were not completed, and so have not been included. The results are provided in the sections below, and the overarching conclusions are given at the end, after all the results have been presented.

4.1.1 Questions of interest

Most respondents asked at least one question for each category provided. There was no prescribed set of key words used, so any question could be asked. The questions have been analysed, and subsequently grouped according to the nature of the questions. All questions have been individually recorded, but the table below presents the top questions according to the number of times similar questions were asked in the different categories. The main aim for allowing a free form entry for questions to be asked was to allow a cross reference with the data being gathered to determine if sufficient data could be provided that could then answer the questions posed. The cross reference of questions with the findings from the prioritisation part of the questionnaire is presented at the end of this section.

Category	Questions grouped by Key words	Number of times asked
Materials	X element-->In which items is it? In which concentration?	4
	Material flow/streams identification: biggest flows of CRM-rich, source-destination.	4
	What are the recovery / recycling rates for a material over the whole life cycle and at different points in the material flow.	10
Stocks	X element (e.g. a CRM, noble metal)-->Quantity available in stocks (e.g. mining waste stockpiles, WEE, ELV, Batteries, household).	9
	Geographical location of stocks/ Stocks per country	2
Forward Prediction of Stocks and Flows	X element (e.g. a CRM, noble metal)--> Average % of evolution of recoverable amount.	6
	Effects of technological improvements on the amount of material recoverable from mining waste / technology requirements for future waste management.	4
	Effects of supply & demand changes (dictated by consumer, market evolution) on the amount of material recoverable from mining waste, WEE etc.	3
	Shortage effects on economy / technological development	2
	What manufacturing trends now impact recovery requirements in the future (for circular economy purposes).	2
	Assumptions: transparency, regular checking.	2
Capacity	Different techniques by country (CRM recycling/mining waste treatment practices/WEEE treatment).	8
	Current capacity (treating WEEE/ extracting material from mining waste) at country, European level.	7
	Location of facilities.	2
Lifetime	Average lifetime of X flow (item, mine, TV, phone). Changes by country (income and GDP).	10
	Evolution of lifetime throughout history. Can be expected to stabilise at current levels?	4
	Ways to track certain components during the lapse of time between sales & collection of a certain product.	2
Drivers	Costs and profits of collecting, separating and recycling certain CRM	3
	Economic viability of CRM recycling in each type/part/component of EEE/batteries/ELVs.	2
	Important environmental concerns related to recovery / LCA comparison: different routes of recovery vs. disposal and production.	2

Table 1 End-user questions grouped by key words

4.1.2 Data Associated with Waste Flows

This section of the questionnaire sought the view of the respondents on the importance of the type of data that could be gathered on the flow of the waste flows. As well as stating the importance of the data to them, respondents were also asked if there were any preferred units for providing information, and if there were any other datasets that should be gathered that had not been listed. For this section, and all other subsequent sections, there were no preferences given. Additional comments will be shown under the respective question sets, although there were only a few additional comments made.

The data for this set of questions, and subsequent sets, is provided in the form of bar charts showing the average score, and the subsequent set of charts shows the spread of scores given by the number of times a score was awarded. The scores indicate how important each data set are to the respondent (with **1** representing the **highest importance**, and **5** as **lowest importance**).

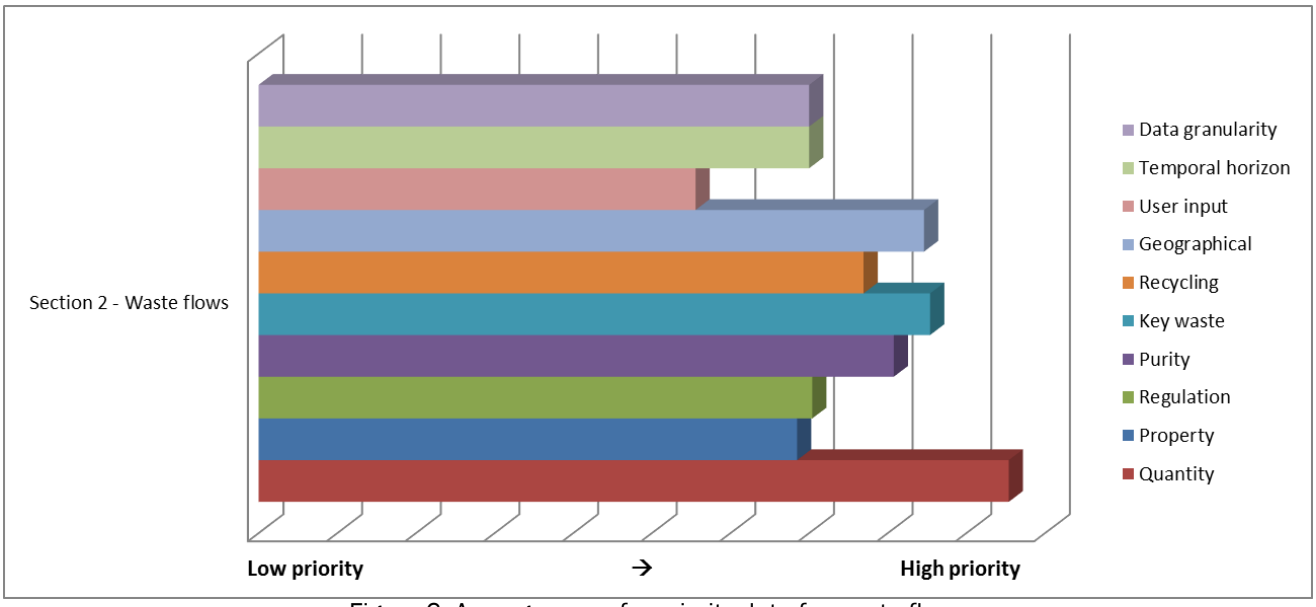


Figure 6 Average score for priority data for waste flows

Figure 7 Range of scores for priority of data for waste flows

4.1.3 Data Associated with Stocks

The questionnaire sought to assess the information that respondents would wish to see gathered about the stock of materials that would be available for the urban mine.

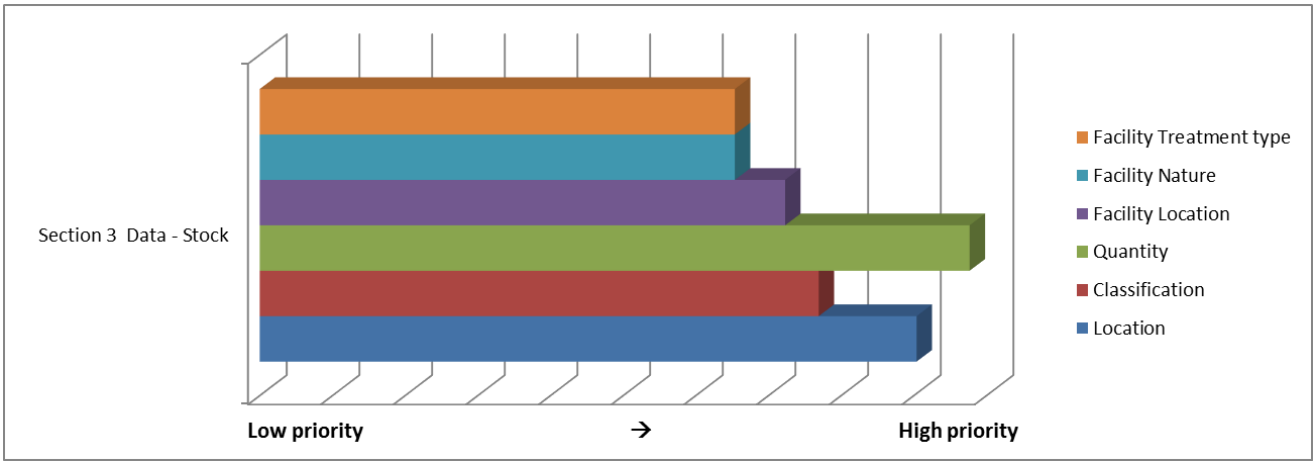


Figure 8 Average score for priority data for stocks

The spread of answers is given below

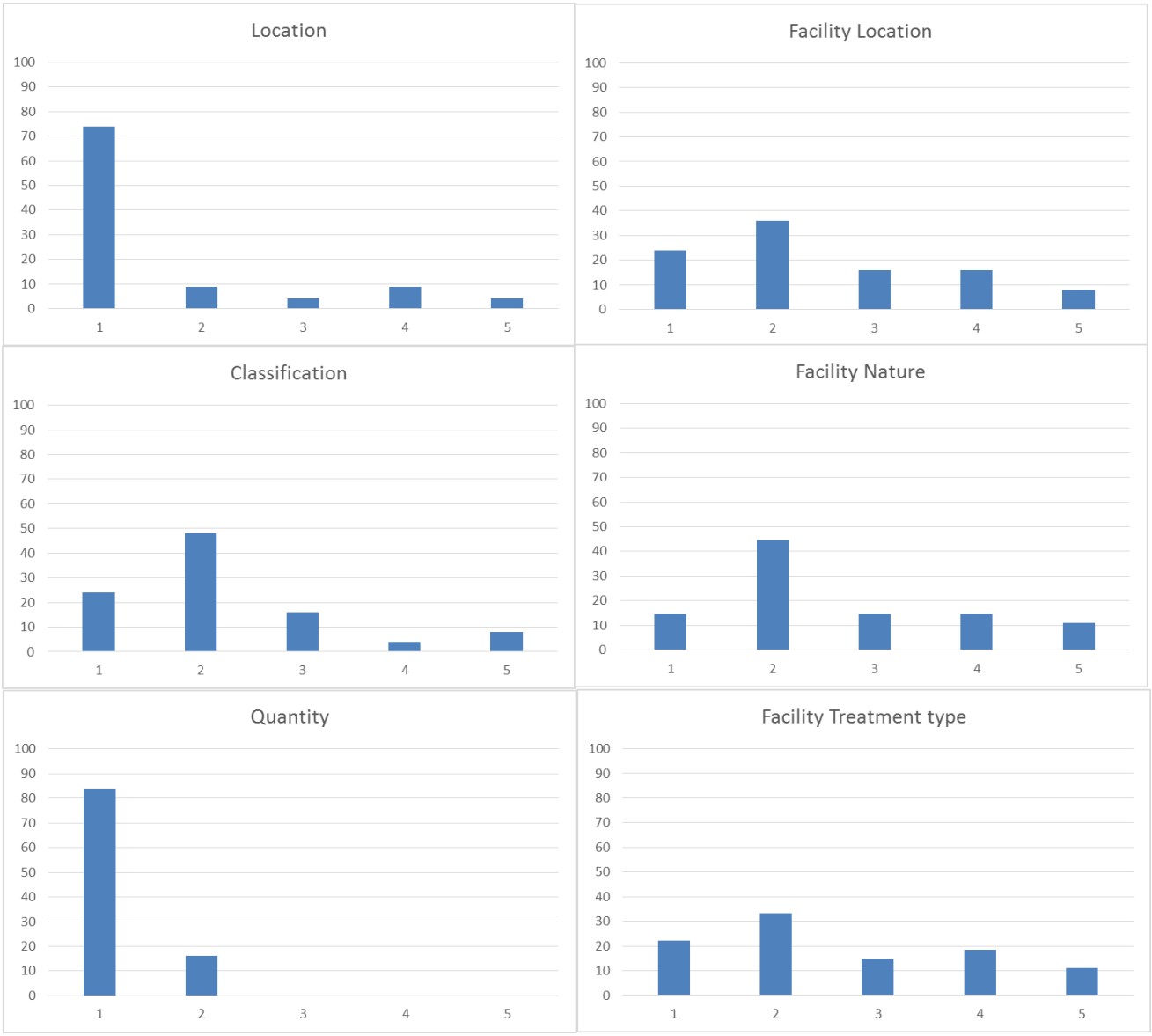


Figure 9 Range of scores for priority of data for stocks

4.1.4 Importance of Supporting Data

As well as gathering key information on the stocks and flow of materials through the economy, respondents were asked if there were other parameters that should be gathered. Examples were given, with the option to add other data. This provides an opportunity to compare data using alternative parameters, for example amount of material per head of population or compared with GDP.

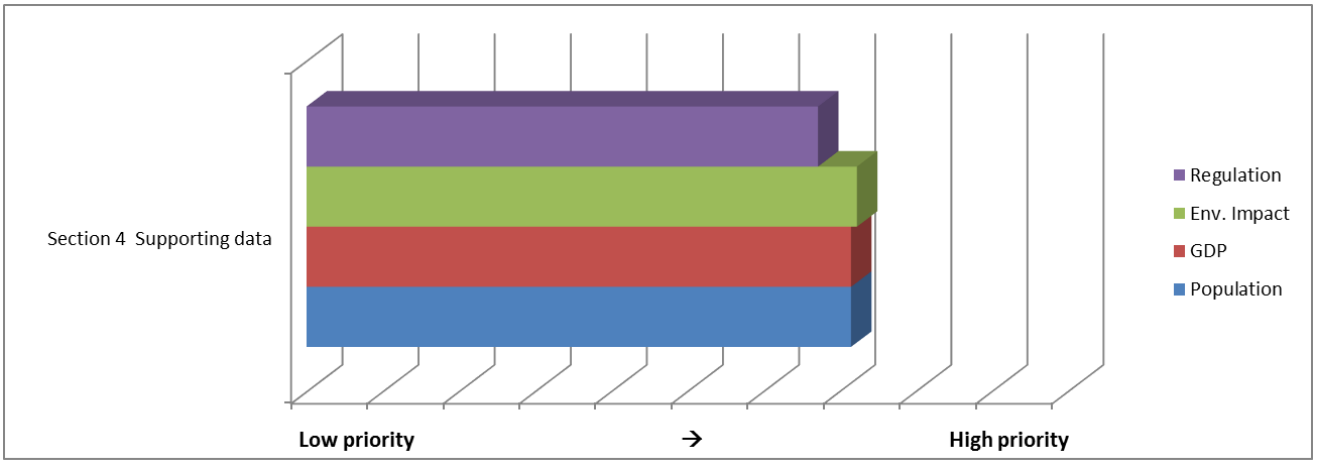


Figure 10 Average score for priority data for supporting data

The spread of scores is provided below.

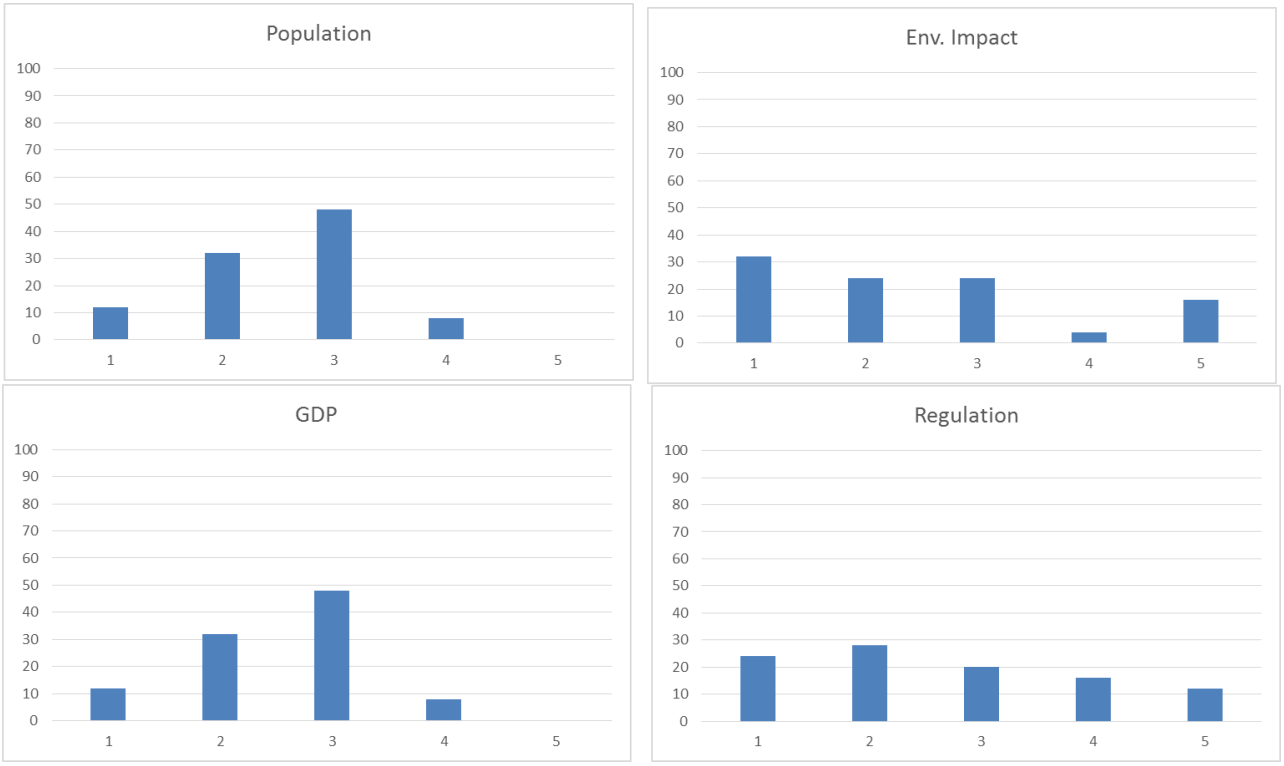


Figure 11 Range of scores for priority of data for stocks

4.1.5 Representation of Data

The final section of the questionnaire sought views on the representation of data, and the method of displaying the results from the EU UMKDP.

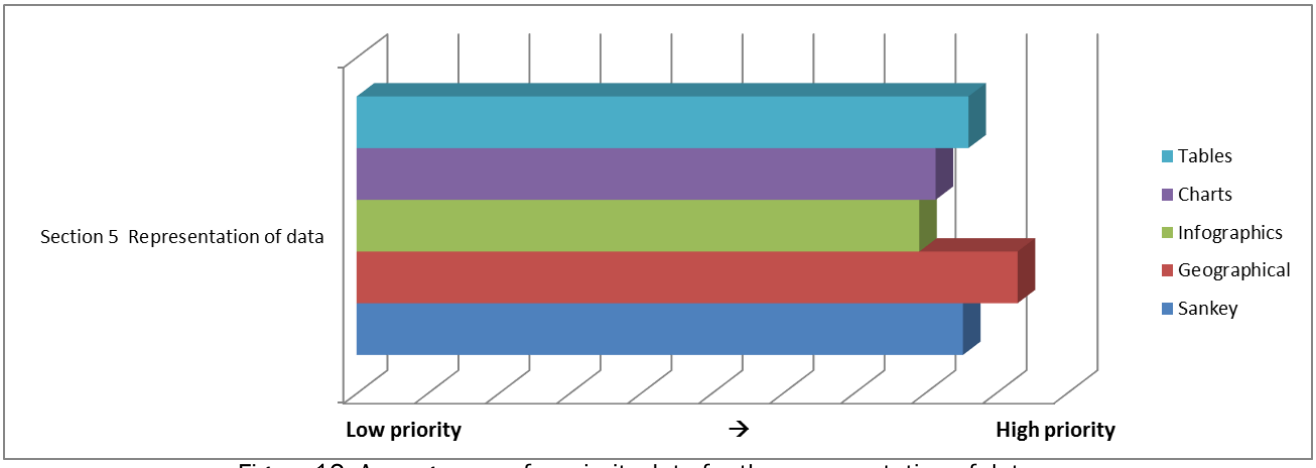


Figure 12 Average score for priority data for the representation of data

The range of results is given below.

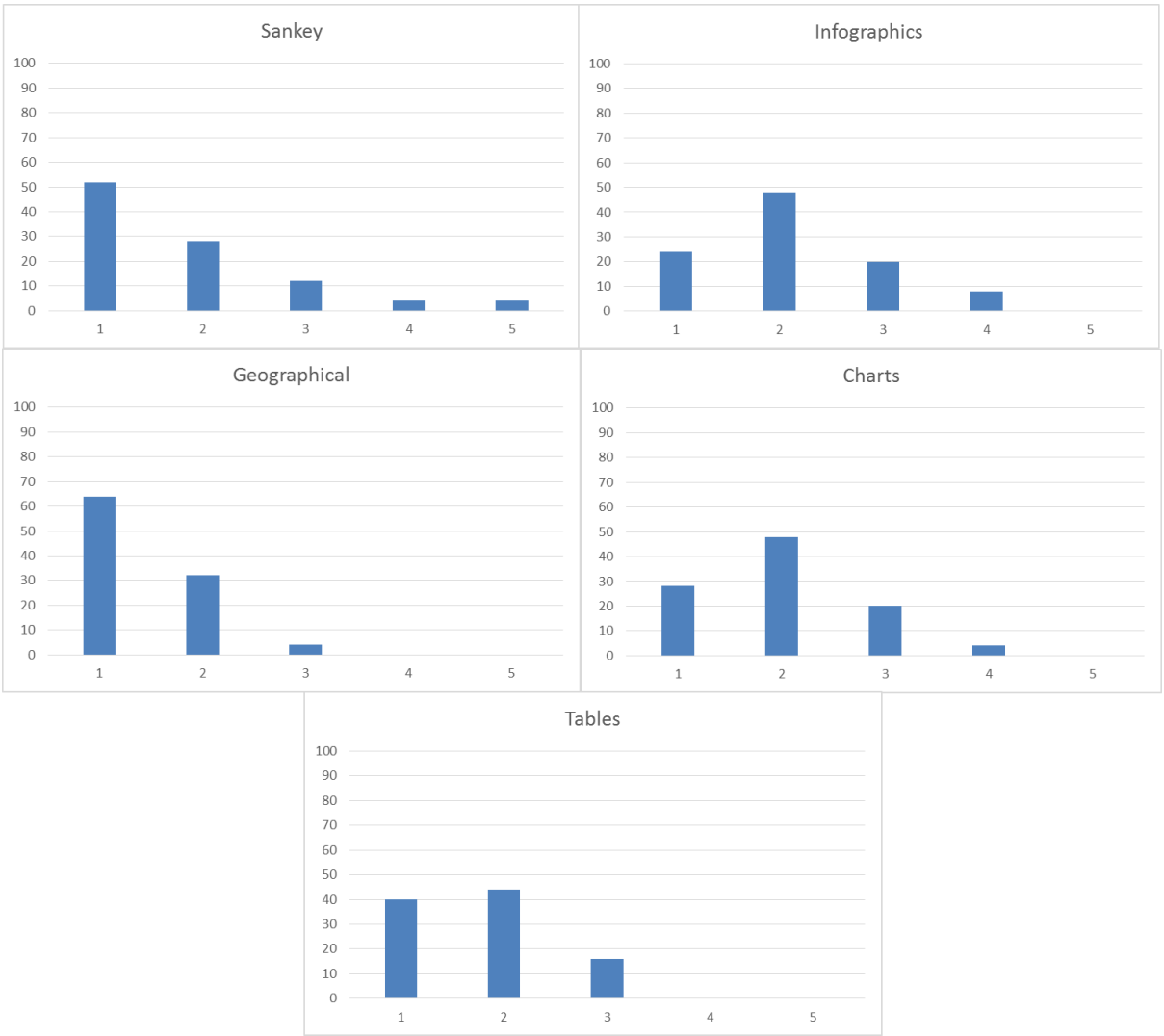


Figure 13 Range of scores for priority for the representation of data

4.2 Responses to the Questionnaire by respondent category

The responses to the questionnaire have also been analysed by the respondent category to assess if there is any significant variation in expectations between the different groups. The categories of respondents are given below

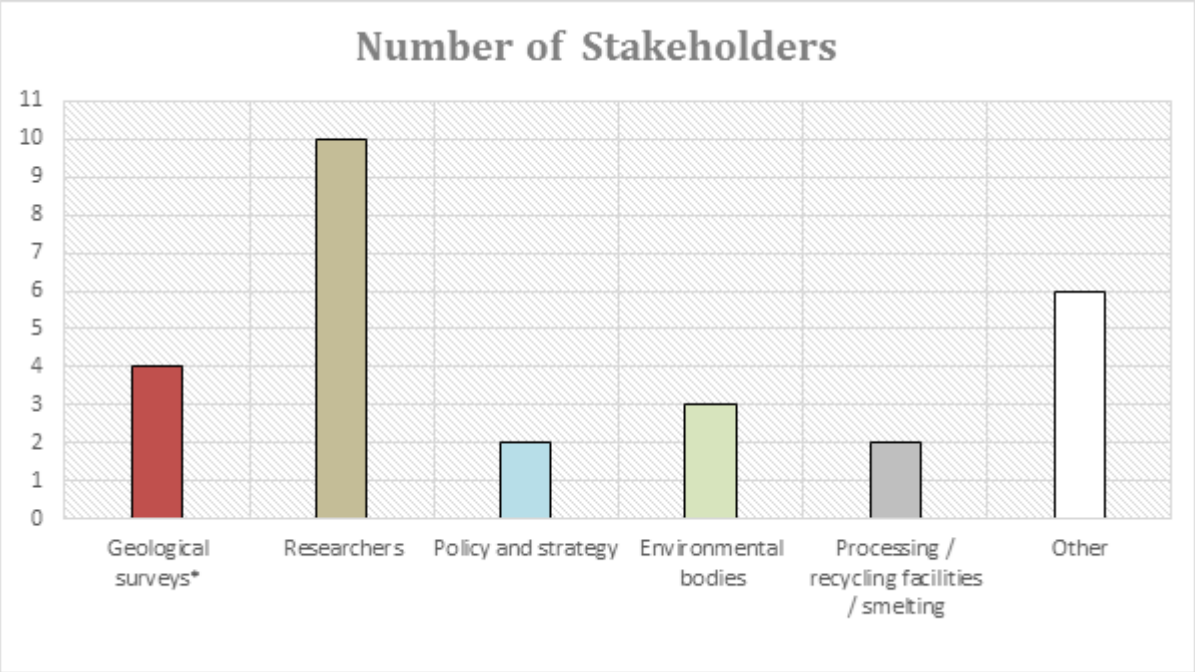


Figure 14 Questionnaire responses by stakeholder group

The group "geological surveys" has been split out separately as the categories chosen by these respondents varied, with some indicating that they were researchers, whilst others assigning themselves to policy and strategy or other.

The charts showing the comparison between responses is given in annex 2. Overall, there was generally good agreement between all the respondents across the categories but the following section highlights some of the variations that have been noted. However, care must be taken when reviewing these comments as for some questions there were only one or two responses from each category.

4.2.1 Responses to importance of characteristics for waste flows

Perhaps unsurprisingly, the respondents who classified themselves under the policy and strategy heading are more interested in the regulations associated with the waste flows, giving this a maximum score while other respondents scored this as between 1 and 2 points lower. This is partially also reflected in score for the "key waste" where again the policy and strategy respondents viewed this as critical with the highest priority assigned to this factor. Whilst the other respondents viewed this as important with the lowest score only being just one point lower and given by the researchers group.

Similarly, for the level of importance assigned to recycling, the processing and recycling facilities scored this with the maximum importance, with the next highest score being a full one point lower, with the geological survey respondents showing least interest in this factor.

The responses by the researcher group for the categories on geographical, temporal and data granularity were all scored lower in importance than almost every other group for each of the three questions. For the scoring of the importance of geographical information, every other group scored this factor at least a full point higher in importance. For the temporal horizon and data granularity issues, the researcher group and the processing / recycling facility group both scored these as of

less importance to them than the other respondents. The environmental bodies and the policy and strategy groups scored both of these to show that they were of quite high importance to them. This possibly reflects the recognition for setting long term plans and strategy as well as strategy that is sensitive to more local issues rather than a global perspective.

4.2.2 Responses to importance of characteristics for stocks

There are no significant variations in score for the level of importance assigned by respondents in this section, except for the responses by the policy and strategy group for the information on facility nature, facility treatment and facility location, with these being viewed as more important than by the other respondents. This may again reflect the nature of the information being sought to understand the exact information in order to set sound policy and regulation.

4.2.3 Responses to importance of characteristics for supporting data

There are no clear variations in the responses in this section except for the policy and strategy respondents again viewing the issues surrounding environmental impact and regulation as more important than any other group. As before, this is not surprising given the role of this group.

4.2.3 Responses to importance of representation of data

The main item to note in this section is that the environmental bodies were ranked the infographics and charts as quite lower priority than any other group, but did score the Sankey and geographical maps with the highest priority with all other groups. However, there is not sufficient difference of views to modify the findings when all responses are aggregated and reported as one.

5. Conclusion

5.1 Analysis of the Scoring on Priorities

By looking at the results of the survey overall, there seems to be a clear, and expected, interest in defining the total quantity of the stocks and flows of materials. However, this is closely linked with the understanding of the geographical location of these, which was the third highest score for the flows and second highest score for the stocks. This finding is supported by the fact that the highest priority in the representation of data is given to the geographical option. An interesting additional high scoring priority is that for identifying the key component in a waste stream. This is shown by the second highest score in the waste flows being that for “key waste”, and also a high score for the “purity” of the waste flow, and the third highest score in the stocks section of the questionnaire being for the “classification” of the stock material.

There is perhaps too small a sample of views to draw any further conclusions for the importance of data associated with the stocks and flow of materials, although there does appear to be interest in the level of recycling that currently exists, and how this compares with the overall environmental impact of recovery of materials. This is evidenced by the score provided for “recycling” under the flows heading, and the slightly higher score than any other in the supporting data for “Environmental Impact”. This relationship will be investigated further by looking at the questions related to the drivers for change.

The opportunity for respondents to provide their thoughts on the importance of data granularity and temporal information was not viewed with the greatest importance. There may be a number of reasons for this, for example respondents may know that current data collection would not allow detailed analysis, and extrapolation of data may be of dubious quality. Again, comparison of the prioritisation section of the questionnaire with the opportunity to pose questions to be answered is discussed in more detail later, but this theory is partly supported by the fact that respondents would expect assumptions in the modelling of the stocks and flows to be transparent. This assertion is also supported by the initial discussion during the workshop when there was a clear statement made that highly variable data (such as price, which can vary with both time and the nature of the waste stream) should not be included in the EU UMKDP. It was stated that data that is extremely variable should be gathered by the end-user at the time of the enquiry, as this would

lead to more robust findings. In addition, the option to provide a "user input" was not well received, being the lowest score in the section on waste flows.

5.2 Analysis of the Questions of Interest

As already mentioned, respondents were given a completely free opportunity to ask questions in the six different categories, as well as asking any other pertinent questions. In the next section, the questions will be matched against the data that has been identified as priority to determine if the supply of this data is likely to be able to answer the questions posed.

The materials questions are clearly aimed at understanding the total flow of materials, the greatest opportunities (both by total amount but also linked to current recovery), and where there are losses in the system. A number of respondents want to know the variations by region, country and EU wide.

For the stocks of these products and materials, there were only two main questions, which are how much is there and where is it. The only geographical level mentioned was by country.

These first two questions are really relatively obvious, and lie at the heart of the EU UMKDP. Although the questions posed may have been expected, it is interesting to note that there is a good level of interest in understanding the current levels of recovery and how these vary by location, and how this links to the mass balance of the flow of materials.

The questions raised for prediction of stocks and flows are more variable, although perhaps can be linked to the initial questions. One set of questions are linked to how the flow of these materials and products have changed historically (presumably to predict an organic growth in this), but secondly, what impact will future technological changes have on the flow of the waste. As well as technological change, the importance of societal behaviour has also been identified as a future key impact.

For the set of questions on capacity, it is interesting to note that the greatest interest is on the current capacity, but even more interest on the techniques and practices being used in different countries. This does not appear to link well with the responses to the prioritisation set of questions posed in the survey.

The responses for the lifetime of a product clearly show that there is interest in how the lifetime changes by country (but also some interest on how this relates to income or GDP). An associated issue is how this has changed with time. It is assumed that this is again to understand how this may change in the future by assessing the "natural" change of this parameter with time.

There was no major theme identified in the drivers as each respondent viewed these slightly differently. Of the key themes that could be identified the costs and profits for the current processing regimes was of greatest interest, and could also be linked to the economic viability of recovery. It was also noted that a LCA or environmental measure should also be considered. It is assumed that these questions are posed to assess the suitability of recovering materials, or whether the most suitable approach at this current time is to fulfil demand by using virgin materials. Answering these questions may also help identify the area for research into enhanced recovery / recycling technologies or business models.

5.3 Comparison between Questions and Prioritisation of Data Needs

The final stage in analysing the data is to compare the set of questions posed and prioritisation of data, including linking the data in different ways to allow end-users to gather the necessary information for their needs. This analysis is shown in Table 6.

It is important to note that some end user requirements identified are closely linked with the expected impact of the ProSUM project. For instance, an expected impact of the project is that the

recycling industry will have better data with which to plan for and invest in increasing the recovery of a wider range of materials. However, it is the aim of the project to produce an inventory of available date in a user friendly platform, it is not the intention to produce an optimising tool that provides for detailed decision making taking into account environmental and economic factors. Where the project does not meet the needs of end users, it will in many cases be possible to undertake additional work to improve decision making based on the data available on stocks and flows by element, material, product and waste type.

Table 6 Comparison of the questions asked, the data which will be gathered and the potential to address the questions through the project

Category	Question raised by potential end-users grouped by Key words	Available data which may answer the question raised	Assessment of match between question and available data relative to the project scope	Within ProSUM Scope according to the Description of Action
Materials	X element-->In which items is it? In which concentration?	Total material flow by elements and chemical and physical state e.g. as an oxide in a component, product and waste.	Data is available and will be collated. Data quality and quantity will determine the granularity at which this is presented.	Y
	Material flow/streams identification: biggest flows of CRM-rich, source-destination.	Above data linked with the location of stocks and flows.	This will be limited to stocks and flows up to the processing step only. This data will be derived by the project.	Y
	What are the recovery / recycling rates for a material over the whole life cycle and at different points in the material flow.	Insufficient data will be available to derive recovery or recycling rates.	End-users may be able to determine what additional research/activity is required to derive meaningful data in specific cases.	N
Stocks	X element (e.g. a CRM, precious metal)-->Quantity available in stocks (e.g. mining waste stockpiles, WEE, ELV, Batteries, household)	Data on the location of stocks and flows, residence times and historic trends.	This will be derived data from published studies compared with national statistics. This may vary across waste streams.	Y
	Geographical location of stocks/ Stocks per country	As above linked with National Statistics.	Data will be derived by the project at the MS level. Mining waste stocks will be presented. It may be possible to present product stocks as amount per household.	Y

Forward Prediction of Stocks and Flows	X element (e.g. a CRM, precious metal)--> Average % of evolution of recoverable amount	Historic data on products placed on the market combined with data collected on future product trends,	Total elemental data may be derived. Evolution of recoverable amounts will not be possible.	Y
	Effects of technological improvements on the amount of material recoverable from mining waste / technology requirements for future waste management	No data is being gathered on technologies.	Not in project scope. End-users may be able to further assess technology requirements based on data presented.	N
	Effects of supply & demand changes (dictated by consumer, market evolution) on the amount of material recoverable from mining waste, WEEE etc.	Short term and medium term future trends in product types and material use will be assessed in the project.	This is not in project scope but information on trends could be used to assess impact on future product and waste characteristics.	N
	Shortage effects on economy / technological development	No direct information available.	This is beyond the scope of ProSUM.	N
	What manufacturing trends now impact recovery requirements in the future (for circular economy purposes)	Short term and medium term future trends in product types and material use will be assessed in the project.	Manufacturing trends are not being assessed directly but product trends may help inform the picture.	N
	Assumptions: transparency, regular checking	N/A	The procedures used to quality assure data will be published.	Y
Capacity	Different techniques by country (CRM recycling/mining waste treatment practices/WEEE treatment).	No information is being gathered on techniques and practices.	Case studies may be presented to illustrate where available data indicates that some practices may be impacting on recycling.	N
	Current capacity (treating WEEE/ extracting material from mining waste) at country, European level …	Some waste treatment data may be available from Eurostat returns.	Capacity data is beyond the project scope.	N

	Location of facilities	Data by industrial classification codes is available.	This is outside the scope of the project.	N
Lifetime	Average lifetime of X flow (item, mine, TV, phone). Changes by country (income and GDP).	Data on residence times for some products is available.	This will be derived and presented at the MS level where possible.	Y
	Evolution of lifetime throughout history. Can be expected to stabilize at current levels?	As above	As above	Y
	Ways to track certain components during the lapse of time between sales & collection of a certain product	Some data available on residence times and in-use phase for products.	The flows of reported and complementary flows of waste products will be determined at the MS level. The granularity of this will be dictated by data quality . Beyond project scope to track components but end-users may be able to assess which products and components require further tracking.	N
Drivers	Costs and profits of collecting, separating and recycling certain CRM	No data is likely to be found for the range of materials and products of interest.	Economic considerations are beyond the scope of the project. Industry will be able to apply their own cost data to the macro data presented.	N
	Economic viability of CRM recycling in each type/part/component of EEE/batteries/ELVs	No data is likely to be found for the range of materials and products of interest.	As above.	N
	Important environmental concerns related to recovery / LCA comparison: different routes of recovery vs. disposal and production	Comprehensive data using consistent system boundaries is unavailable.	The environmental properties for mining wastes will be presented where available from the Geological Surveys.	N

			Recovery optimisation and environmental performance are beyond the scope of the project.	

Annex 1: Questionnaire circulated to Members of the Information Network

Identifying End User Data Requirements for the ProSUM Urban Mine Knowledge Data Platform

Questionnaire to assess the needs of stakeholders for key data on the availability of secondary raw materials

INTRODUCTION

The ProSUM project will build an EU Urban Mine Knowledge Data Platform (EU-UMKDP) to provide access to data collated on secondary raw materials in the urban mine, particularly Critical Raw Materials (CRMs). An Information Network (IN) has been established to allow partners in the network to provide and use data in an inventory for those waste streams with a high potential to serve as a source of CRMs. Members and potential members of the Information Network are being consulted to establish what data and intelligence they would want to have access to and how they would like to see it presented.

This questionnaire has been developed by building on the comments made by stakeholders at the Information Network meeting held in April 2015. It may not be possible to provide all of the data in the format requested by potential end users of the EU-UMKDP. We have not been overly restrictive in the options presented in the questionnaire, however, we need to point out that the data quality and availability may limit how we meet end user expectations. This will help us in defining recommendations to meet your data and intelligence needs in future.

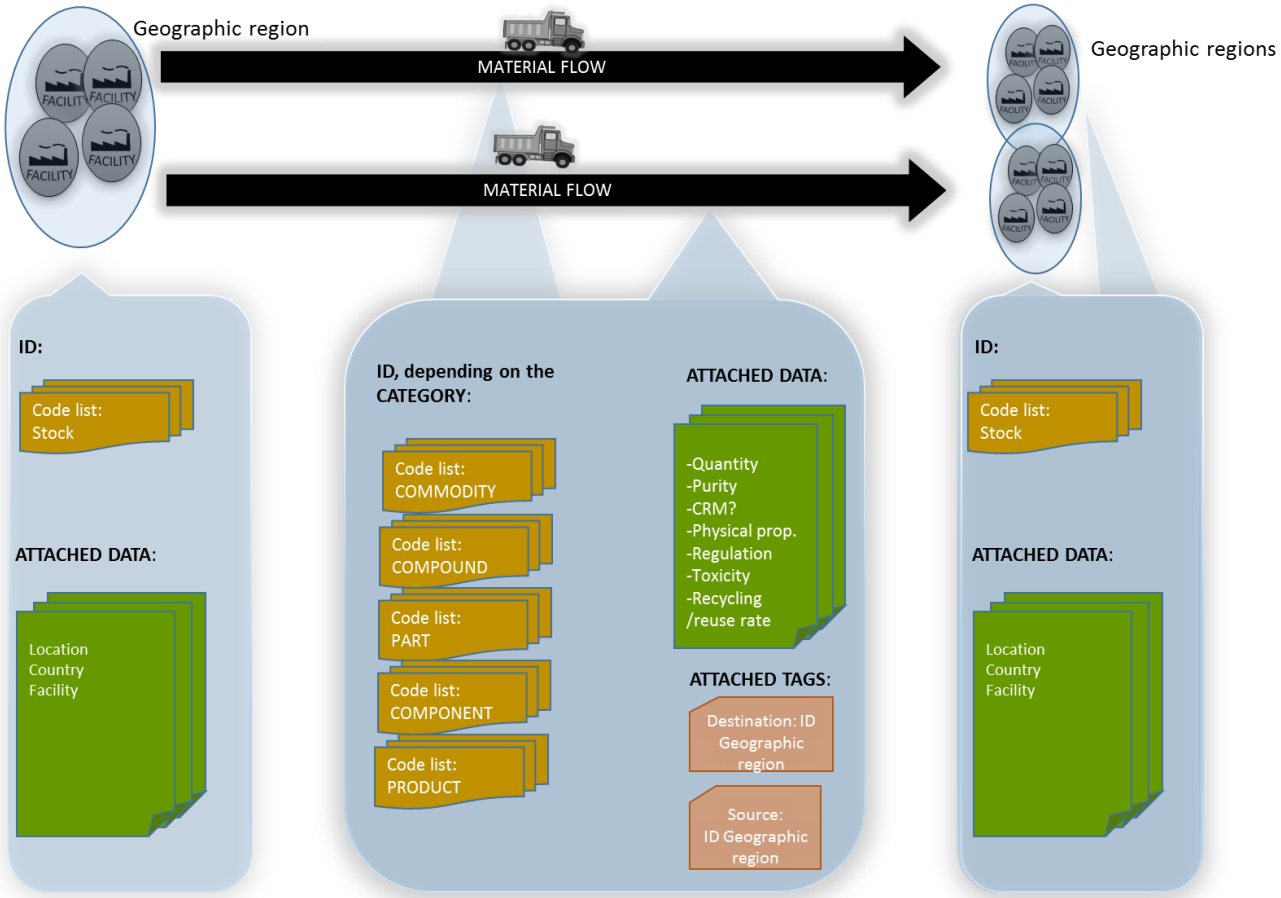
By completing this questionnaire you will assist ProSUM with one of our key objectives, which is to:

Construct an inventory and a portal providing state-of-the-art data on CRMs in ELVs, WEEE, batteries, and mining wastes. Enable access to the inventory via a multi-user portal allowing for the presentation of data and information on primary and secondary materials with the potential for yearly updates and reports.

We envisage that the questionnaire will take you no longer than 30 minutes to complete. There is a brief section to complete about your organisation and then the questionnaire is split into five sections:

3. **Questions for which you need to get answers**: These questions are split into 6 groups to help identify specific issues you may have, and therefore specific questions you are likely to ask and need data from the Knowledge Platform to answer. Example questions are provided to help prompt your thoughts. Using these questions is aimed at helping to understand the amount of data required from the knowledge platform and to ensure that sufficient data is being gathered to help stakeholders answer their key questions.
4. **The level at which data is presented for secondary raw materials:** This part of the questionnaire is designed to identify the granularity and detail you wish to see e.g. for materials, elements, commodities, whole pieces of equipment, such as computers, lighting, cars etc. or parts, such as magnets, motors, printed circuit boards etc.
5. **Data associated with a waste or material stock**: The information you would like to know about where materials and wastes arise, including information about facilities that handle the materials.
6. **Supporting data**: This information is used to help understand information gathered within the Knowledge Platform. For example, the GDP or population of a country may help understand the level of secondary materials being generated, and also give a basis for comparison.
7. **Representation of data**: Having gathered the data, it is possible for information to be represented in many different formats. Examples are provided that could be used in the final Knowledge Platform, but this section allows you to highlight any preferred type of data representation you may have.

The diagram below represents a simple flow of waste materials through one part of the value chain and the data that can be associated with this material flow. By interrogating the Knowledge Platform, the aim is that end users should be able to extract useful information on secondary raw materials.



Annex 1 contains more information on definitions. If you have questions about the meaning of a term, please refer to the Annex.

Information about you

Name

Contact details – please provide e-mail and phone number

Mark (X) the description that best represents you and your organisation.

Manufacturers and retailers__	Collection	Dismantling, pre-processing/pre-treatment__	Processing/Recycling facilities/smelting__
Environmental bodies__	Policy and Strategy__	Researcher__	Other:_____

Can we contact you for further information?

Are there particular topics you are interested in?

Section 1

Questions by type of information sought

The questions have been split into 6 categories:

1. Current material flow
2. Available stocks
3. Future stocks and flows of materials
4. Existing waste treatment practices and capacity
5. Information on the lifetime of products
6. Economic and environmental drivers

Please see the annex for a description about each of the question types. Please expand the boxes to cover any and all questions that you may wish to have answered. It is currently intended to focus on the critical raw materials identified by the EU ad-hoc working group, but if you have any other key items that you wish to be included, please state them below.

Which specific questions do you expect to be answered?

TYPE	Sample questions	Your specific questions
Current material flows	How much Indium is recovered from WEEE today?	
Available stocks	How much Indium is available in stocks of waste WEEE?	
Forward projection of material flows	Is the amount of recoverable Indium likely to change in the future?	
Existing capacity for treatment	What is the current capacity for treating WEEE?	
Lifetime of products in the value chain	What is the average lifetime of a television, and does this change by country?	
Economic and environmental drivers	Are there any differences in treatment and dismantling practices in different countries?	

Section 2

Data associated with waste flows

The table below shows the data needs which were identified by stakeholders at the Information Network meeting in April 2015. Please provide an indication of how important each data set would be to you by providing a number between 1 and 5 (with 1 representing the highest importance, and 5 as lowest importance). It is unlikely that all of the information can be gathered from current statistical information, but efforts will be focussed on providing data identified as the most important. Also, please add other data that you would want to have collected or presented. You can also add any comments for any of the data sets proposed.

Data	Measure / specification	Preferred unit	Importance (values between 1-5) & comments
Quantity	kg, Tonnes, by volume, by weight		
Physical properties, i.e. nature of stream	Complete, shredded to >10mm, shredded <10mm, other		
Regulation	Covered by REACH, RoHS		
Purity/ Composition	%		
Key waste, material, product, component of interest	PGMs, Gold, silver etc		
Current recycling/reuse rate	% of waste, material, product, component		
Geographical location	Latitude and longitude		
User input values	Opportunity for the user to identify their own input data for their own use		
Temporal horizon	The date at which this information is known.		
Data granularity	Level of reporting for waste flows, e.g. by overarching WEEE category, or by motors, pumps etc. that are used within the product, or by material, alloy, element, commodity	In this section only – 1 represents greatest detail – for example by very small components, and 5 represents less detail – e.g by WEEE category only	
Other:_____			
Other:_____			
Other:_____			

Section 3

Data Associated with waste stocks

The term stocks refers to waste which are available as secondary raw materials. As with the other data, please provide an indication of the importance of the data to you (on the scale of 1 to 5, with 1 as the highest importance and 5 as the lowest importance), and add any comments.

Data	Unit / specification	Importance (values between 1(high)-5(low)) & comments
Location of stocks	Geographic location for each of the stock types	
Classification of the stocks	Sorted, unsorted, whole, shredded,	
Quantity of stocks	Tons	
Facility	Location of facility	
	Nature of facility (e.g. classification of facility according to NACE codes) or stocks in households	
	Treatment type (for facilities that treat waste materials)	
Other:_____		
Other:_____		
Other:_____		

Section 4

Supporting Data

In many cases it will only be possible to present data at the Member State level. Where this is the case there may be supporting information which is of interest to you e.g. to explain differences between Member States. As previously, please indicate the importance of these items between 1 and 5 (1 highest importance and 5 of little importance). Please add other information that you would like to be held within the Knowledge Platform, and please provide references for where this data may be obtained if known

Data	Unit / specification	Data source	RANK (values between 1 (high)-5 (low)) & comments
Population	Number of people by NUTs level	Eurostats	
GDP	GDP by NUTs level	Eurostats	
Environmental impact for waste streams	CO_{2e}	National carbon balances / European LCA database	
Differences in implementation of legislation			
Other:_____			
Other:_____			

Section 5

Presentation of Data

This is the final question in the questionnaire. We want to understand how you would like to see data and intelligence presented in the EU-UMKDP. This project is a sister project to the Minerals4EU project which is collating data on mineral reserves.

The data and intelligence can be presented in a number of formats. Please rate these between 1 and 5 (1 is greatest importance and 5 is of little importance). Examples of the types of data that have been used in the past for similar data sets are given in the annex.

Display Option	Importance (1-5)	Description, comments, suggestions
Sankey flow diagrams		
Geographical maps		
Infographics		
Charts		
Tables		
Other:_____		
Other:_____		
Other:_____		

Annex

Further information on each of the data sets and outputs sought

Information about you

Description of Stakeholders

Different stakeholders who are likely to use the Knowledge Data Platform have been identified as follows regarding the type of relationship they have with platform:

1. **Data Providers** have access to data which is necessary to map the urban mine for CRMs.
2. **Future Changers** can radically alter the way CRMs are used and generated.
3. **Implementers** will use the outputs of the project to increase CRM collection, recycling and recovery rates, for example through changes in collection and dismantling techniques, or investment in CRM end-processing capacity.
4. **Policy Makers** also have the ability to be Future Changers but through changes in policies and legislation.
5. **Knowledge Improvers** can influence the market through knowledge exchange.

Section 1

Description of the question categories

1. Current material flows

This is the core function of the data platform to be able to understand and map flows. However, the key aspect was the associated data that will provide the end user with key information on which to make business decisions or policy recommendations. The flow data needs to include relevant data that will determine whether a material is recoverable based on a number of parameters. The user may want to be able to identify not only the type and amount of material flowing but also:

- The composition of the stream with which it is associated
- The main constituent that is of economic importance
- Anything present that is subject to regulation or special treatment requirements
- Etc.

2. Available stocks

This is the equivalent to the reserves of a virgin material. Information will have to be gathered from historical data to understand how much material is likely to be still within the economy.

3. Forward projection of likely flow of materials

Each of the material flow data sets should have the ability to run forward in time. This needs to show any significant changes in the amount of waste likely to be available, its location, and its composition.

4. Existing capacity for treatment of materials

Some users may be interested in the flow of materials and the capacity for treating the materials.

5. Information on the lifetime of a product

Information on the lifetime of a product may be of interest to identify how long is spent in each form. This will help identify how long it takes for waste products to pass through the economy.

6. Economic and Environmental Drivers

Comparisons between different regions can be normalised by including information on the population, economic activity, and environmental impact of the consumer behaviour for products containing critical raw materials.

Section 2

Data associated with waste flows

This table includes the type of information stakeholders have already expressed they would like better intelligence on. In this table, we want to further refine your data needs by understanding what units and terms we use to present data on waste flows, and also the level of detail you would wish to see for mapping the material flows. Flows may simply be mapped by the major categories of waste, i.e. electrical, end of life vehicles, batteries, mining waste, their materials, or more detail may be presented for components used in the manufacture of these items.

Section 3

Data associated with waste stocks

It may be possible to present information on waste stocks at different geographical levels e.g. specific locations for minerals and Member States for products. Here we would like to know your preferred geography for waste stocks.

If it is possible to further broken down recycling facility by category then the following breakdowns may be available:

- mechanical crushing of metal waste from used cars, washing machines, bikes etc.

- shredding of metal waste, end-of-life vehicles etc.

- other methods of mechanical treatment as cutting, pressing to reduce the volume

Section 4

Supporting data

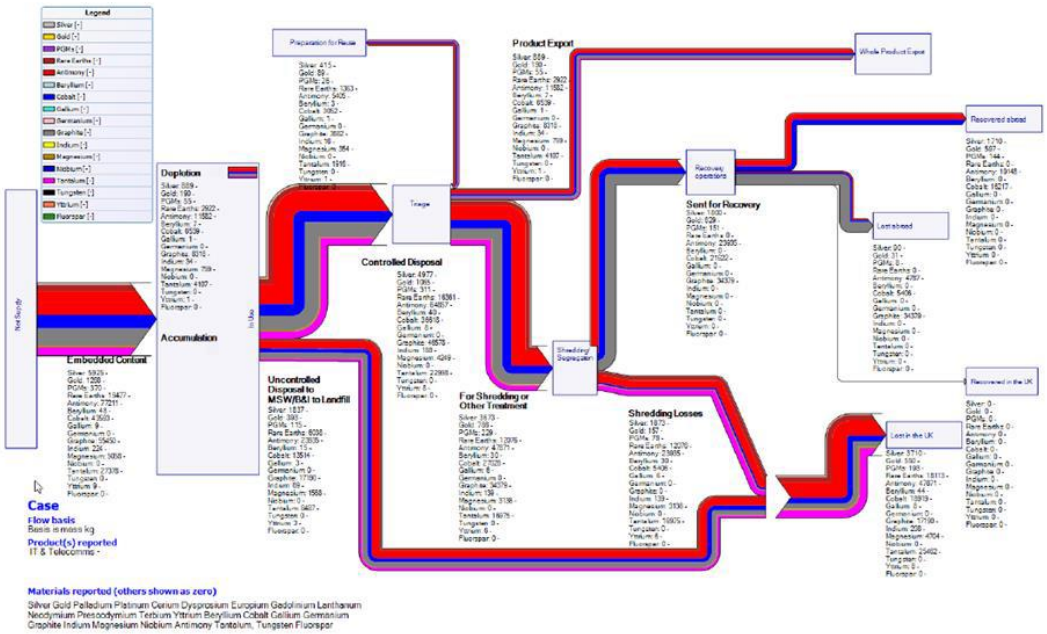
Although large quantities of secondary data can be held by the Knowledge Platform, this data should be of relevance to the rest of the data held, and will enhance the interrogation of the data sets. For example, the level of a particular type of waste collected may have some correlation with the wealth of the country in which it is generated. This may be useful information for policy stakeholders when looking to map future increases in waste generated in line with increases in a country's wealth.

Section 5

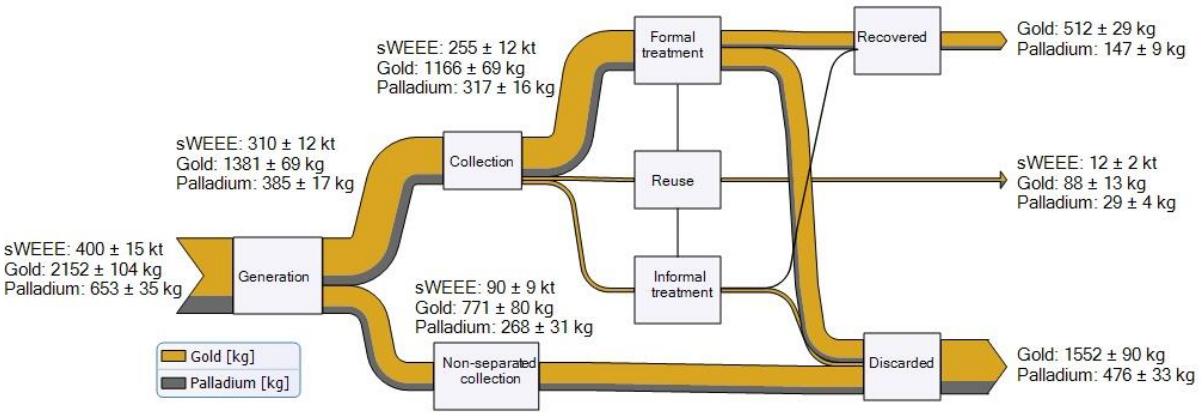
Presentation of data

There are many ways to represent the data that is gathered. Some examples of infographics used for representing similar data are provided to help prompt your suggestions for your future needs.

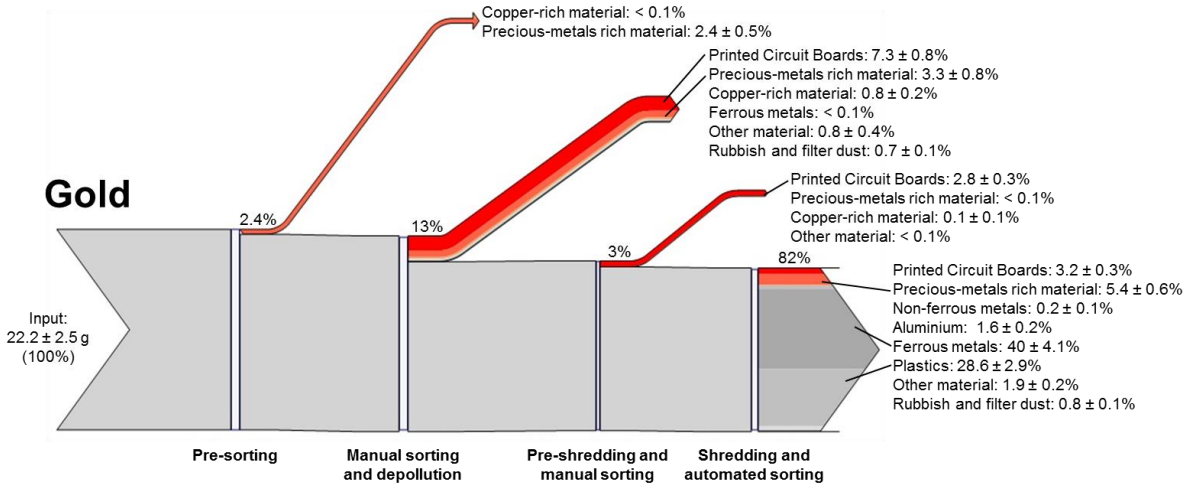
Figure 6 IT and telecomms equipment (Source: Oakdene Hollins)



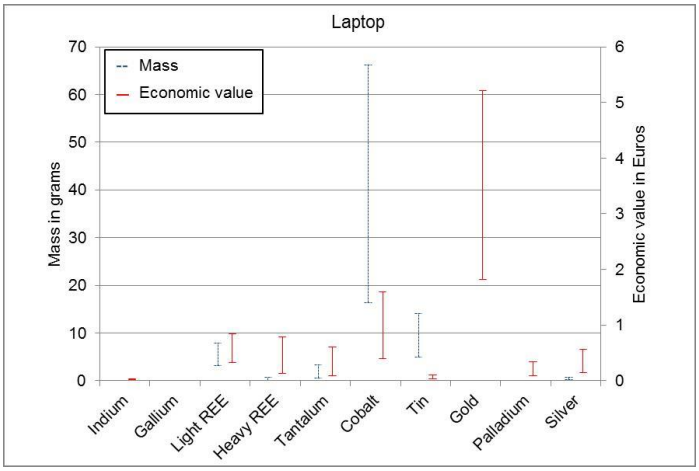
Sankey diagram representing the flow of material between facilities in the UK



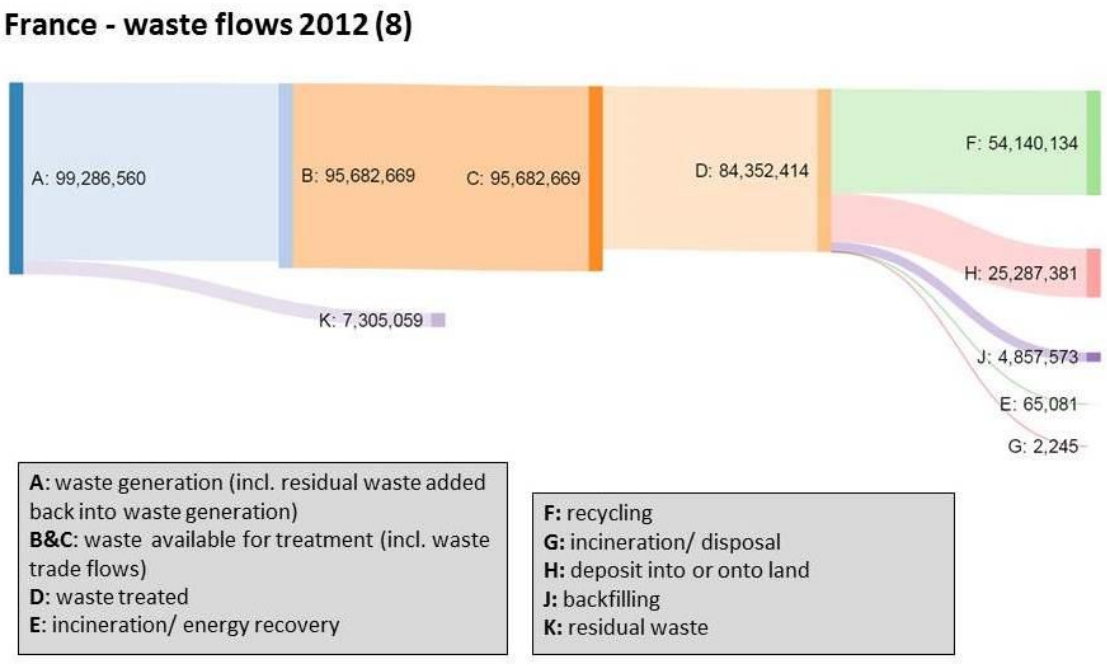
Total flows of gold and palladium contained in small WEEE in Germany in 2007 (source: Chancerel, P. Substance flow analysis of the recycling of small waste electrical and electronic equipment - An assessment of the recovery of gold and palladium. Dissertation, Technische Universität Berlin, 2010)



Flows of gold during preprocessing of one tonne of input WEEE (wt.%)
(source: Chancerel, P., Meskers, C. E. M., Hagelüken, C., & Rotter, V. S. (2009). Assessment of Precious Metal Flows During Preprocessing of Waste Electrical and Electronic Equipment. Journal of Industrial Ecology, 13(5), 791–810)

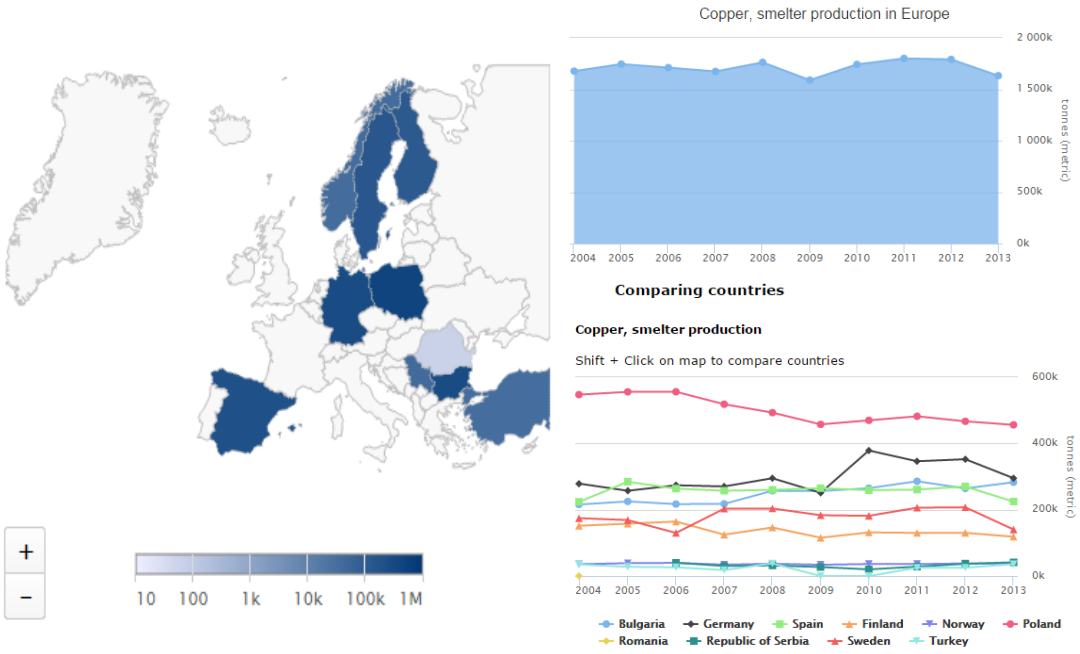


Average ranges of the mass and the economic value of the target metals embedded in a laptop sold in Germany in 2012 (source: Chancerel, P., Marwede, M., Nissen, N. F., & Lang, K.-D. (2015).
Resources, Conservation & Recycling, 98, 9–18)



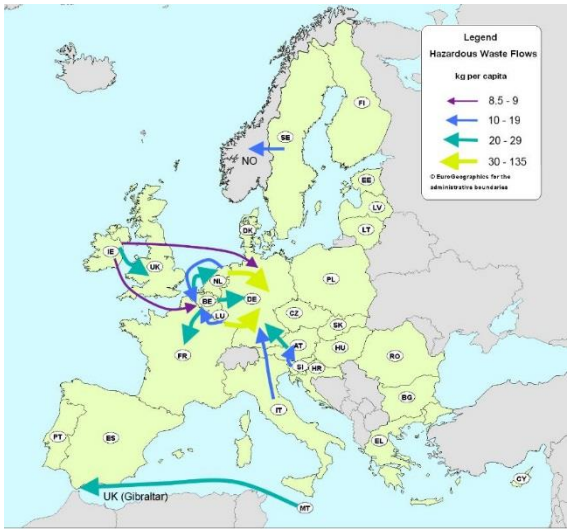
http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html

Copper, smelter production by European countries in 2013



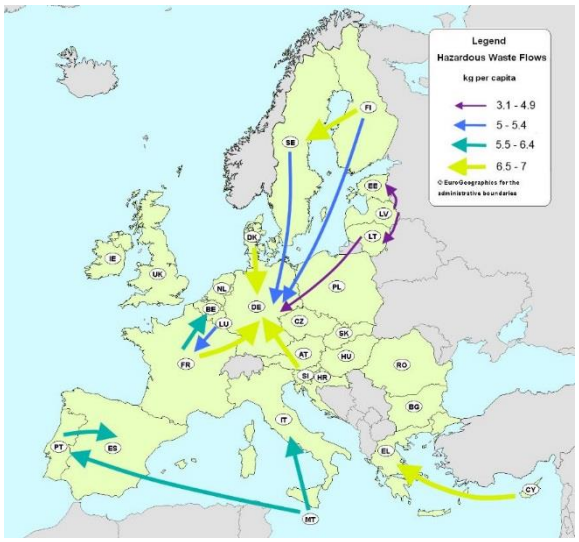
http://minerals4eu.brgm-rec.fr/m4eu-yearbook/theme_selection.html

Hazardous waste shipments from EU Member states (larger flows), in kg per capita, 2011



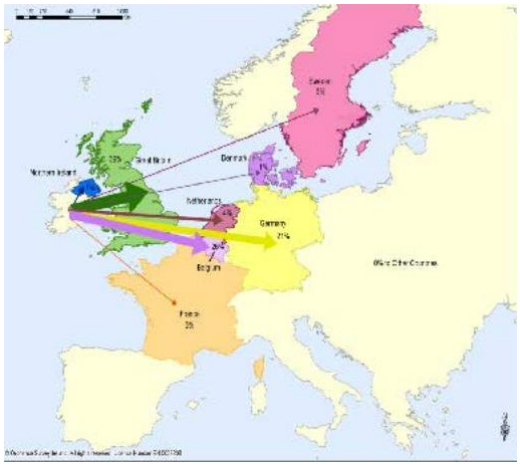
http://ec.europa.eu/eurostat/web/waste/transboundary-waste-shipments

Hazardous waste shipments from EU Member states (smaller flows), in kg per capita, 2011



http://ec.europa.eu/eurostat/web/waste/transboundary-waste-shipments

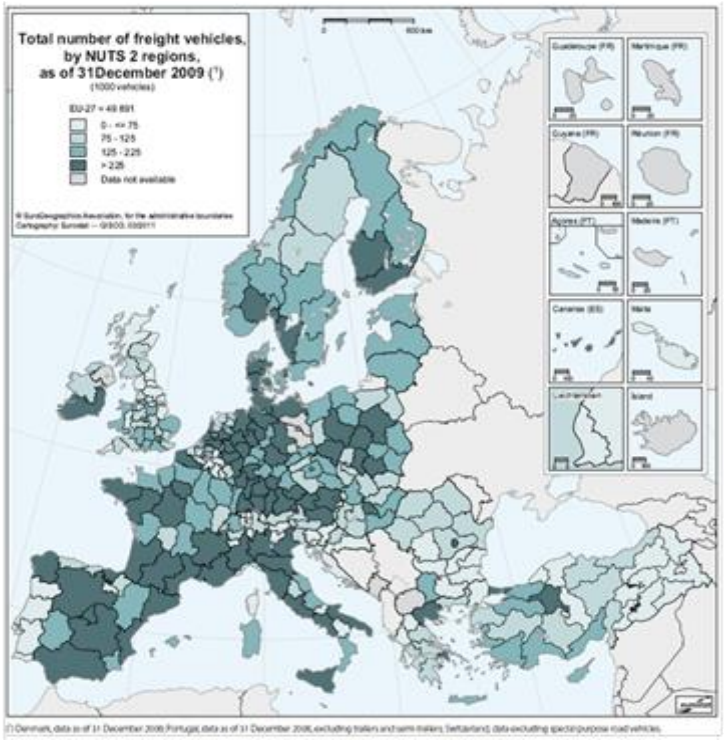
Exported hazardous waste from Ireland 2011



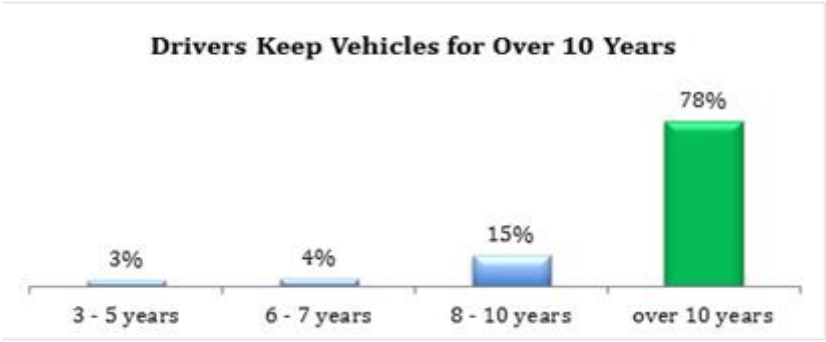
http://www.rilta.ie/quarterly-environmental-newsletter-2014/

Examples demonstrating flow of materials linked by GIS data

Total number of freight vehicles, by NUTS 2 regions, as of 31 December 2009.

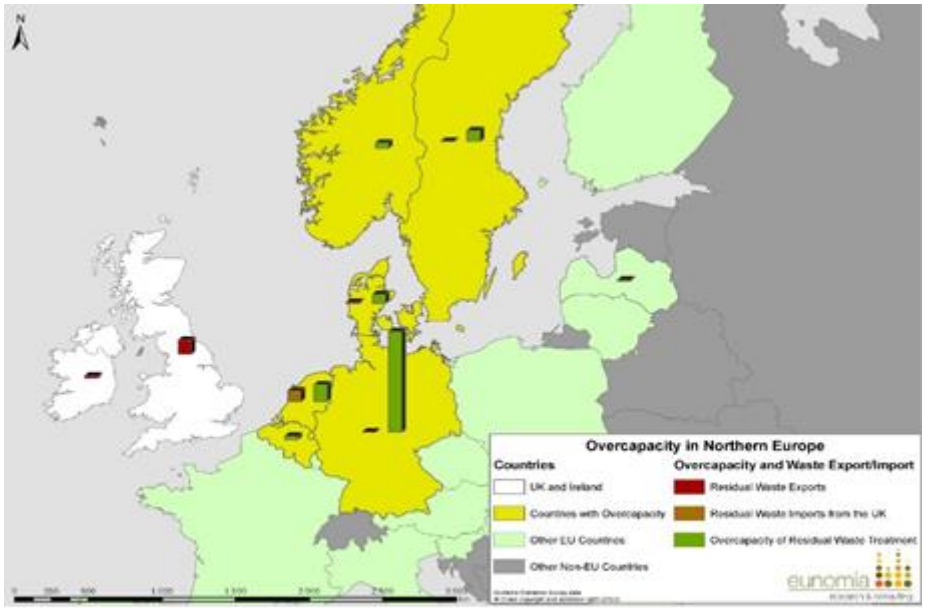


http://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Vehicle_fleet_statistics_at_regional_level



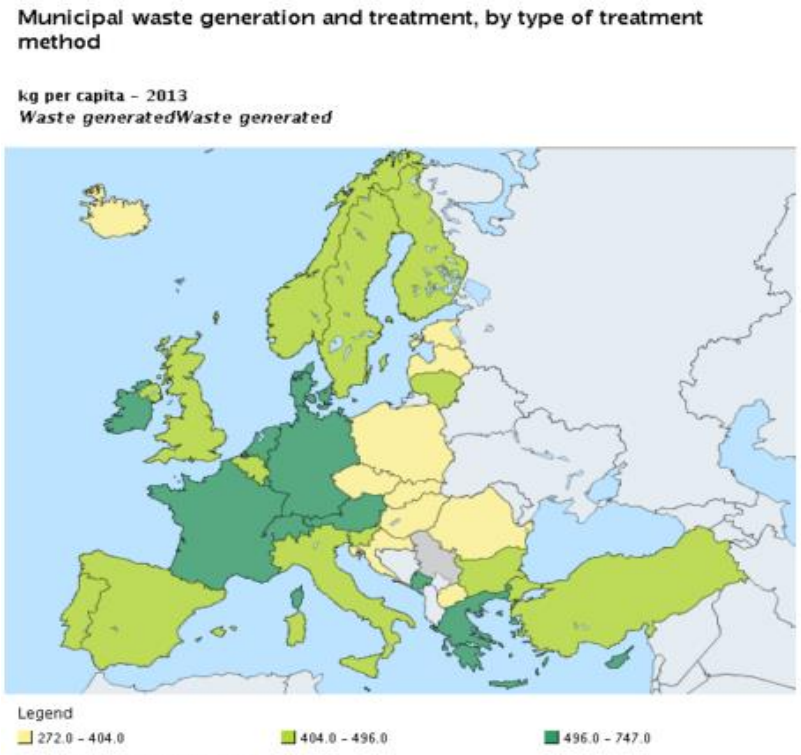
https://www.automd.com/about-automd/press/07-23-2012/

Examples of information linked to transport use, by geography (at NUTS 2 level) and by lifetime



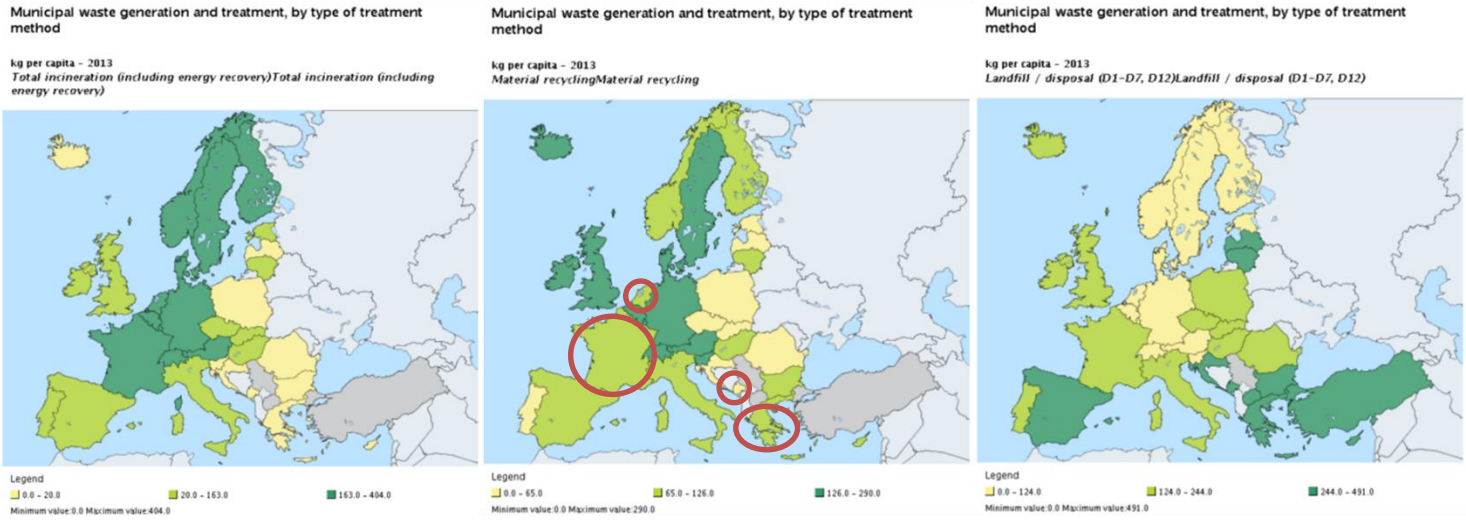
http://www.isonomia.co.uk/?p=1894

Figure 5 Information linking facility capacity with flow of materials



http://ec.europa.eu/eurostat/web/waste/key-waste-streams

Figure 6 Examples of information reported at country level



http://ec.europa.eu/eurostat/web/waste/key-waste-streams

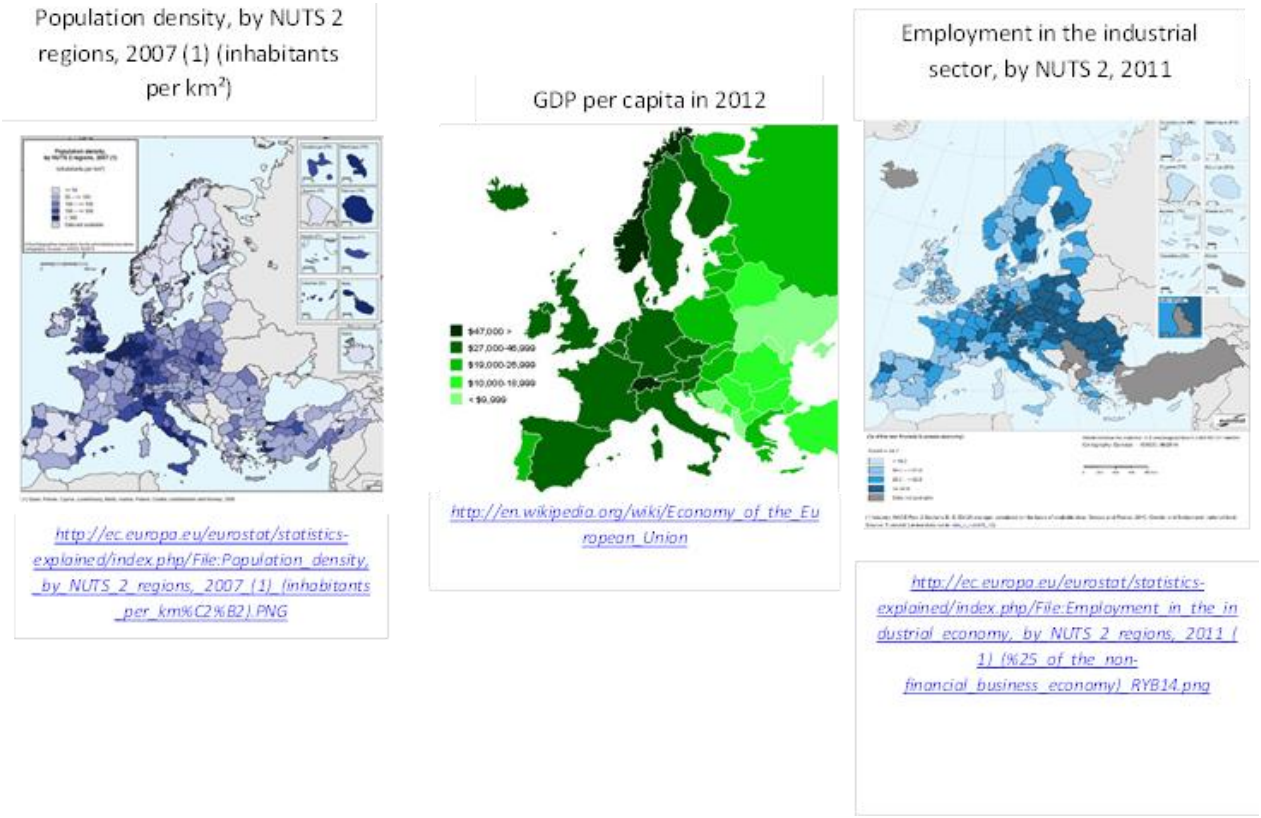
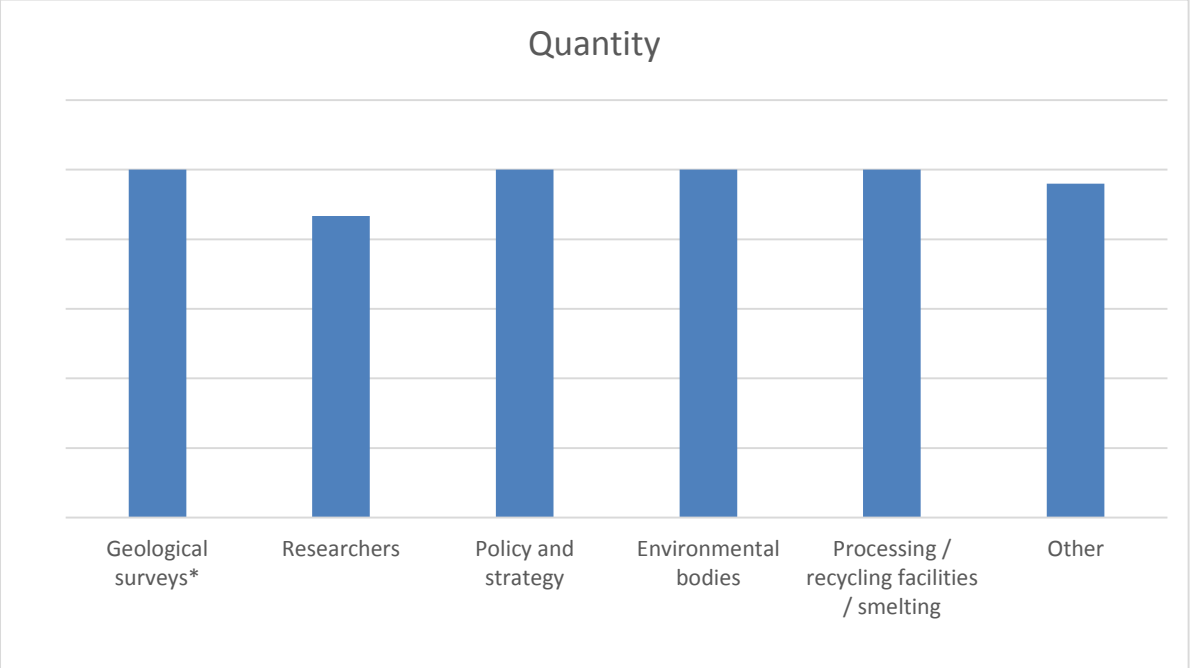
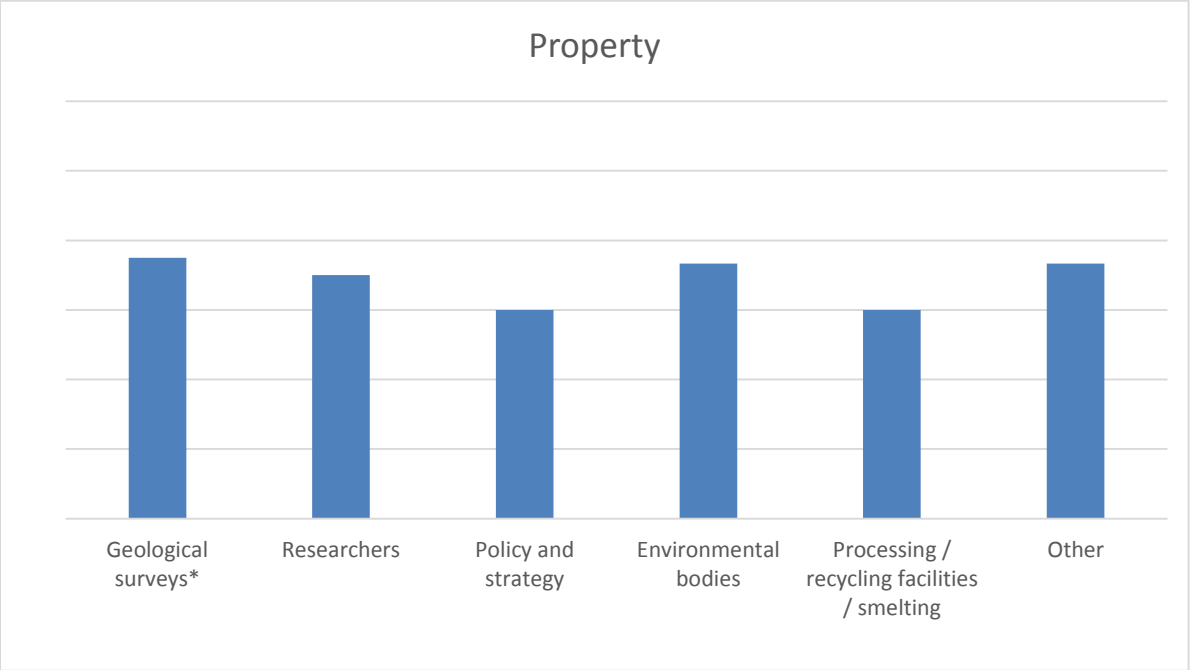


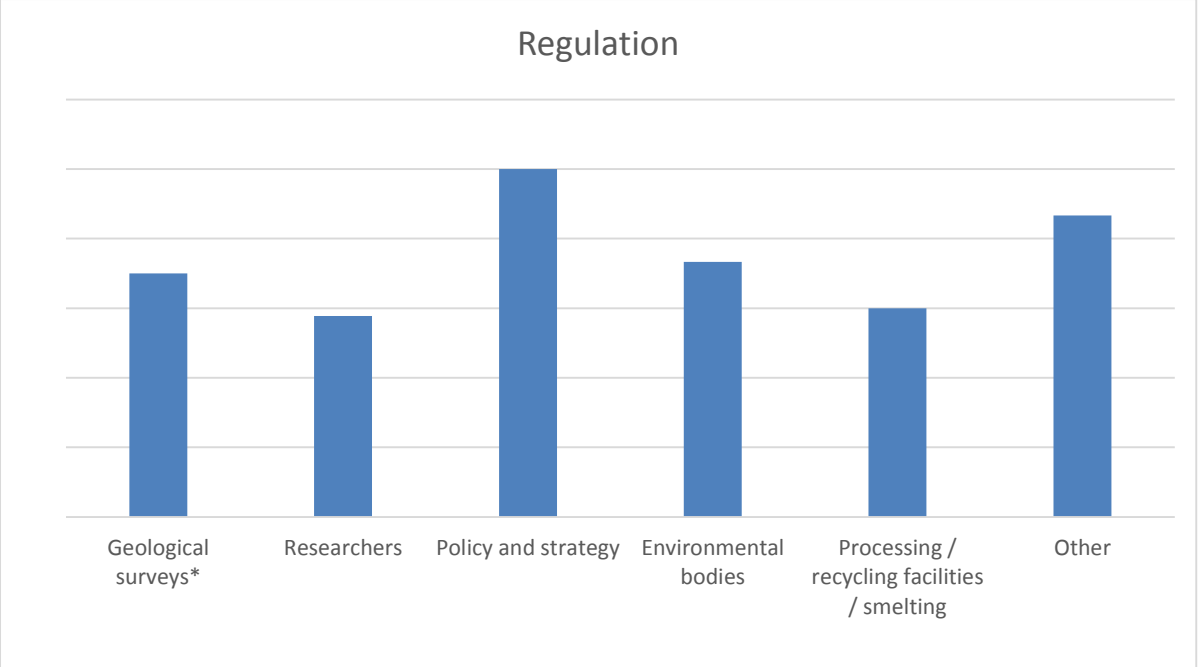
Figure 8 Data and mapping for the overarching data identified in section 3.3

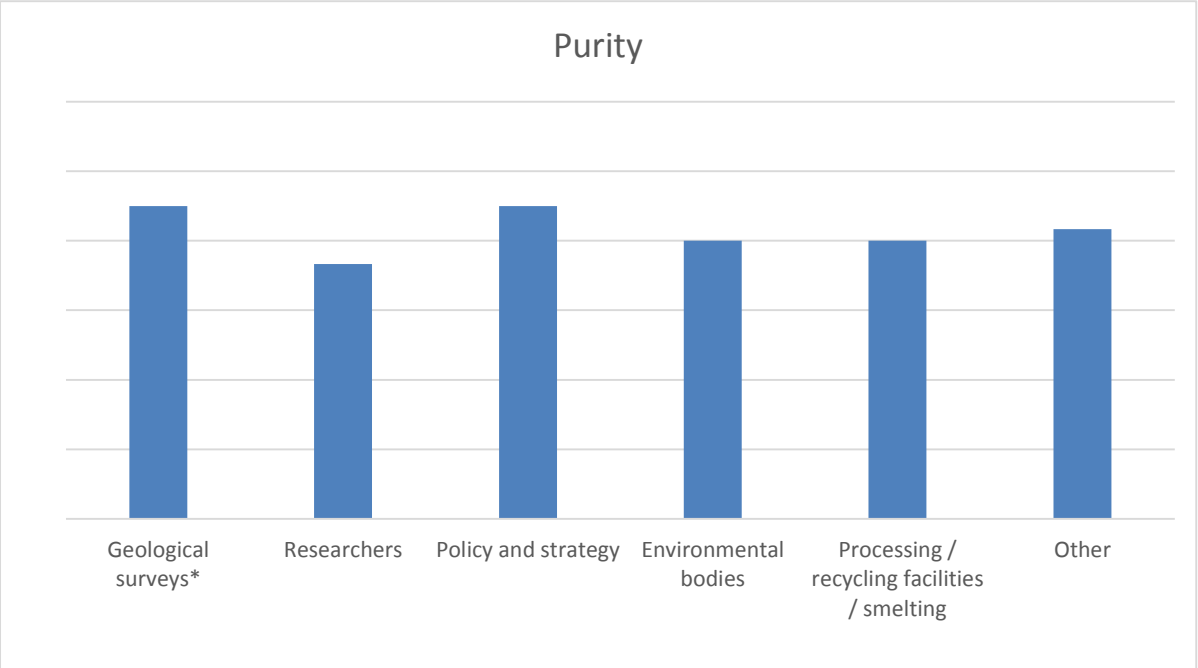
Annex 2 Comparison of Responses to Survey by Category of Respondent

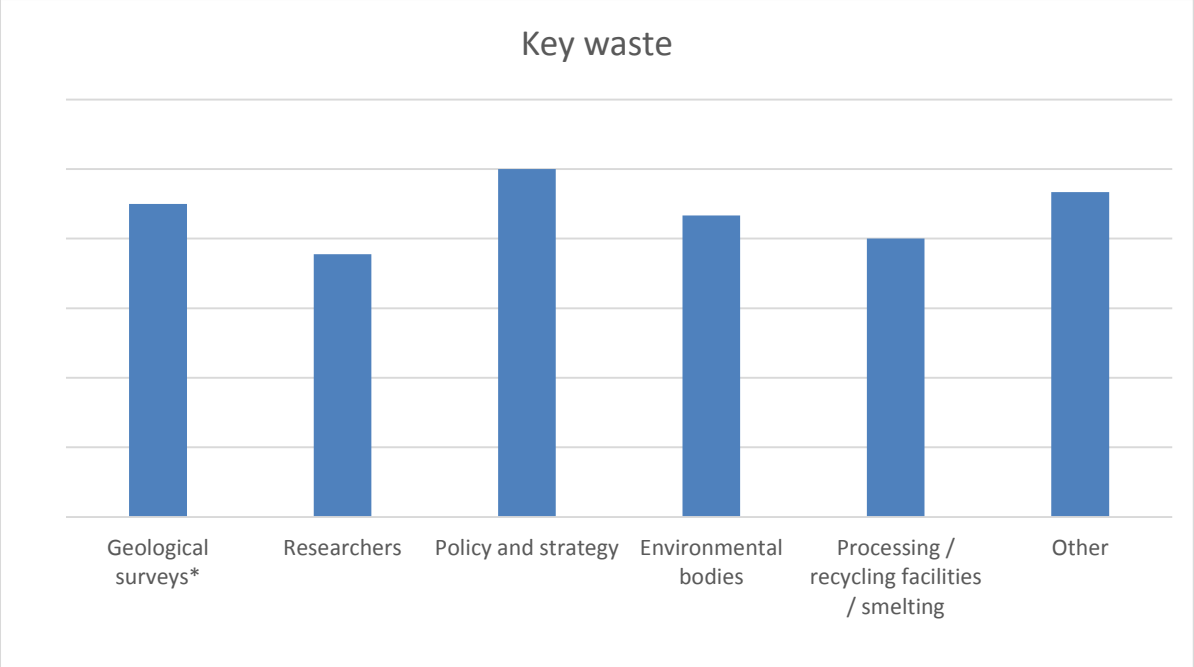
Section 2. Waste flows

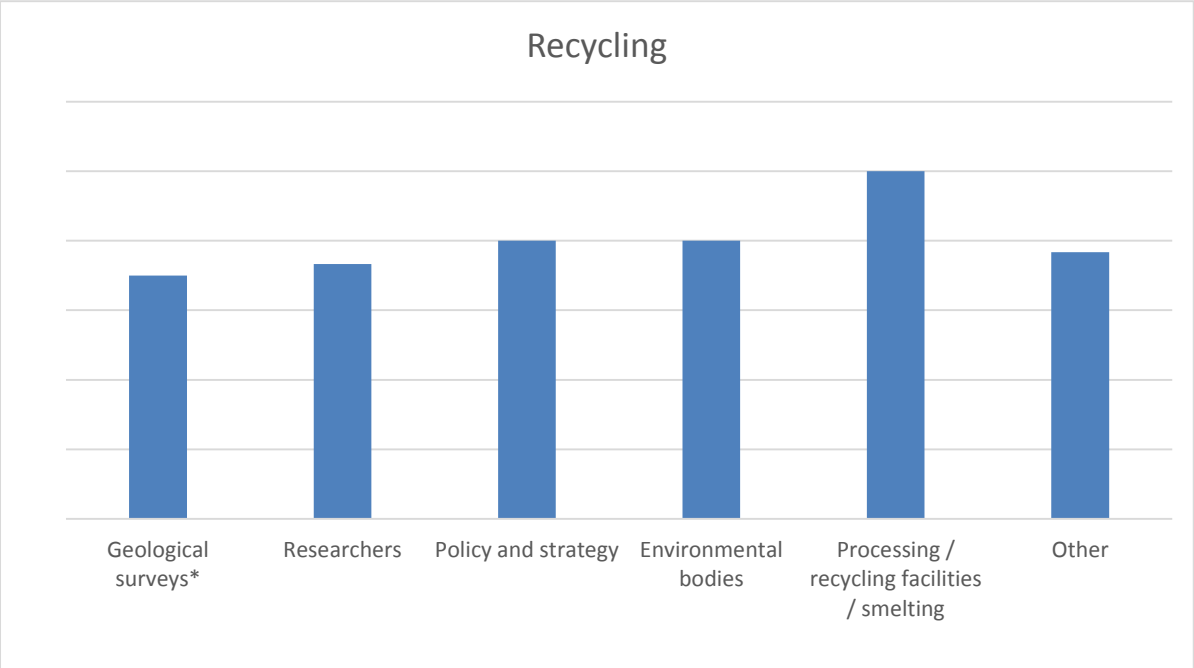


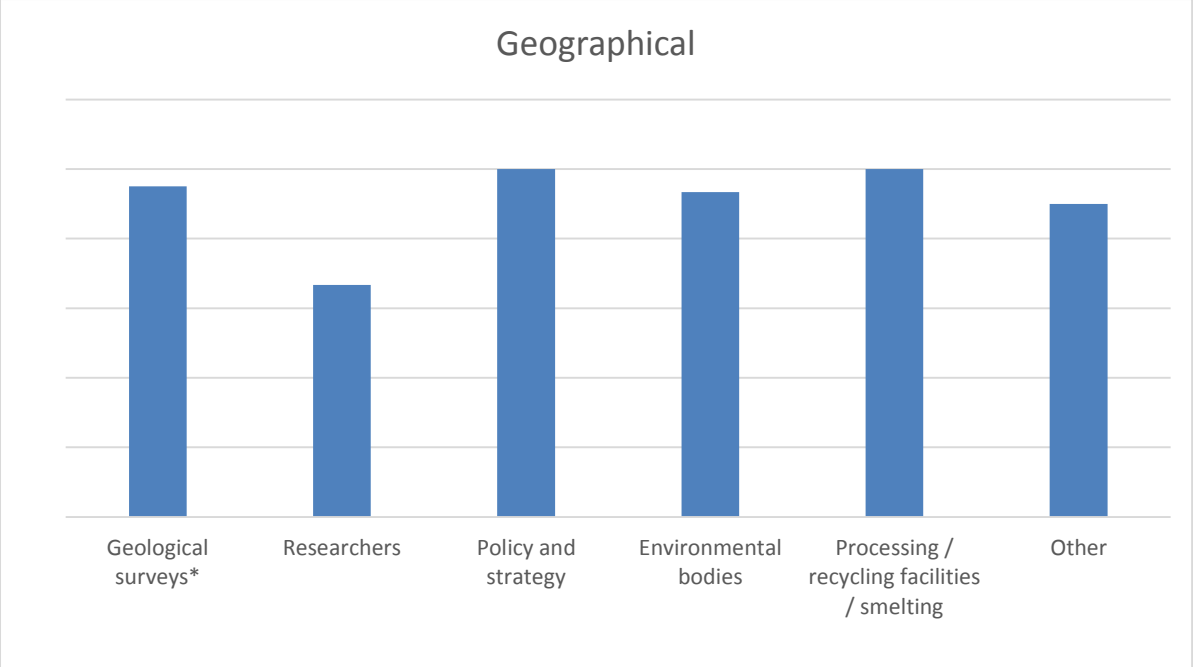


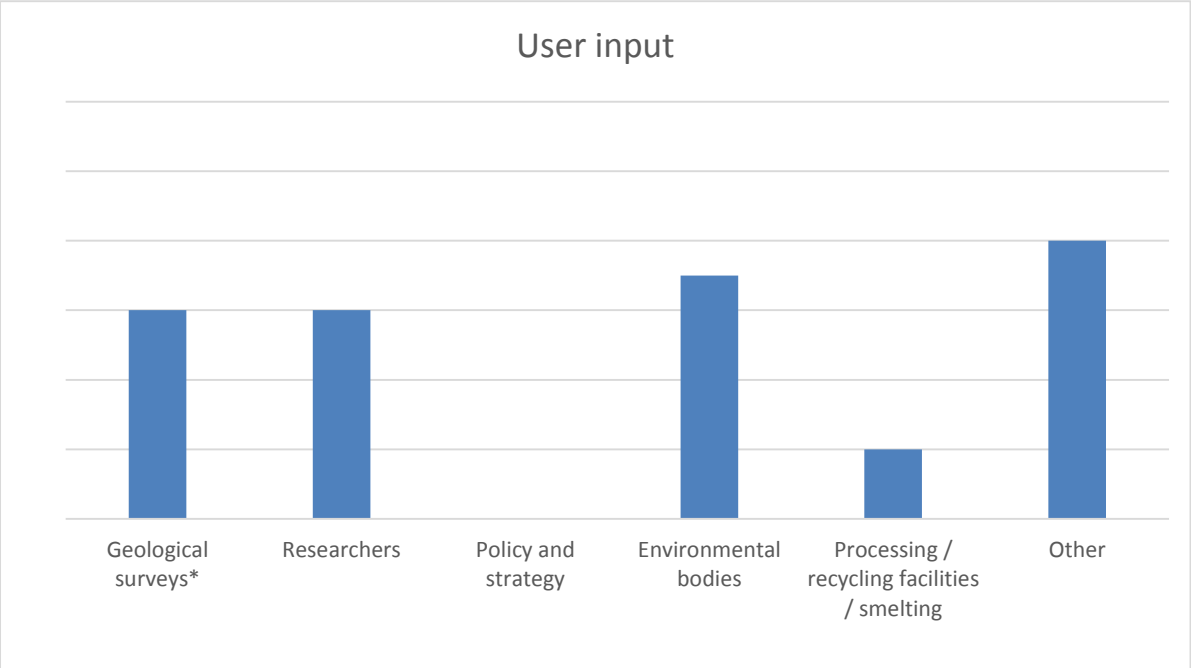

Regulation
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

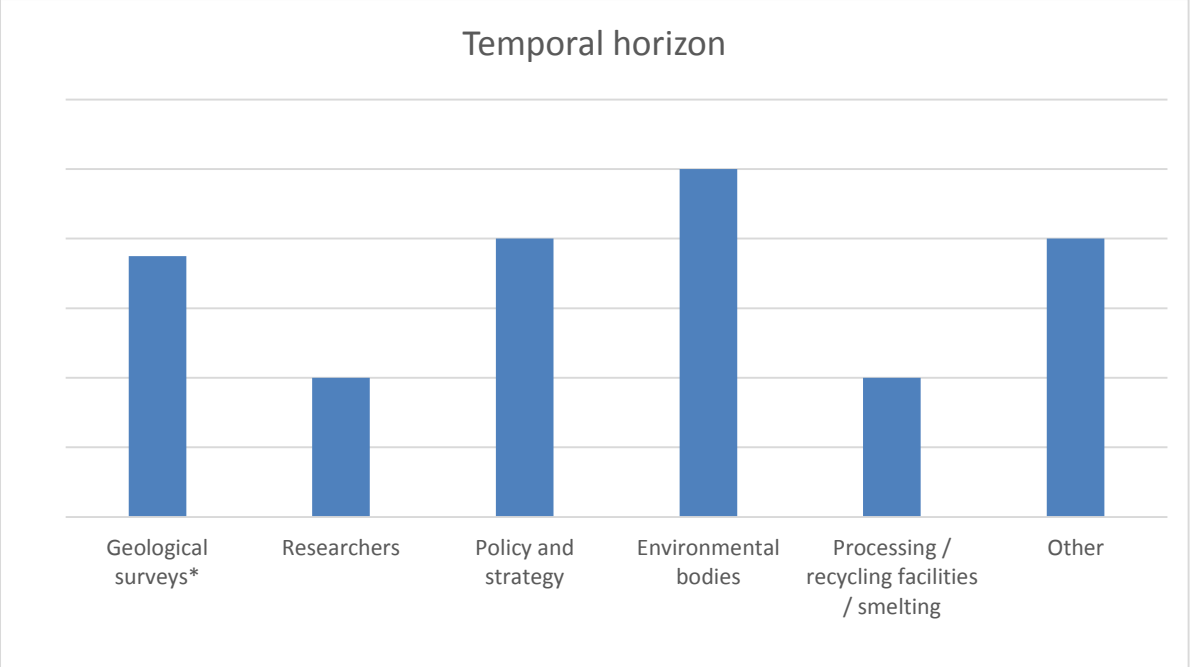

Purity
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

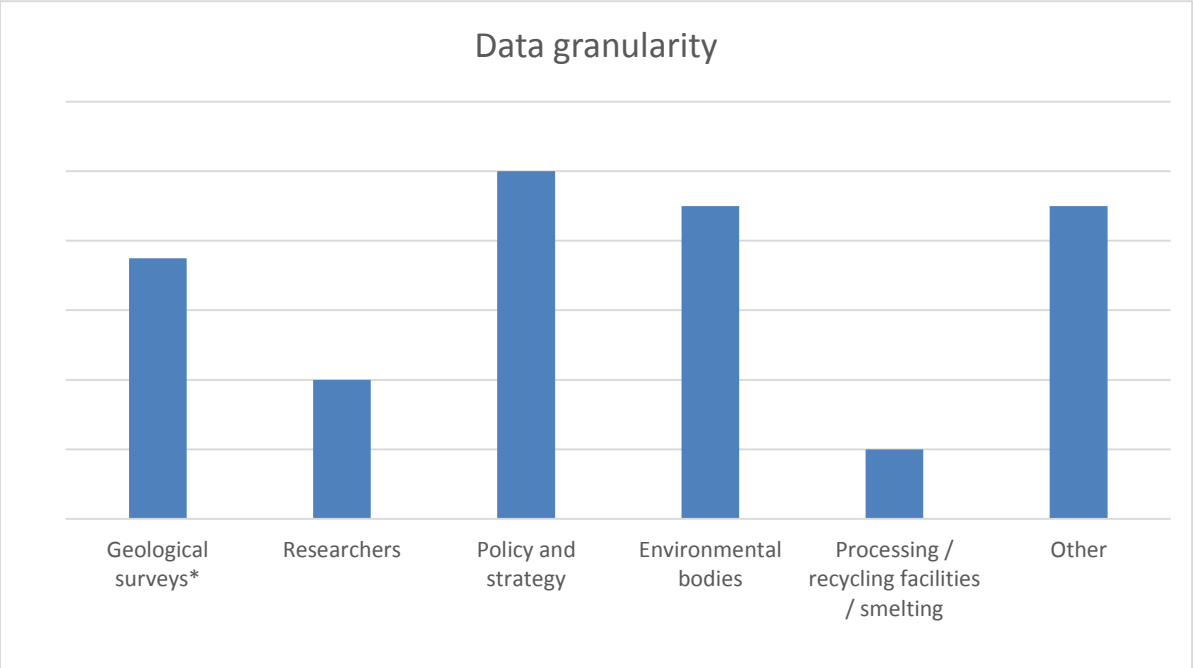

Key waste
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other


Recycling
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

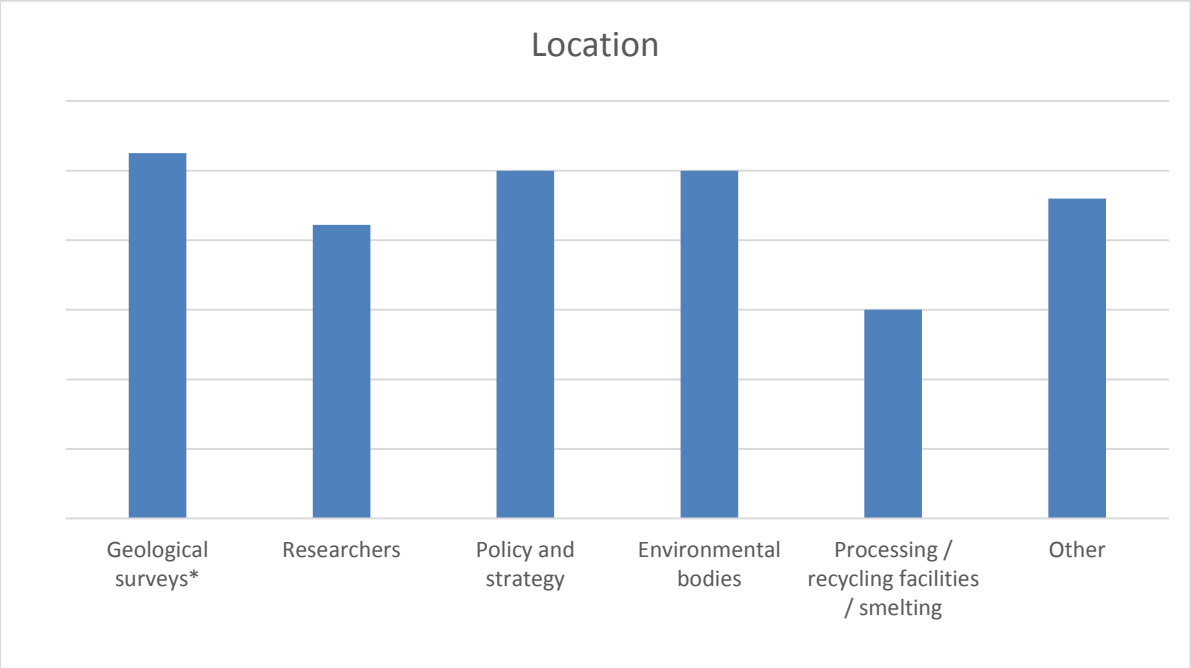

Geographical
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

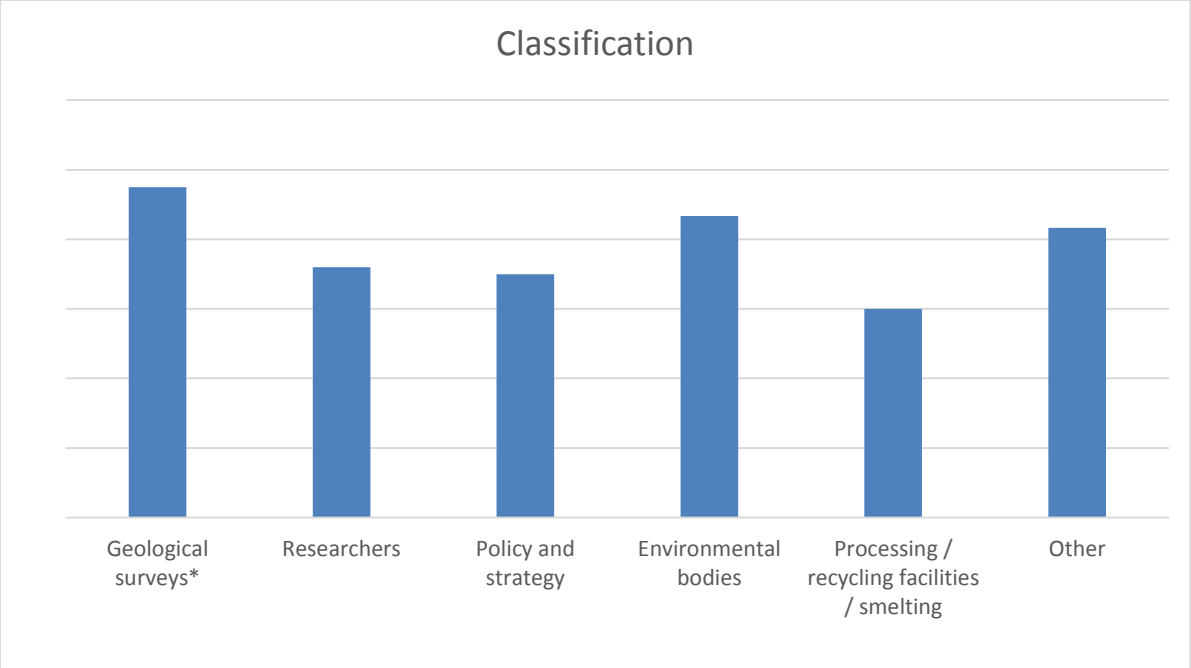

User input
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

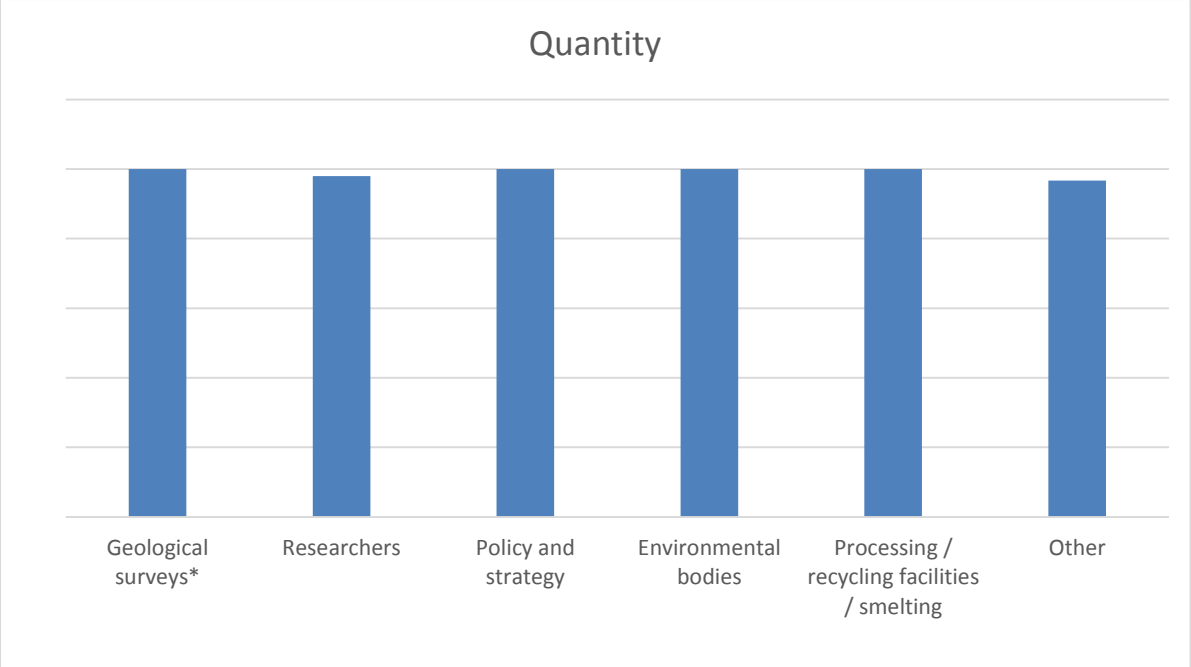

Temporal horizon
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

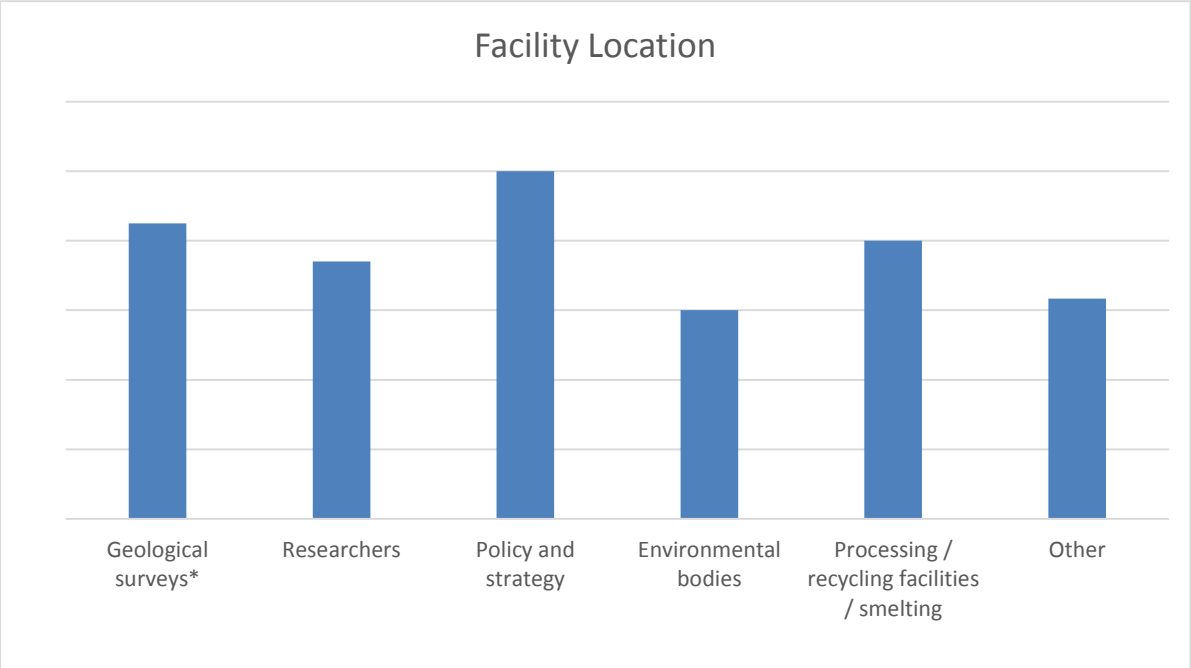

Data granularity
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

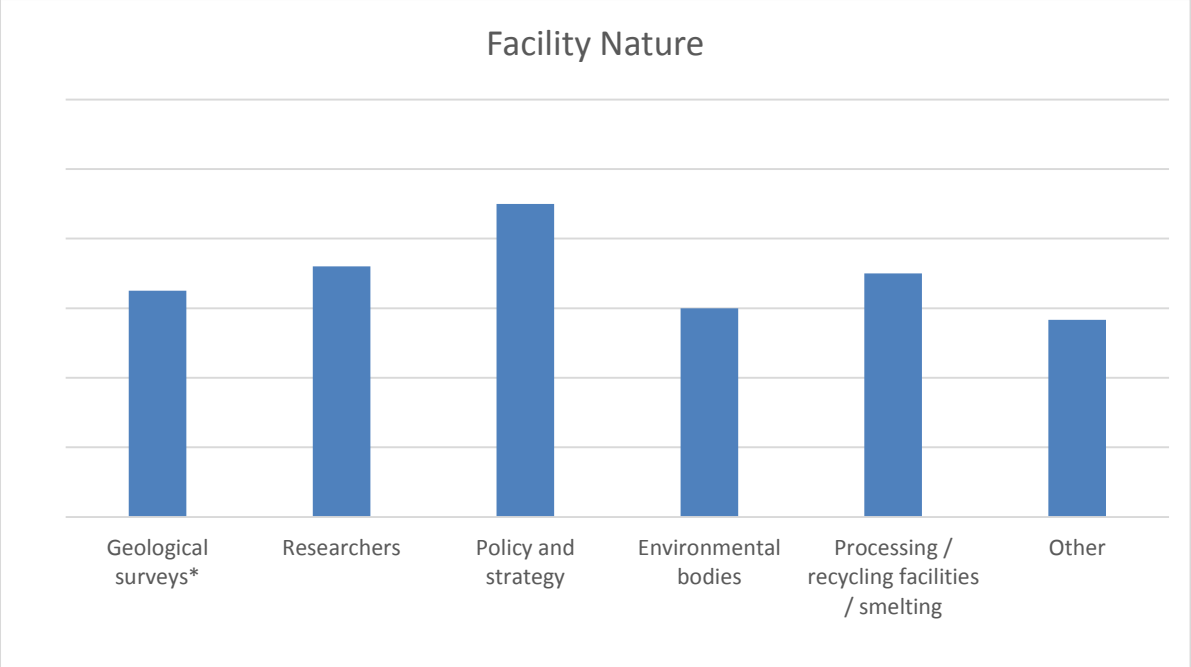
Section 3. Data – Stock

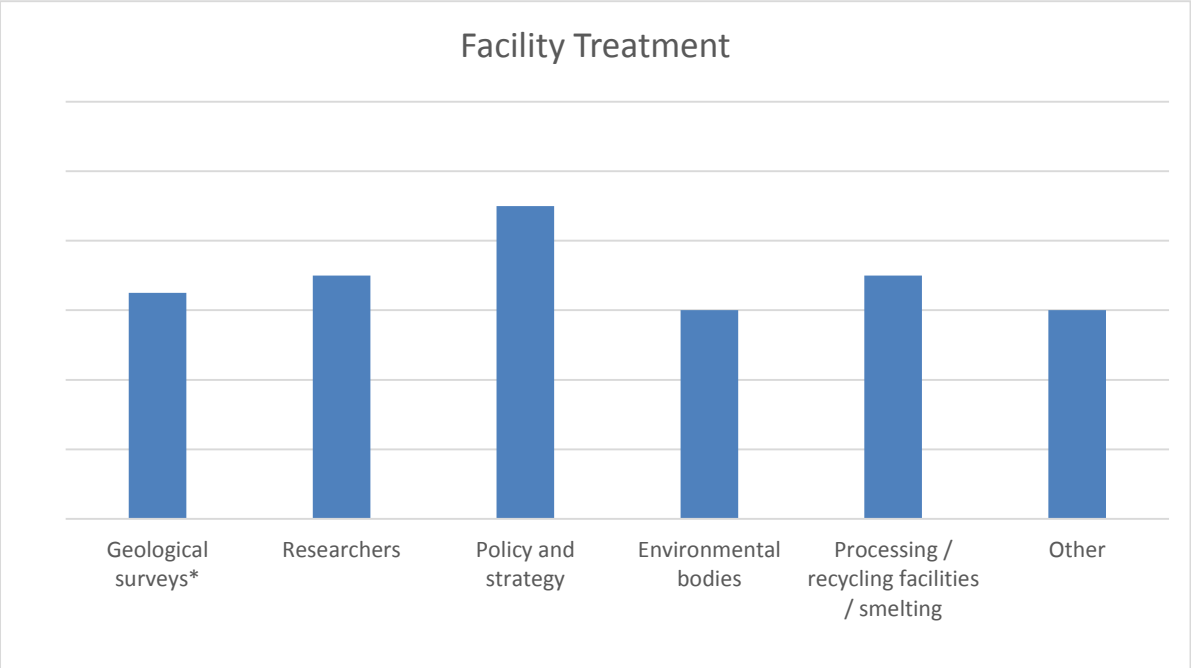





Quantity
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other


Facility Location
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other


Facility Nature
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other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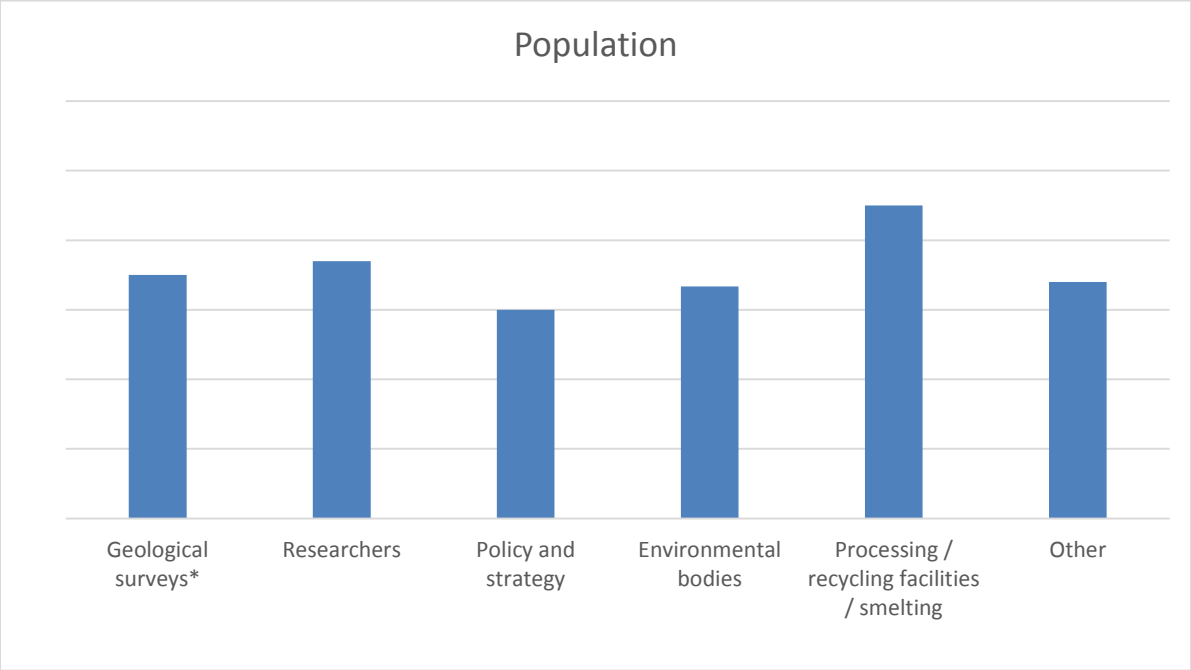
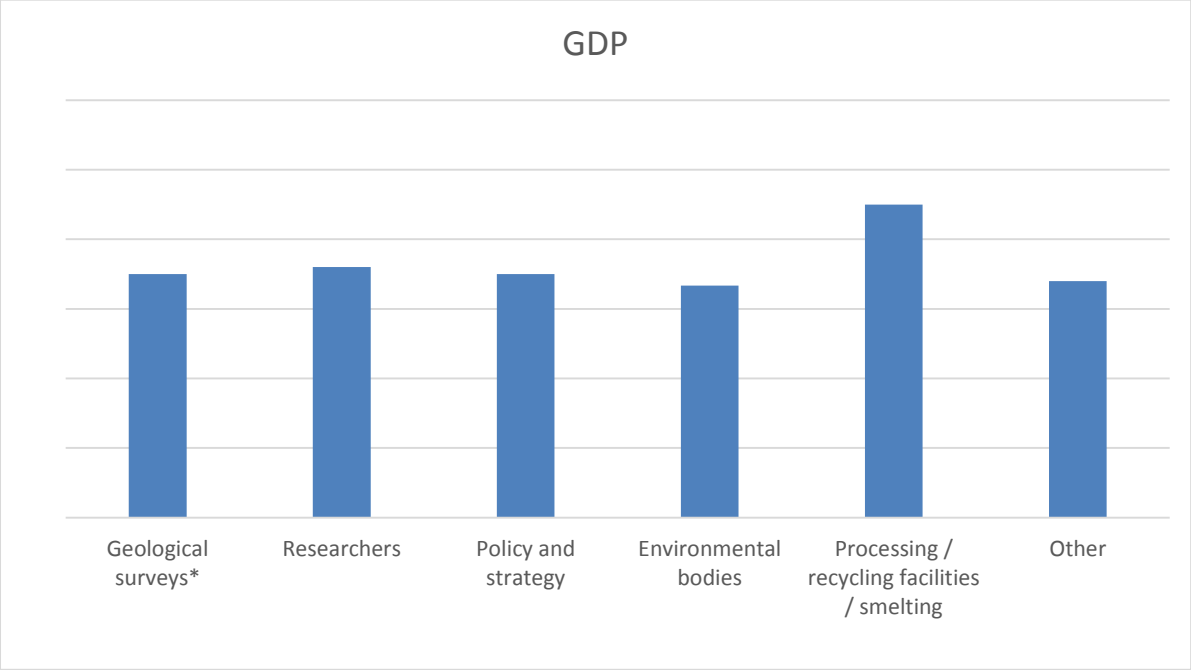
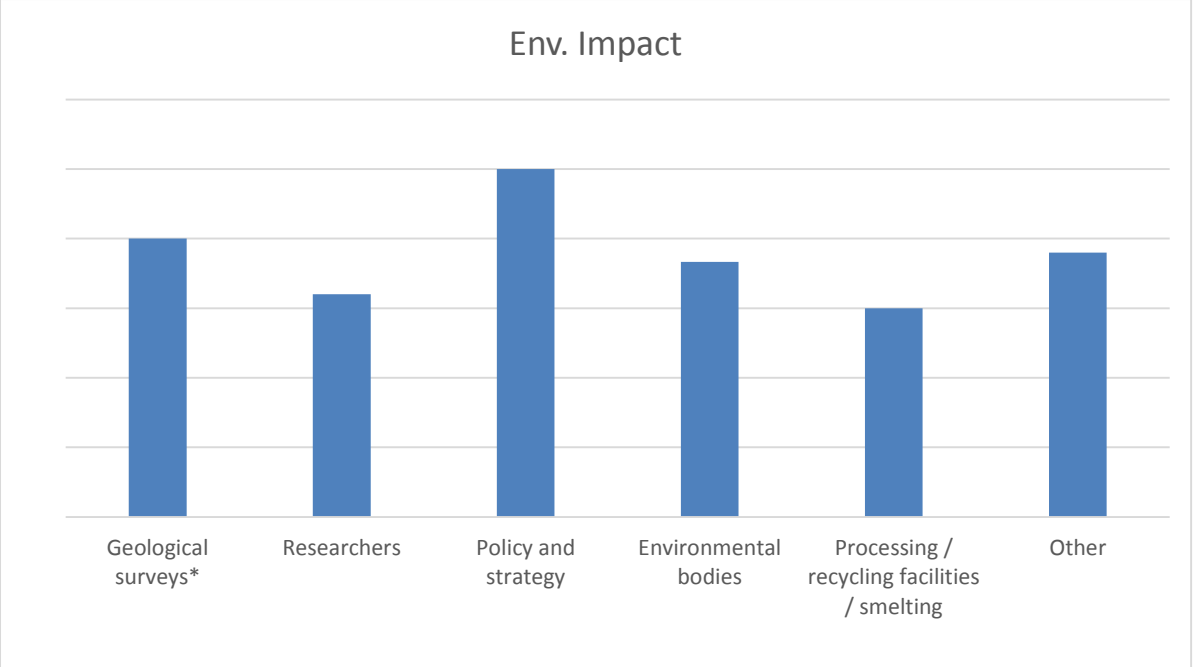
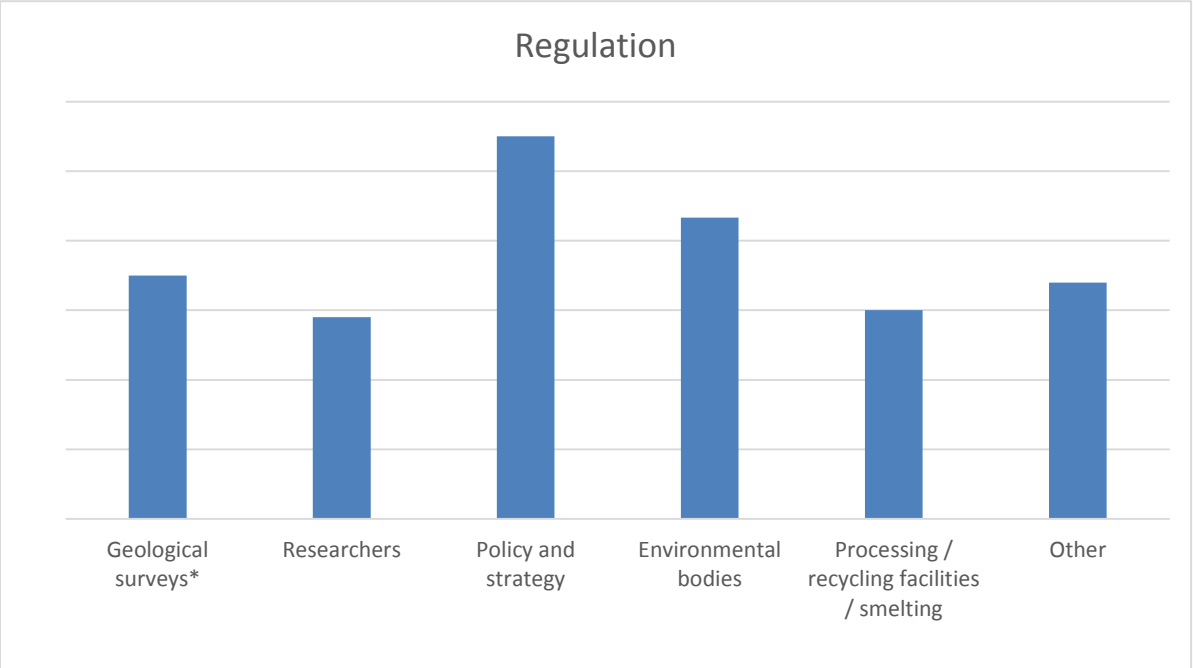
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

Section 4. Supporting data

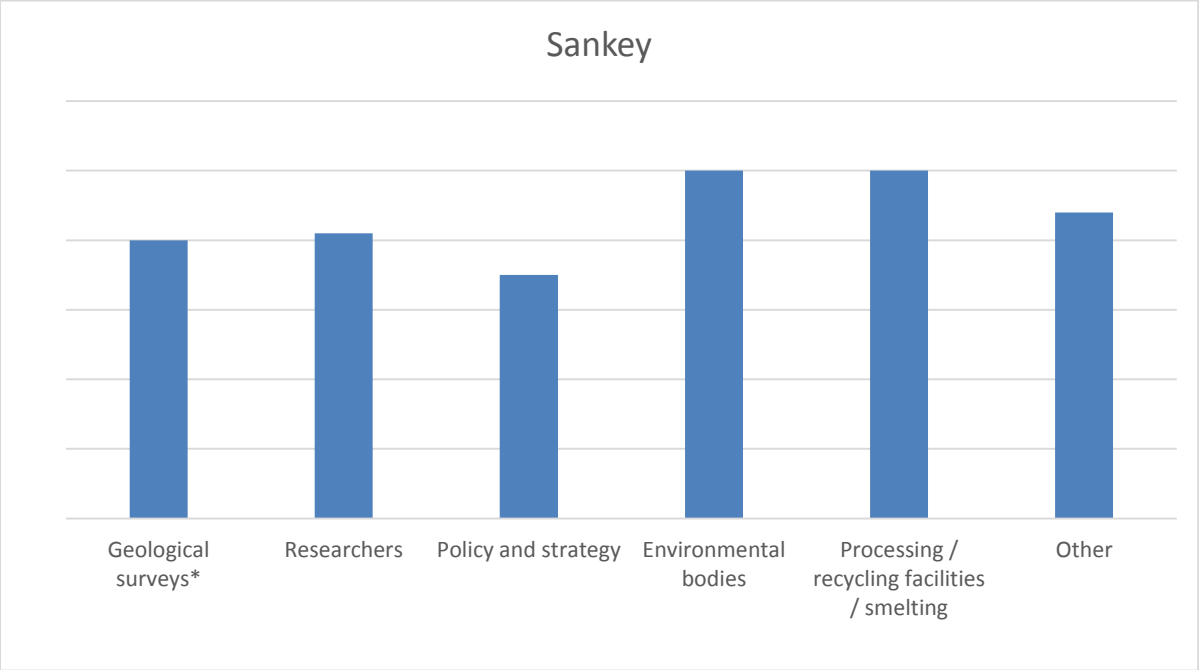


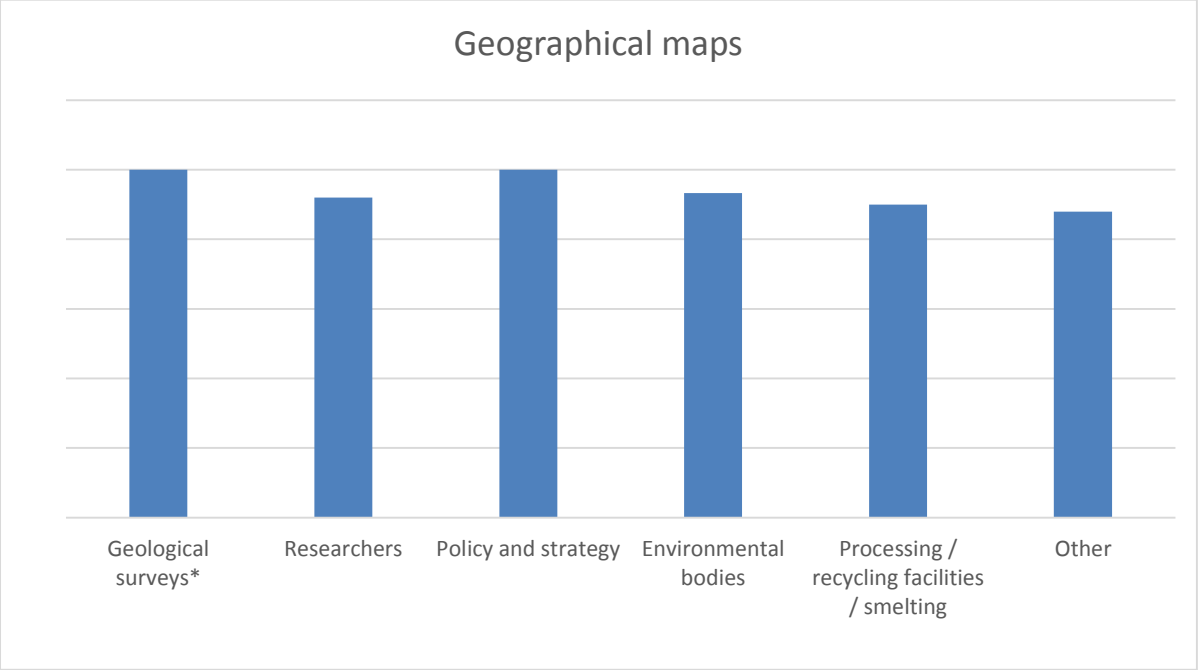


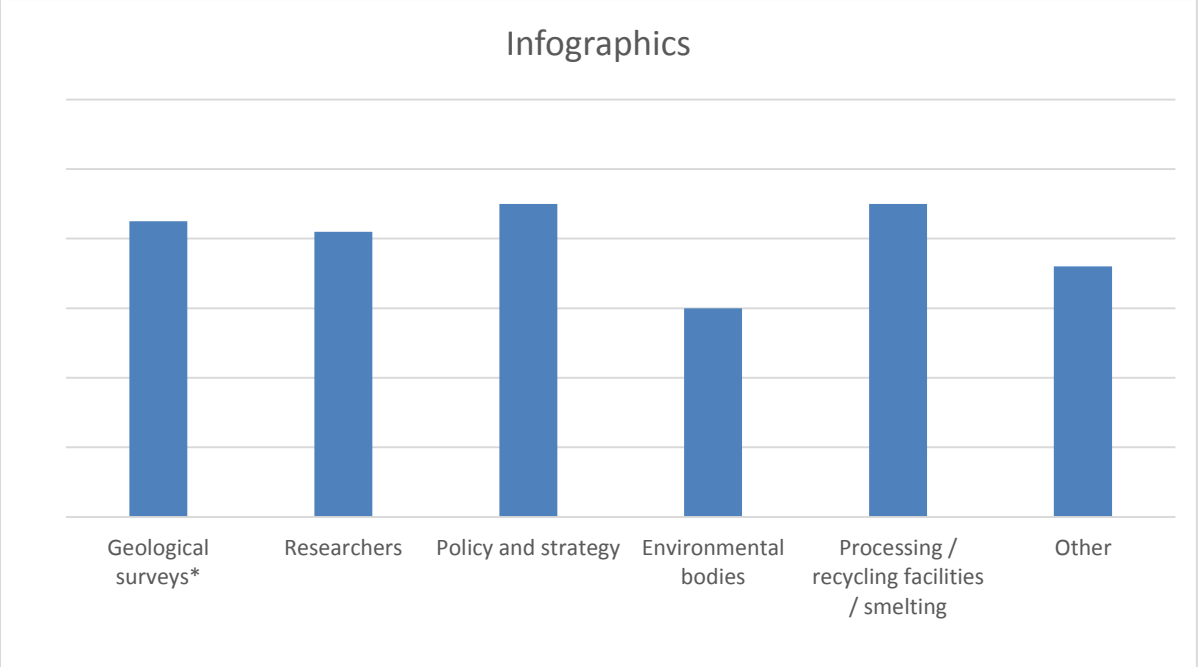

Env. Impact
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

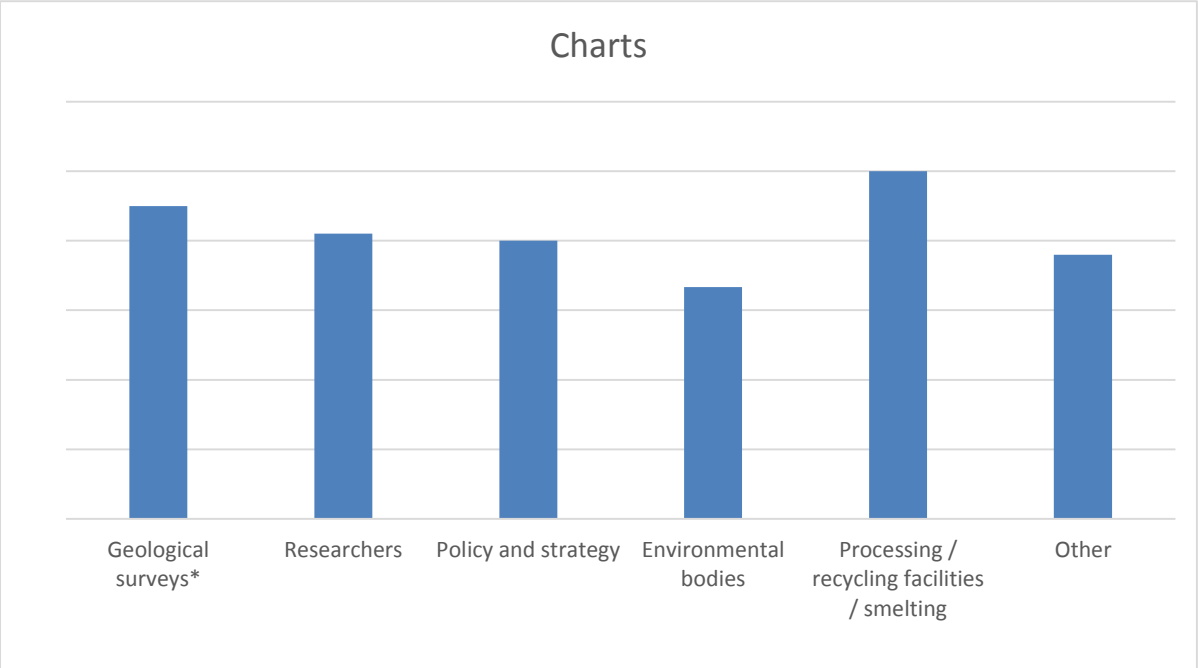

Regulation
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other

Section 5. Representation of data






Infographics
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other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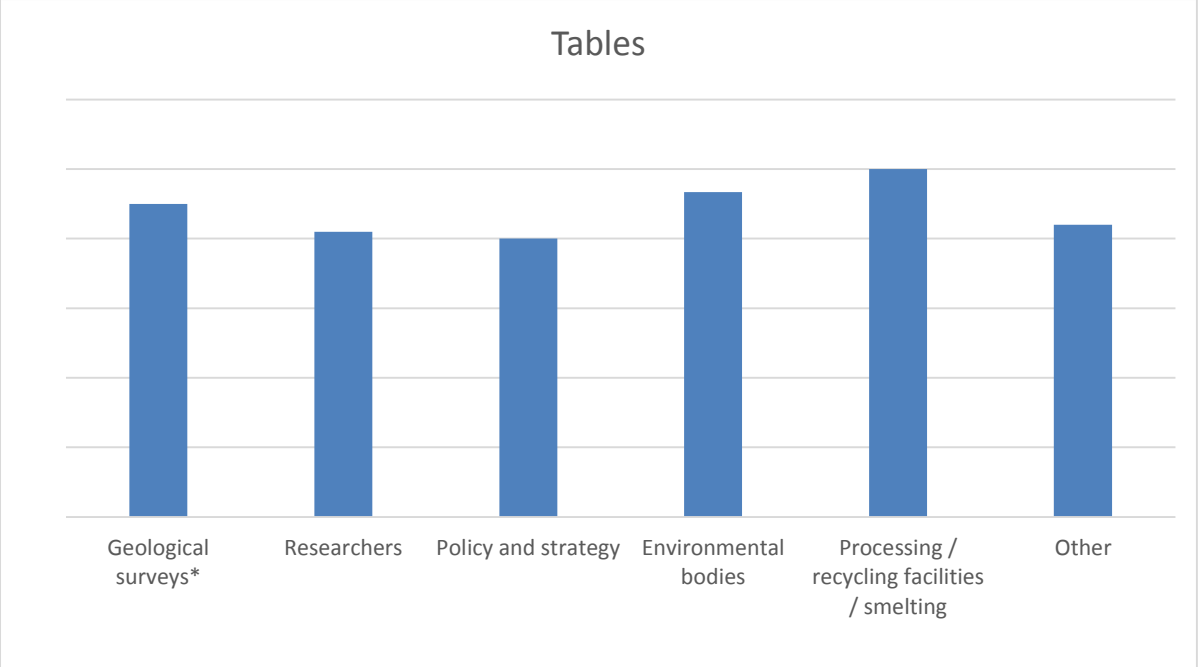
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other


Tables
Geological surveys*
Researchers
Policy and strategy
Environmental bodies
Processing / recycling facilities / smelting
Other