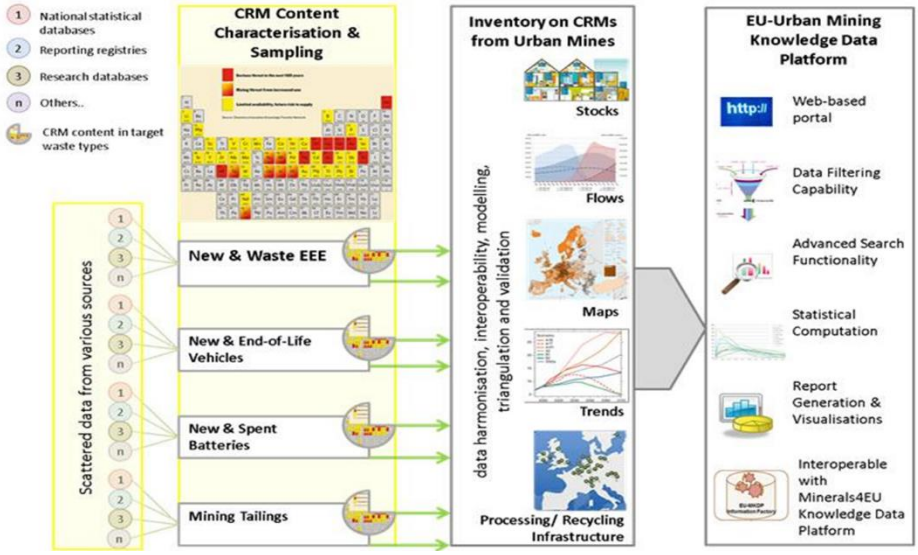
Review and harmonisation of data
Deliverable 5.3



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V3	10.11.15	Restructure by Scientific Coordinator and review	UNU
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NOTICE

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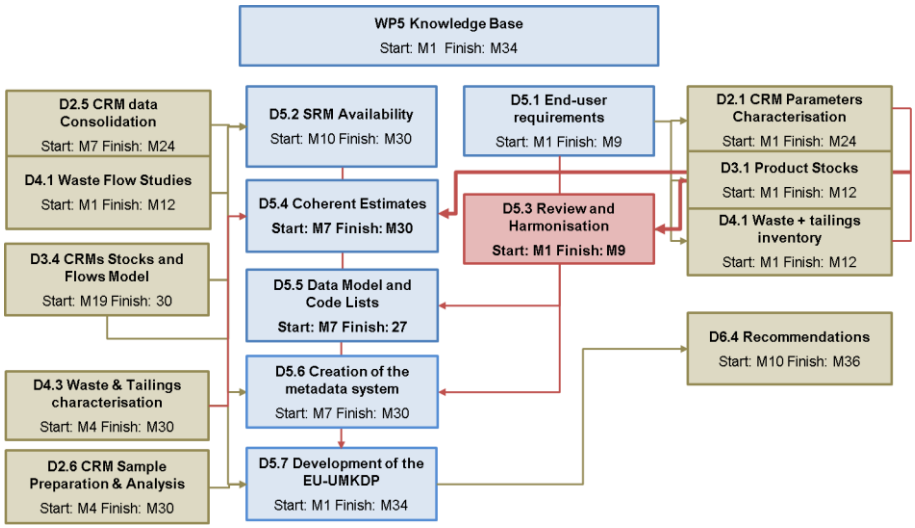
PURPOSE

This document presents the classification and harmonisation system produced by the project. It describes the complexity of the task at hand and the process which has been used to develop the classification system. It outlines how the data will be organised, collated and aggregated to go into the databases used for the EU-Urban Mine Knowledge Data Platform, and the process for validating data. It concludes with the Classification System and Correlation Tables which will be used to harmonise data.



This Deliverable Report D5.3 relates to Task 5.2.1. The Pert Chart above illustrates the importance of this task in determining the organisation of data, data structure and data modelling in future tasks. The main purpose of D5.3 as outlined in the Grant Agreement is:

- Reviewing and harmonising relevant data identified by WP2, 3 and 4, related to WEEE, ELVs, batteries and mining wastes available from organisations dealing with wastes and from European databases, projects and other sources pertinent to the project;
- Reviewing the data formats which will be used in WP2, 3, 4 to make sure that they are harmonised;
- Linking the harmonised data formats with several statistical data sources at Eurostat, such as PRODCOM, International Trade, WEEE Directive, ELV Directive, Battery Directive, and Waste Statistics Regulation. (Data from those directives will serve as continuous empirical data input for future updates of the urban mine);
- Reviewing the reporting format at Eurostat and providing correlation tables to provide a conversion between these reports and the ProSUM Classification System;
- Harmonising all of the additional data sets collated and provided during the course of data screening in Work Packages 2,3 and 4 to provide data to the EU-UMKDP;
- Identifying spatial data when possible, taking into account local, regional and national levels.

EXECUTIVE SUMMARY

To contribute to the ProSUM project objectives to create an inventory of available data on secondary raw materials, the critical first step is to produce a system for harmonising and classifying that data for all relevant products, waste streams and their composition. This requires correlation with published statistics and recognised classification systems e.g. PRODCOM. Importantly, it also requires a harmonised approach for collating and aggregating data from other 'non-standardised' sources such as research reports which may identify the composition of a particular product, or determine the number of these products in use. This latter harmonisation is critical to ensuring that high quality data is included in the inventory, and the databases which support it, and will support the development of the standard protocols for gathering new compatible data in future. These classifications are described in tables which will be further developed into code lists.

Deliverable 5.3 describes how the data will be organised within the overall ProSUM architecture and defines a common language to set clear and univocal definitions for all of the constituent data which form the inventory.

Given the complexity of the products which we are gathering data on, it is necessary to construct detailed layers which describe how each of the products and wastes and their flows is constituted and linked together. This allows for the presentation of data constructed from a number of different screened, harmonised and correlated data sources. This, in turn, will provide well-structured data for the EU-UMKDP in practice.

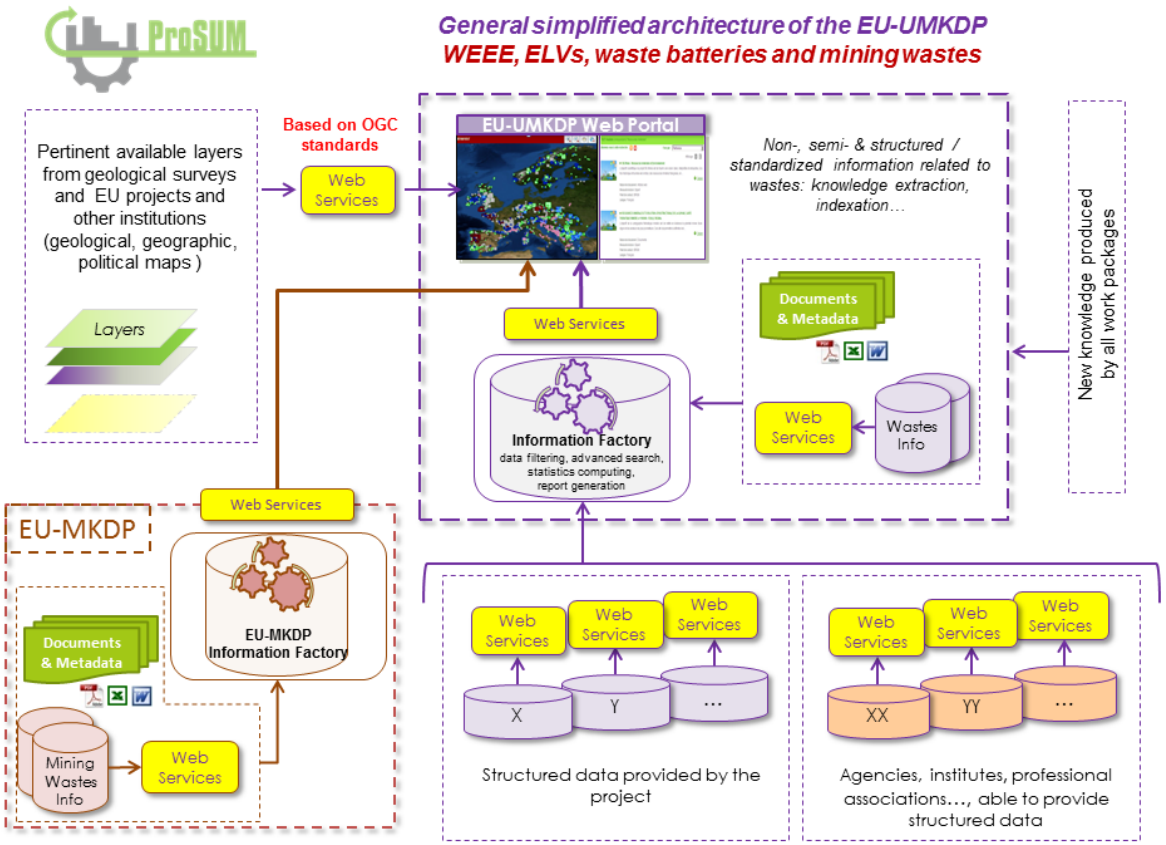


Figure 1 - The EU-UMKDP general architecture and its link with the EU-MKDP.

The EU-UMKDP will be linked with the EU-Minerals Knowledge Data Platform (EU-MKDP) developed by the EU-FP7 Minerals4EU project[1]. This will allow for the comparison of secondary raw materials with primary minerals data. The general architecture of the platform is illustrated in Figure 1.

For mining wastes, the EU-MKDP will provide the EU-UMKDP with data derived from the EU-FP7 ProMine project[2]. The ProMine AC database stores data related to anthropogenic concentrations such as mining wastes and smelting residues. The INSPIRE MR/ERML (Mineral Resources/EarthResource ML) data model for mining wastes from ProMine was used to develop the EU-MKDP central databases which are thus fully INSPIRE[3]/OGC compliant. However, for the products and wastes which form the 'Urban Mine', namely, End-of-Life-Vehicles (ELVs), waste batteries (BATs) and Waste Electrical and Electronic Equipment (WEEE), no standardised data models exist. They will be developed in the ProSUM project. When combined, the EU-UMKDP will contain all of the data related to secondary raw materials for the four target waste groups.

Task 5.2.3 will develop for each domain in the EU-UMKDP (mining wastes, WEEE, ELVs and BATs) data models that represent the objects of the domain (also called features or concepts) with their intrinsic properties and the links and interactions between these objects. For mining waste the framework is defined by the INSPIRE Directive 2007/2/EC but needs to be expanded to address the ProSUM project scope. For the 'urban mine' new vocabularies (code lists) for describing these properties have to be developed as a harmonised language is not in existence.

Correlation Tables (CORR) have been developed to combine all of the data sources within the databases. Figure 2 illustrates the organisation of the complex layers of data which will be used to produce structured data. Data will be screened in Tasks 2.1.1, 3.1.2 and 4.1.2 by Month 12.

EEE products have already been clustered by UNU into 54 UNU keys and have a hierarchical classification from product groups to device types all based on 1:n relations. For batteries and vehicles it has been necessary to define an approach to correlate data. A further complexity is that batteries are embedded in vehicles and in EEE (as components), built in to products and sold separately. Hence, a classification of 16 BAT keys has been adopted, primarily based on the composition of the electrochemical cells, which allows for data inclusion on stand-alone battery products, batteries linked to industrial equipment and, or with batteries used as components in EEE or vehicles.

In contrast to the classification of EEE, there is little previous work to build on for the classification of vehicles. Therefore, a classification is being developed for vehicles as defined in the EU End-of-Life Vehicle Directive combined with mapping of 'hotspots'' of priority elements. The classification will include all possible combinations of vehicle type, vehicle powertrain and vehicle weight classes currently used in existing regulations and statistical databases as well as a vehicle segment category, which is commonly used in the automotive industry. Further work is required to develop a set of 'ELV keys', if appropriate

[1] http://www.minerals4eu.eu/
[2] http://ptrarc.gtk.fi/promine/default.aspx
[3] http://inspire.ec.europa.eu/

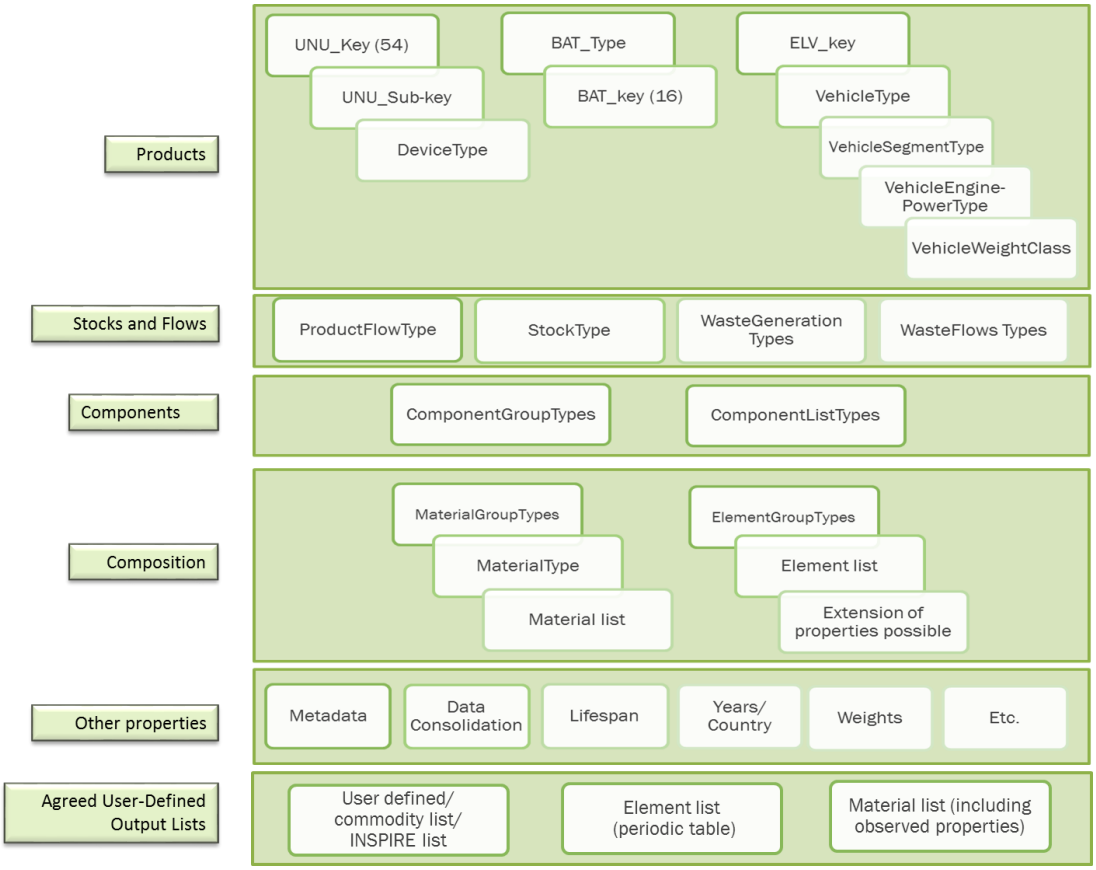


Figure 2 – Simplified view of ProSUM data organisation describing secondary raw materials in BAT, ELV and WEEE

All of the data used in the database must follow the INSPIRE Directive rules and have a clearly defined procedure as such. There are two sources of data for the products in the Urban Mine, structured data obtained from national statistics; and structured data produced from a variety of unstructured data sources to combine data on secondary raw material composition and location with national statistics. Correlation tables exist for WEEE, new correlation tables have been produced for batteries and ELVs. As new products come onto market, or the composition of products changes over time, it will be necessary to update the Correlation Tables and Classification System.

Table 1 shows where Correlation Tables are interoperable with national or EU statistics and reports; and where they classify data which will be gathered within the project to create the databases. Further description on the work to produce the correlation tables and classification system is shown in the Chapters identified in the left hand column.

Table 1 – Development of correlation tables

Chapter	Correlation table	Data linked to Statistics/ National or EU Reporting	Data derived and classified within the project
4	Mining Waste	X	√√
5.2	(W)EEE	√	X
5.2.1	EEE to CN trade codes	√	X
5.2.1	EEE to PRODCOM	√	X
5.3	Classification of (Waste) batteries	X	√
5.3.3	Waste batteries to CN trade codes	√	X
5.3.3	Waste batteries to PRODCOM codes	√	X
5.4	(EOL) vehicles	X	√

7	Components	X	√
6.3	Composition properties, materials and substances	X	√
6.4	Composition properties to periodic table	X	√
8.3	Classification of Stocks and Flows	X	√
8.3.2	Waste batteries to Battery directive	√	X
8.3.2	Waste batteries to List of wastes codes	√	X
8.3.2	Waste batteries to UN transport codes	√	X
8.3.1	WEEE collection categories	√	X
9.2	Periodic table of elements	X	√
9.2	INSPIRE/ commodities	X	√
9.2	Specific materials	X	√

X = not applicable; √ = realised as part of this Deliverable work

Robust data screening and procedures for data inclusion are required to ensure only reliable data is included in the databases feeding the EU-UMKDP. These procedures are outlined in Chapter 11.

Development of the data models and the associated code lists are the subject of Task 5.2.3. Improvement of data quality and reliability with respect to the mass balance of stocks and flows is covered in Task 5.2.2. The development of a business plan identifying how 'one off' data derived for the project will be maintained and updated is covered by Task 6.2.

1. Introduction

The aim of the ProSUM project is to create an inventory for waste streams with a high potential to serve as a source of secondary raw materials. The project focuses on those waste streams in modern society with a high potential to supply secondary critical raw materials (CRMs): Waste Electrical and Electronic Equipment (WEEE), End-of-life vehicles (ELVs) and Waste batteries (BATs), collectively described as the 'Urban Mine', and mining wastes. The inventory will be accessed through the EU- Urban Mine Knowledge Data Platform (EU-UMKDP). All of the data held within the EU-UMKDP must be INSPIRE Directive compliant. Deliverable 5.3 describes the correlation tables and classification system which has been developed by the project to produce reliable, INSPIRE compliant data. To assist in the future interoperability of the EU-UMKDP, the correlation tables also include linkages with national and EU statistics and reports.

The European Union has developed a number of Directives concerning the management of waste. To monitor the effect of these Directives, they rely on data from Eurostat collected from Member States predominantly via the National Statistical Institutes (NSIs). The NSIs collect data using registrations, data from the National/Federal Environmental Protection Agencies (EPA), and questionnaires. With respect to the creation of an inventory on secondary raw materials, particularly CRMs, these 'Directive Reports' are limited to high level waste statistics, material flow accounting, other economic statistics and demographic statistics.

More detailed data which can be utilised to characterise the Urban Mine is available from published reports and studies, including EU funded projects and studies, and data collected by the recycling industry to monitor performance and/or quality requirements. There is also a lot of data available in research institutes and universities. These data are scattered across many organisations, in many cases are commercially sensitive and often in very different formats (usually the owner's preferred format).

It is necessary to create a new classification system to produce harmonised data to allow for the collation and aggregation of data from different sources. To date considerable work has been undertaken for minerals to produce INSPIRE compliant lists of materials and products, and the EU-MKDP. This includes some mining wastes but this has limitations with respect to CRMs.

There are large differences between the constituents within the urban mine and mining wastes when it comes to the amount of waste, metal grade, residence time of the waste and proportion between waste flow and waste stock. This requires somewhat different ways of describing and classifying the wastes.

In mining countries, the mining wastes constitute the largest part of society's total waste flow and make up the largest waste stocks but also in countries with historic mining, the mining waste stocks can be significant. The metal grade of mining wastes is low in comparison with some products in the urban mine. The flow of material in the urban mine is extremely complex while the mining waste flow is more simplified: mining wastes are tipped, or concentrated and treated in tailings dams. These represent the current major stockpiles of mining wastes which current waste production rates low in relation. In the urban mine, on the other hand, the stocks and flows are far from static, with both the number and type of products and product composition evolving over time. For these reasons, data describing the urban mine and the mining wastes are managed very differently and described separately in this report. Ultimately, the output data will allow for comparison of data from all wastes types and minerals.

For mineral resources and mining wastes, the first steps for classification and harmonisation were undertaken within the INSPIRE specifications for the Mineral Resources (MR) domain and further improved in the Minerals4 EU project. There is a need to improve this to address CRMs, and more generally, the set-up of an operational classification enabling a CRM inventory for products. Chapter 4 on mining wastes, presents clear classifications which have been derived from the EU-MKDP development work.

As outlined above, the situation for the urban mine is more complex. New classifications need to be developed to correlate and characterise products and wastes by components, materials, and elements. These classification systems for WEEE, ELV and BAT products and the relationship with existing statistical formats are presented in Chapters 5 and 8 for products and wastes, respectively. Chapters 6 and 7 describe how this data is linked to component and composition data to provide data on secondary raw materials.

A harmonised way of storing metadata is described in Chapter 10. The procedures for screening, aggregating and collating high quality harmonised data from unstructured sources is described in Chapter 11. The steps necessary for data screening and inclusions in the next deliverables are outlined here.

To illustrate how data will be organised and the way in which the classification system has been developed, a case study for laptops is included in Annex 7.

The organisation of ProSUM data in relation to the EU-UMKDP architecture is contextualised in Chapter 2.

Chapter 3 provides a list of terms and definitions to create a common language and consistent terminology.

2. The ProSUM data organisation for the Urban Mine

2.1. Developing the EU-UMKDP

As indicated, there is a lack of a common classification system for the urban mine. The production of harmonised data is hindered by a lack of transparency on the assumptions used to produce data; variable data quality and representativeness; differences in scope and measured parameters; and data availability. The ProSUM Classification System sets clear definitions to unambiguously describe secondary raw materials in the urban mine. This requires detailed descriptions of market inputs and outputs, the flows of waste products and components, and the composition of products and wastes to populate the EU-UMKDP databases. Data models will be built in Task 5.2.3 for the WEEE, ELV and BAT domains. The data model for mining wastes exists already. It will be improved by this project.

The EU- UMKDP architecture is made up from data models, databases, Extract, Transform and Load (ETL) processes, and catalogues. A Classification System has been developed to populate the databases for the urban mine. This system has taken into account how the data models will function within the architecture of the EU-UMKDP and considering the type of data granularity we want to present.

A data model is the representation of a domain, of its objects (called features) with their intrinsic properties, of the links/interactions between these objects, with defined vocabularies (code lists) as parts for describing these properties. Data models are an agreed representation of a domain, which will 're-organise' the data provided to make them harvestable by the system. This is called the ETL process and the preparation of the Web Feature Services (WFS). This enables the 'digestion' of different data formats and the creation and linking of different databases, used internally as well as externally.

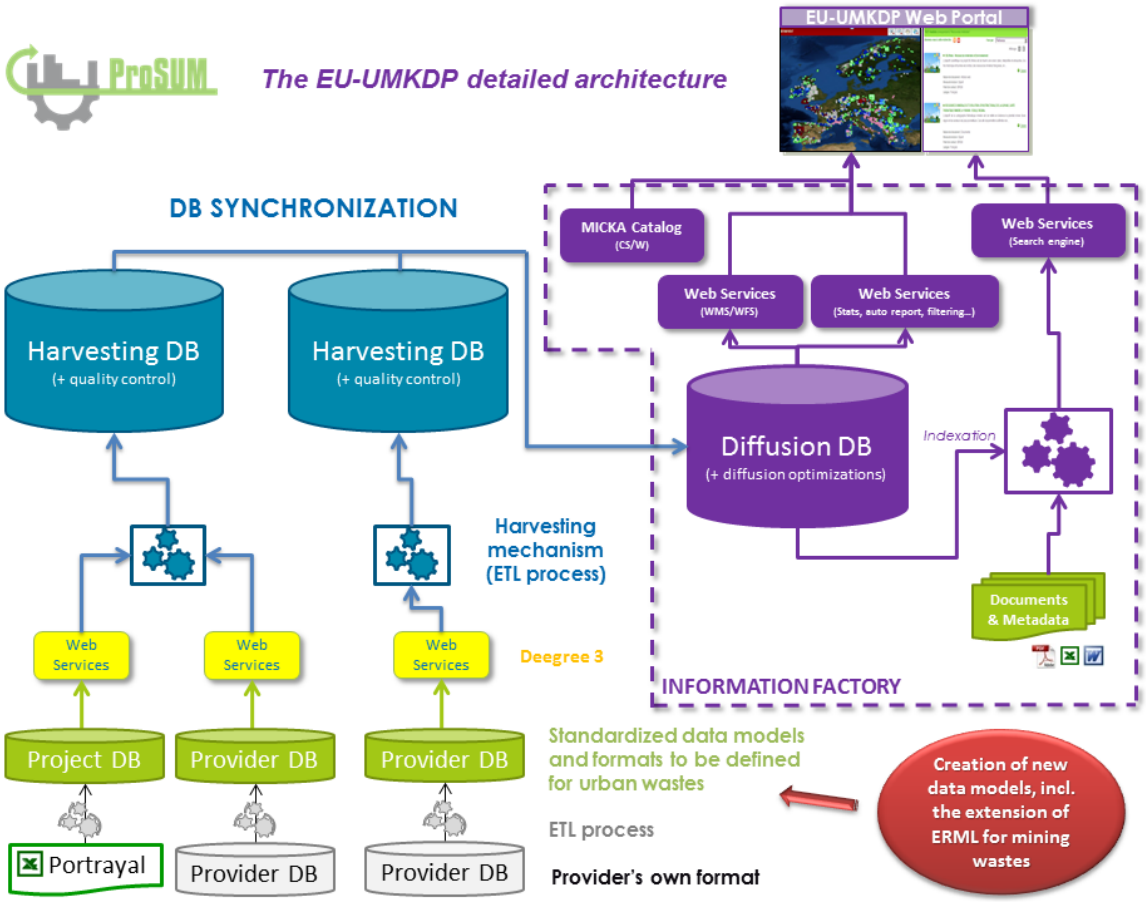


Figure 3 - The EU-UMKDP detailed architecture

Figure 3 shows the harvesting system which will retrieve the harmonised data. The role of the harvesting database is to retrieve the data from harmonised providers' databases, to enable quality control and to warn when abnormal or suspect figures are detected. Harvesting and Diffusion databases are synchronised using SQL scripts. The Diffusion database optimises data from the data models to improve the reaction (speed) of the portal accessing the EU-UMKDP, for example by flattening data into fewer but larger tables.

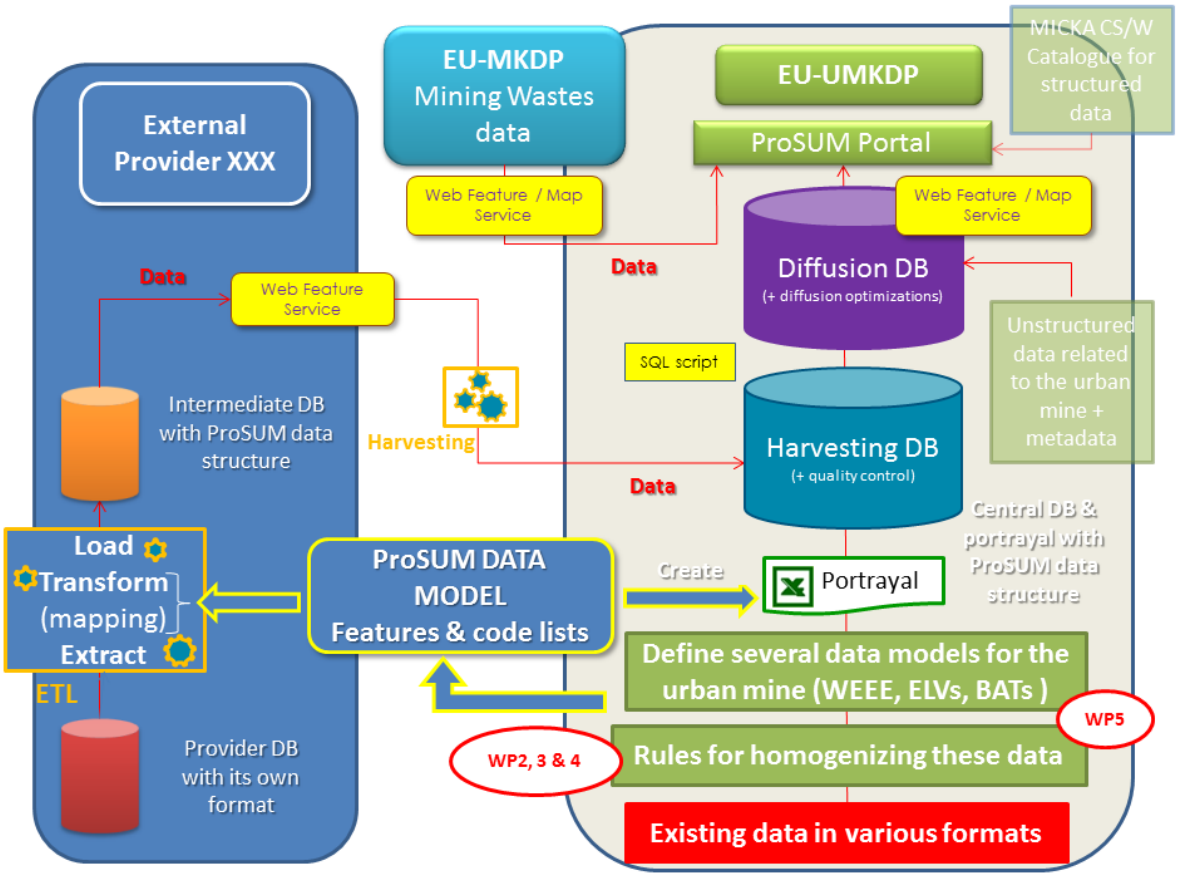


Figure 4 - The central role of the ProSUM data models in the EU-UMKDP development

In more detail, the information is extracted from the Provider DB (existing or new databases, Excel spreadsheets, etc.). This information is then transformed by one of the three corresponding ProSUM data models (WEEE, ELVs or BATs). Finally, the information is loaded in a harmonised database or in a portrayal. This is retrieved in the three steps of the ETL, Extract (data from the Provider DB), Transform (data to fill the data models) and Load (data into the harmonised database/portrayal). Once these data are stored in their harmonised database/portrayal, the Harvesting System is able to retrieve them and store them in the Harvesting Database.

So, whatever their original source, data related to stocks and flows and composition of the secondary raw materials will be “described” in the same way, with the same fields, using the same vocabularies.

In Work Packages 2, 3 and 4 the process of classifying, harmonising and linking of data has been produced as the first building block in this architecture.

The major step forward that ProSUM will deliver, is that by using a harmonised classification system on which the data models are based, heterogeneous data will be transformed in a specified format. Ultimately allowing for the linkage of multiple data sources and the processing of new updated and homogeneous information. Put simply, this means that data collected during the project in

'Provider Databases' will be consolidated in the Harvesting database which will then be forwarded to the Diffusion database to feed the various web-services of the EU-UMKDP.

Figure 4 sketches in more detail the process described in Figure 5, and its application to ProSUM, going more in depth on data models and the role of the correlation (CORR) tables in the ETL process.

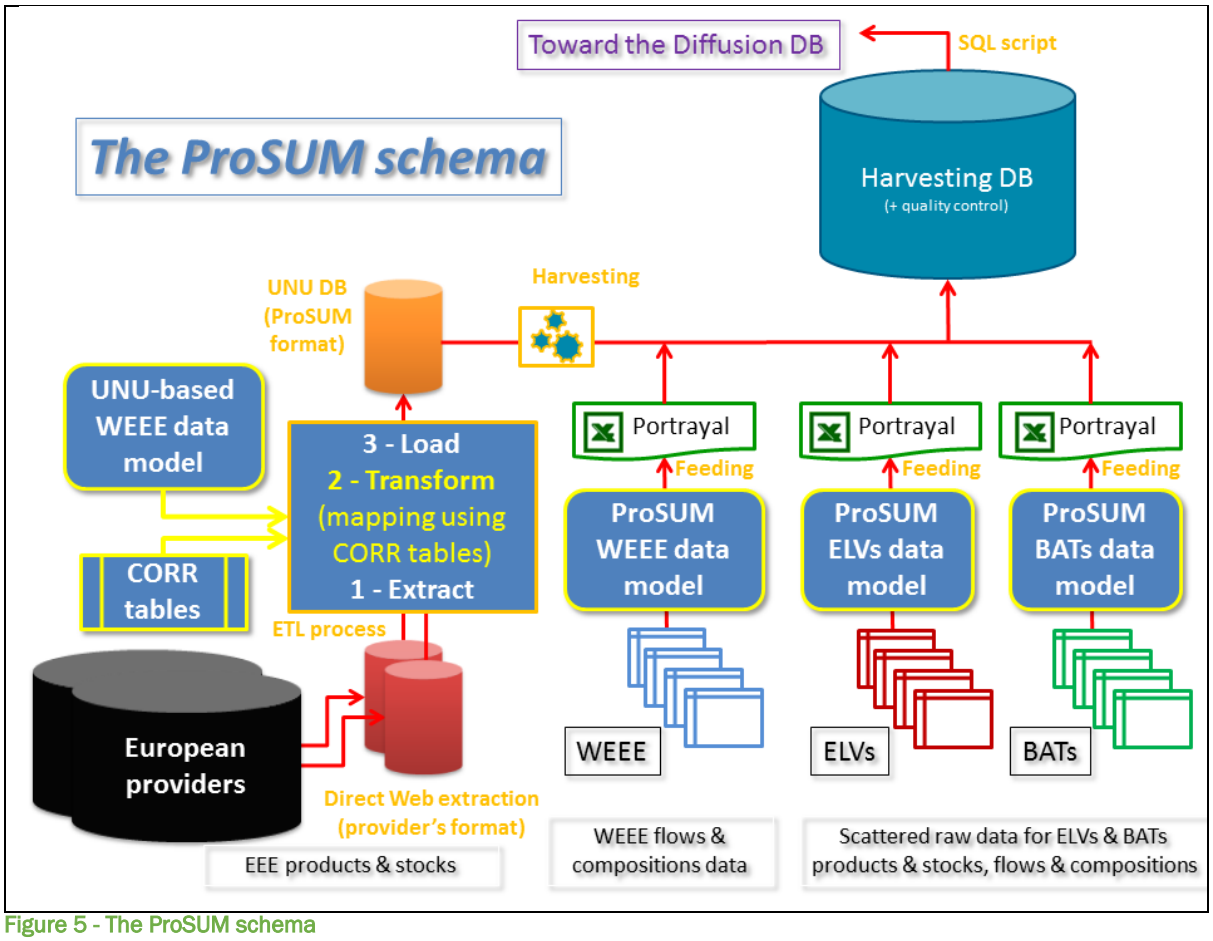


Figure 5 - The ProSUM schema

This figure shows that the ProSUM schema is building on what is partially already existing (the UNU database and associated data model for managing EEE products and stocks), developing all the missing parts of the system, notably: (i) the ProSUM WEEE data model for WEEE flows and composition data, and (ii) the ProSUM data models for ELVs and BATs based on currently scattered data related to products and stocks, flows and compositions. Figure 5 also highlights the fundamental role played by the correlation (CORR) tables in the transformation of data (part of the 'T' of the ETL process) and their harmonisation for the mapping on the UNU-based WEEE data model. The harvesting database will be thus fed by the already existing UNU database which will be harvested and by the ProSUM-designed portrayals for completing the WEEE description and entering all data related to ELVs and BATs in the EU-UMKDP. Remember here that all this structured information will be accompanied by non-structured information – see the right side of figures 1, 3 & 4a – and its metadata to provide full access to the all available information.

Technically, the CORR tables will need to be annually updated as new products are regularly coming onto the market. The ETL process will be automated, as far as possible, in order to minimise human intervention, and bearing in mind the maintenance of the system in the future, after the end of the project.

2.2. Approach

The core of this deliverable is organising the data which represents the urban mine and mining wastes. Chapter 4 describes the approach taken to classify data for mining wastes. For the urban mine the classification system developed is described over six different chapters reflecting the complexity of products, components and waste composition and their stocks and flows.

Chapter 5, Products and their Classifications, describes how we have created clusters of products grouped by predictable properties, in particular, for CRM content. This allows for subsequent linkage with product statistics to characterise products.

Chapter 6, Components Present in Products and their Classifications, describes the relationship between complex products consisting of highly specialised components that differ in composition due to their function. CRMs are often concentrated in specific components, defined in the project as 'hotspots'. Such components are often traded as commodities in the recycling economy e.g. printed circuit board, batteries, cables etc. ProSUM data will be organised by product types for the three product groups (BAT, ELV and WEEE) and constituent components. The products and components can then be linked in tables with varying compositional properties.

Chapter 7, Compositional Properties, describes how data on the materials and element content of products and components is organised. This has been constructed to allow for data to be combined with data on products stocks and flows to 'scale up' the composition of the urban mine.

Chapter 8, Stocks and Flows, describes the linkages between the data above and the stocks and flows of products, components and wastes in the urban mine. The stocks and flows data will be combined with mass flow data by 'Keys' for WEEE, waste batteries and ELVs. This approach to harmonisation allows for improved prediction of the properties in particular sales of product types, stock size, lifespan of product in the stock and the associated quantities and timescales for wastes generated. The resulting consolidated stock and flow data will be constructed in such a way that it can be directly linked with all product properties.

Chapter 9, User Defined Output Lists, takes account of the fact that users of the EU-UMKDP may not want to retrieve data in the way it has been collected for the purposes of unifying data. It is necessary to present and group data in different ways to allow users to access data which is meaningful to them. This chapter describes the approach taken to further link the harmonised data into 'user friendly' categories. For instance, a user may want to know what chemical and physical format an element is in to make decisions about its recyclability in their process.

Chapter 10, discusses harmonised use of the metadata descriptions with a set of standard fields common to academia, the preceding Min4EU work, and the additional fields needed for ProSUM.

Chapter 11, deals with data consolidation and data quality. It sets out the procedures used within the project to gather and assure the quality of data which will be added to the databases. A number of different sources will be used to obtain data. This data will have been generated in different ways and for different purposes which impact on data usability. A robust and consistent screening and categorisation process is sketched and will be further developed to address this issue in the respective later deliverables. This allows for the inclusion of reliable high quality data and provides a transparent and traceable system back to the source.

Annex 7 includes a case study to illustrate how the classification system works in practice using a laptop case study including the batteries contained.

One of the challenges in organising and correlating data is the inconsistent use of terminology within and between different disciplines and sectors. Chapter 3 presents the definitions and terms used for the purposes of ProSUM.

3. Definitions

Unless stated otherwise the definitions in this chapter are ProSUM working definitions and project terminology. Where they are available standard terms have been used e.g. those described in legislation.

3.1. Glossary of terms – Data Organisation

Classification
Organisation and arrangement of items into groups according to their similarities. (Adapted from the Oxford English Dictionary, 2015).

Classification System
A system which organises the classes according to their common relationships or affinities. (Adapted from the Oxford English Dictionary, 2015).

Code List
A type of controlled vocabulary containing a finite list of codes and meanings that represent the only allowed values for a particular data item. This list can be extended in certain conditions.

Correlation
The process of establishing a relationship or connection between two or more things (Oxford English Dictionary, 2015).

Data Consolidation
Data consolidation refers to the collection and integration of data from multiple sources into a single destination. During this process, different data-sources are put together, or consolidated, into a single data store (Techopedia 2015).

Data Quality
Characteristics of data that relate to their ability to satisfy stated requirements, as defined by ISO 14044. Data quality evaluates whether the accompanying characteristics are in accordance with the objective: time-related, geographical and technology coverage, precision, completeness, consistency, reproducibility, sources of data and uncertainty (Biemann et al., 2013).

Database
A collection of structured data held on a computer. Data is organised to allow for easy access, management and updating (Oxford English Dictionary, 2015).

Diffusion Database
Database optimised for diffusion. This central database contains all of the data retrieved (harvested) from the project databases and is used to provide services on top of the EU-UMKDP (search facilities, maps, statistics etc). The optimisation provides end-users with the best experience with the platform.

Dublin Core
The Dublin Core Metadata descriptors are a set of vocabulary terms which can be used to describe resources for the purposes of discovery. The original set of 15 classic Metadata terms, known as the Dublin Core Metadata Element Set are endorsed in the following standards documents:

- IETF RFC 5013
- ISO Standard 15836-2009
- NISO Standard Z39.85

EU Member States/Countries
For spatial data, the ISO 3166 alpha-2 list is going to be used for reporting and the alpha-3 list in the databases.

EPA
Environmental Protection Agency interchangeable with Ministry of Environment or Government Department. Each Member State has their own arrangements for which of these organisations collects data concerning environmental Directives.

EU-MKDP
European Minerals Knowledge Data Platform, created by the Minerals4EU project to 'house' data on minerals.

EU-UMKDP
European Urban Mine Knowledge Data Platform, being created by the ProSUM project to 'house' data on secondary raw materials. Both platforms will be linked to allow for comparisons between primary and secondary resources.

Harmonisation
Adjustment of differences and inconsistencies among different measurements, methods, procedures, schedules, specifications, or systems to make them uniform or mutually compatible.

Harvesting Database
Database making the bridge between the project databases used to stored harmonised data and the Diffusion database. This database allows for the retrieval and consistent formatting of data from different sources before being sent to the Diffusion database.

Knowledge Base
Systematically organised or structured repository of indexed information (usually as a group of linked data files) that allows easy retrieval, updating, analysis, and output of data. Stored usually in a computer, this data could be in the form of graphics, reports, scripts, tables, text, etc., representing almost every kind of information, structured and unstructured (adapted from Wikipedia 2015).

Metadata
Metadata uses descriptors to describe other data-sources, and acts as label for cataloguing and indexing purposes.

Metadata Descriptors (see section 3.6)
Metadata descriptors are the elements of Metadata. ISO 16642

NSI
National Statistical Institute

Output Query
A precise request for information retrieval from a database.

Project Database
Database coming from activity within the project used as raw data for feeding the Knowledge base.

Properties (Database Field)
Properties describe the value and format of a database field.

PropertyType

Code list that allows for further description of the (compositional) properties (of products and components).

Relations (and types)
An association or connection between objects.

Split-factors
Multipliers that are used to convert a value or number into various values that sum up to the original value.

User defined output lists
Retrieval of information from a database in pre-defined format based on user demands, by means of using specific output queries

3.2. Definitions and glossary of terms - Products

EU Directive definitions are used where available.

Batteries (BAT)
A 'battery' or 'accumulator' is any source of electrical energy generated by direct conversion of chemical energy and consisting of one or more primary battery cells (non-rechargeable) or consisting of one or more secondary battery cells (rechargeable) (Directive 2006/66/EC).

CPC
The Customs Procedure Codes (CPCs) identify the customs and/or excise regimes to which goods are being entered and from which they have been removed (where this applies). The CPC is completed at export as well as import. The CPC itself is based on a two digit Community Code which identifies a customs procedure, e.g. removal from warehouse, entry to free zone, export under OPR. From this the CPC is built up into a 7 digit code. (http://www.uk-customs-tariff.com/content/contentlist/volume/vol3_11.pdf)

Distributor
Any natural or legal person in the supply chain, who makes EEE available on the market as defined in Directive 2012/19/EU. This definition does not prevent a distributor from being, at the same time, a producer within the meaning of the definition of *Producer*.

Electrical and Electronic Equipment (EEE)
Equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current (Directive 2012/19/EU).

End-of life Vehicle (ELV)
A vehicle which is waste within the meaning of Article 1(a) of Directive 75/442/EEC (Directive 2000/53/EC).

POM – Placing on the market
Placing on the market (also commonly referred to as 'put on the market' means the first time a product is sold on the market within the territory of a Member State on a professional basis (Directive 2012/19/EU).

Producer

Any natural or legal person who, irrespective of the selling technique used, including distance communication within the meaning of Directive 97/7/EC of the European Parliament and of the Council of 20 May 1997 on the protection of consumers in respect of distance contracts:

i. is established in a Member State and manufactures EEE under his own name or trademark, or has EEE designed or manufactured and markets it under his name or trademark within the territory of that Member State;
ii. is established in a Member State and resells within the territory of that Member State, under his own name or trademark, equipment produced by other suppliers, a reseller not being regarded as the 'producer' if the brand of the producer appears on the equipment, as provided for in point (i);
iii. is established in a Member State and places on the market of that Member State, on a professional basis, EEE from a third country or from another Member State; or
iv. sells EEE by means of distance communication directly to private households or to users other than private households in a Member State, and is established in another Member State or in a third country.

Whoever exclusively provides financing under or pursuant to any finance agreement shall not be deemed to be a 'producer' unless he also acts as a producer within the meaning of points (i) to (iv) (Directive 2012/19/EU).

Vehicle
Any vehicle designated as category M 1 or N 1 defined in Annex IIA to Directive 70/156/EEC, and three wheel motor vehicles but excluding motor tricycles (Directive 92/61/EEC).

Waste Batteries (BAT)
Waste battery or accumulator' means any battery or accumulator which is waste within the meaning of Article 1(1)(a) of Directive 2006/12/EC and Directive 2006/66/EC.

Waste Electrical and Electronic Equipment (WEEE)
Electrical or electronic equipment which is waste within the meaning of Article 3(1) of Directive 2008/98/EC, including all components, sub-assemblies and consumables which are part of the product at the time of discarding (Directive 2012/19/EU).

3.3. Definitions - mining wastes and minerals

Mining waste and minerals terms are those used commonly within the Geological Survey community, as defined in the Minerals4EU project and as defined within the INSPIRE Directive framework. See also the US Geological Survey (USGS) 2014.

CGI
Commission for the Management and Application of Geoscience Information

Geologic Materials
The rocks and sediments that make up the land where we live. The characteristics of geologic materials reflect the processes that form them and the environments in which they form. Geologists divide these materials into three basic rock types.

IFCD
INSPIRE Feature Concept Dictionary

Industrial Minerals and Rocks
Minerals which are neither metallic nor used as fuels, but which are mined and processed for their economic use. A broader definition describes an industrial mineral as any rock, mineral, or naturally occurring substance of economic value, exclusive of metallic ores and mineral fuels, and

[4] http://geomaps.wr.usgs.gov/sfgeo/geologic/stories/geologic_materials.html

gemstones. In essence, they are the raw materials used in many industrial, agricultural and construction products.

Material
The term material is used ambiguously in geological science and in engineering science. Materials in natural systems are distinctly different from engineered materials. The term 'Materials' as used here refers to 'engineered materials' that are composed, manufactured and processed to achieve intended properties.

A Metal (Metallic) Ore
A type of rock (mineral raw material) from which metal can be extracted at a profit.
Metals may be present in ores in the native form (such as native copper), or as noble metals (not usually forming compounds, such as gold), but more commonly they occur combined as oxides, sulphides, sulphates, silicates, etc. The generic wording 'metals' covers 'true' metals (see Periodic Table of Elements) but also includes semi-metallic substances or metalloids such as As and Ge which are often intimately associated with metals.

Mineral Raw Material
A natural inorganic or organic substance, such as a metallic ore, industrial mineral, construction material or energy fuel, but excluding water.

Open Geospatial Consortium:
The Open Geospatial Consortium (OGC) is an international not for profit organisation committed to making quality open standards for the global geospatial community. These standards are made through a consensus process and are freely available for anyone to use to improve sharing of the world's geospatial data.

Ore
Any naturally occurring (raw) material from which a mineral or aggregate can be extracted at a profit. The term 'ore' originally applied only to metallic minerals but now includes such non-metallic substances as sulphur, calcium fluoride (fluorite), and barium sulphate (barite). Ore is always mixed with unwanted rocks and minerals, known collectively as gangue. The ore and the gangue are mined together and then separated. The desired element (often a metal which is usually contained in chemical combination with some other element in addition to various impurities) is then extracted from the ore. It may be still further refined (purified) or alloyed with other metals.

ProMine AC database structure
The structure stores all the information related to Anthropogenic Concentrations of mining wastes and smelting residues.

3.4. Definitions and glossary of terms – Stocks and Flows

Exported
WEEE, BAT or ELV products that are exported as defined by Regulation (EC) No 1013/2006 on shipments of waste.

EOL
End-of-Life.

Lifespan or Residence Time
The time equipment spends at a household, business or the public sector is called the lifespan or residence time. This timeframe includes the exchange of second hand equipment among households and businesses within the given territory usually being the country borders. This is to be distinguished from the commonly used lifespan that is reflecting first use by the first consumer or business (Baldé et al., 2015; Wang et al., 2013).

Material Flow Analysis (MFA)
Also referred to as Substance Flow Analysis, is the analysis of a set of material flows, stocks, and processes within a defined boundary (e.g. a region, country, a private household, etc.) (Brunner and Rechberger, 2004). The system boundary is defined in space and time. It can consist of geographical borders (region) or virtual limits (e.g. private households, including processes serving the private household such as product residence time, waste collection, etc.). For the purpose of this project, the default geographical boundaries are the national territories of the EU member states (Brunner and Rechberger, op. cit.).

Non-Compliant Treatment
This working definition is used and also aligned with the information from the CWIT project (Huisman, 2015). Recycling with other waste streams involves recycling of WEEE with, for instance, mixed metal scrap. This type of recycling does not always meet the same efficiency and treatment standards as the officially reported amounts, and is financed via other (mainly market) mechanisms. The amount of WEEE treated this way is very difficult to quantify, and if data is available, it is mainly estimated. The term non-compliant does not necessarily imply substandard treatment, but rather refers to these quantities not being declared to national/ EU levels. Other terms commonly used are **complementary treatment** or **unreported treatment**. The term unreported is not utilised here as often these amounts are actually declared to regional authorities under different reporting regimes.

Product Stocks
Material reservoirs (mass) within the system analysed that have the physical unit of kilogrammes and tons (per inhabitant or household). For the purpose of the project and the sales-stock-lifespan model, stocks are differentiated between dynamic (in-use stocks from past, present, and future material use) and accumulative stock (tending to be accumulated).

Scavenging
To search for and collect (anything usable) from discarded waste as defined in the On-line Oxford Dictionary, 2015. Though the essence of scavenging within ProSUM is the collection of useable electronics prior to collection or processing. This may be a legal or an illegal activity.

Waste
Means any substance or object in the categories set out in Annex I of Directive 2006/12/EC which the holder discards or intends or is required to discard.

Waste Bin
WEEE or waste batteries put in the waste bin and not separately collected for recycling but typically landfilled or incinerated includes household waste and mixed bulky waste.

WEEE Collected
The WEEE that is collected, reported and regulated by national transposition of the WEEE Directive. This includes WEEE that is collected, exported and treated according to the national standards of the receiving country.

WEEE Generated
The amount WEEE discarded after consumption within the member state in a given reporting year, prior to any collection, reuse, treatment or export, as defined in the WEEE Directive. Generally WEEE generated is calculated using a sales-lifespan approach, according to internationally agreed statistical guidelines (Baldé, 2015) using the UNU-KEYS.

WEEE Officially Collected and Treated
The WEEE that is reported as collected and recycled under the producer compliance regime within the member state and recorded in national and European statistics.

3.5. Definitions - Composition

Component
Uniquely identifiable part or subunit of products. Components are usually mechanically removable in one piece and are considered indivisible for a particular function or use. A component can consist of other components e.g. a printed circuit board may contain a capacitor which is also a component. Some products may contain other products as components, for instance, a car has a battery. Other terms include subsystem, part, cluster of parts, or assembly.

Component Group Type
The ComponentGroupType aggregates all components included on a 'ComponentList' to a higher level of component groups. The aggregation is based on characteristics, application purposes, and composition.

Component List
A comprehensive list of components contained with products.

Composite Material
A composite material or composite is a material made from two or more distinct constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components, adapted from Wikipedia, 2015).

Engineered Materials
Refined and processed raw materials to achieve specific functions and specifications e.g. alloys.

Homogeneous material
One material of uniform composition throughout or a material, consisting of a combination of materials, that cannot be disjointed or separated into different materials by mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes;" (Council Directive EC 2011, RoHS Art. 3 (20)).

HREE
Heavy Rare Earth Elements: Y, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu.

LREE
Light Rare Earth Elements: (Sc[5]), La, Ce, Pr, Nd, Pm and Sm.

Material Group Type
Defines the main categories in which materials are clustered into lists.

Material Type
The specification of the above mentioned material groups into material types.

Material List
The list of constituent materials within the material types.

Substances
Any (chemical) element or compound composed of uniform units (Brunner and Rechberger, 2004). All substances are characterised by a unique and identical constitution and are thus homogeneous.

[5] Not included in EC, 2014

3.6. Definitions and terms - Metadata

The main purpose of metadata is to facilitate in the discovery of relevant information, more often classified as resource discovery. Metadata also helps organise electronic resources, provide digital identification, and helps support archiving and preservation of the resource. Metadata assists in resource discovery by allowing resources to be found by relevant criteria, identifying resources, bringing similar resources together, distinguishing dissimilar resources, and giving location information.

This project uses 15 mandatory Dublin Core metadata descriptors taken from www.dublincore.org. See Annex 4 for the comprehensive definitions and guidelines.

4. Mining Wastes

Standardised classification methods are needed to bring together dispersed information on mining wastes from several countries into a common database and to compare the metal and mineral potential of mining wastes with the urban mine.

The ProMine Mining Waste data model was one of the first attempts to describe, organise and store data related to mining wastes, linked with primary resources, at a European scale. The database structure in ProMine is easier to understand than the M4EU data model and the code list describing the different types of mining wastes is more exhaustive than the official INSPIRE list.

This ProMine data model led to the INSPIRE Mineral Resources (MR) data model (for primary and secondary mineral resources), from which the M4EU data model is directly derived, and to the improvement of the International EarthResourceML (ERML) data model.

The ProMine 'Mining Waste' layers can be seen through the ProMine Portal[6] . They are shown in the EU-UMKDP as external layers, see Figure 1.

4.1. The ProMine AC database structure

The Anthropogenic Concentrations (AC) database created in the EU-FP7 ProMine project (2009-2013) stores all the information related to anthropogenic concentrations, primarily mining wastes and smelting residues (Cassard et al., 2013). Each site is described through approximately 35 fields distributed into 6 folders shown in Table 2 below.

(1) General information includes status, owner, location and the list of the processing that has been implemented on the site. From this folder a link with the Mineral Deposit (MD) database can be created, identifying which deposits fed the site.

(2) Information on wastes and products includes the type of storage, the type of waste, the mineralogy, estimation of volume/tonnage, the type of commodity available and the grade, with automatic calculation of potential resource, per commodity, at the site scale and the type of environmental impact.

(3) The environmental aspects, which show per environmental impact, the type of environmental pathways and receptors, the type of water treatment and the description of the type of restoration used.

The last three folders are Comments, Iconography and Bibliography.

Table 2 – Organisation of Access-based ProMine AC database

1. General Information
Lexicon guided fields
▪ **Status: information on mining site or plant (mill, smelter, active, inactive, …)**
▪ **Country: link to list of countries**
▪ **Implemented processing(s): information on ore processing**
Free text fields
▪ **Owner(s)**
▪ **District/province**
▪ **Longitude (xx.xxx° and xx°xx'xx"), Latitude (xx.xxx° and xx°xx'xx") (WGS 84)**
▪ **Mining site / plant name(s): multi-entry field to list all possible names of the same mining site / plant**
▪ **Author + date of entry, Controller + date of control**
▪ **URL + source of the mine site / plant (if any)**
▪ **Links to other databases and numbering in these databases**

[6] http://ptrarc.gtk.fi/ProMine/default.aspx

⇨**Possibility to create a link with the MD database: 'Comes from' deposit(s): Name(s) of deposit(s) related to ore processed.** ***Note that the site record has to be created first, and then entered in the Mineral Deposit (MD) database.***

2. Wastes and products

Lexicon guided fields

- **Multi-storage/waste window: per type of storage and type of waste:**
  - **Waste or product storage: type of storage used for wastes or products**
  - **Type of waste or product: description of wastes and products; hierarchical listing**
    - **Mineralogy: waste or product mineralogy**
    - **Class: category class information on waste or product**
    - **Commodity(ies): type of commodity(ies) available in wastes or products**
      - **Unit: unit of commodity grade**
      - **Manual calculation of estimated resource per commodity**
    - **Impacts: type of environmental impacts with area affected by pollution and volume of water affected (linked to 3. Environmental aspects)**

Free text fields

- **Surface area (m^2), volume (m^3), and tonnage (t) of a type of waste or product**
- **Density retained for calculation**
- **Grades (min, max, average), date, accuracy of estimation (%)**
- **Area affected by pollution (km^2)**
- **Volume of water affected (m^3)**
- **Comments on impacts (free text)**

- **Automatic calculation of potential resource, per commodity, at the site scale (synthesis)**

3. Environmental aspects (new window with impact recapitulation - linked under 2. Waste and products/Impacts)

Lexicon guided fields

- Per environmental impact**:**
  - **Pathways: type of environmental pathways**
  - **Receptors: type of environmental receptors**
  - **Water treatment: management and treatment processes and structures of water**
  - **Restoration: description of restoration used**

4. Comments

- **General comments on environmental issues, plant infrastructure (free text)**

5. Iconography

- **Illustrations (photographies, schemas, maps, etc.) related to the site**

6. Bibliography

- **Reference(s)**

The vocabulary (lexicon, or code list) used in ProMine for describing mining wastes is given in the following table.

Table 3 – 'Type of waste' hierarchical lexicon used in ProMine

ID	From	Description
A		Unknown
B		Mine products and waste (unprocessed)
B10	B	Run-of-mine ore
B20	B	Ore stockpiles unprocessed
B30	B	Mine waste dump
B40	B	Barren overburden
C		Ore processing wastes
C10	C	Cobbing waste
C20	C	Wash tailings
C30	C	Flotation tailings
C40	C	Leach residues
C50	C	Magnetic-separation tailings (heavy minerals from glass sand)
D		Treatment waste (metallurgical residues & slags, etc.)
D110	D	Smelter waste
D120	D	(Smelting) Slag
D130	D	Secondary refining residues

D140	D	Flue dust (pyrometallurgical, electrochemical processes)
D150	D	Roasting residues (pyrometallurgy)
D160	D	Dephosphorization slag (Fe ores) Thomas' process slag
D170	D	Electrolytic sludge
D180	D	Matte (intermediate product)
D190	D	Chemical treatment waste
D200	D	"Red muds" from bauxite refining (Bayer)
D210	D	Brine, liquor (e.g. Bayer liquor, H3PO4)
D220	D	U leach tailings (sludge)
D230	D	Combustion and incineration residue
D240	D	Fly ash (e.g. thermal power plant)
D250	D	Bottom ash (e.g. thermal power plant)
D260	D	Lagooned ash
D270	D	Cocking plant residue, solid, liquid (e.g. coal tar)
D280	D	Municipal solid waste incineration (MSWI) bottom ash
D290	D	Incineration residues
E		Manufacturing waste and end-of-life of manufactured goods
E10	E	Manufacturing waste (new scrap)
E20	E	End-of-life of manufactured goods (old scraps)
E30	E	Final waste (MSWI fly ash) from urban waste burning

4.2. Mining wastes in the Minerals4EU (M4EU) database

Information about mines, mining activity and mining wastes are stored in a structured manner in the M4EU relational database (Table 4). It is based on the INSPIRE Mineral Resources core (version 3.0) and extension models (version 2.0) for the characterisation of mining wastes, mines and mining activities. The combination of these two models is compliant with the EarthResourceML version 2, an international standard for exchanging information about mineral resources. Lexicon values are INSPIRE Code list values that were described by C. Schubert et al. (2014). Examples of lexicon values related to mining waste are found in Table 2, Table 3 and in Table 5. Code list value descriptions can be found when following the hyperlinks in Table 5 and Table 6, Table 7. These lexicons will be adapted and improved to meet the requirements of the ProSUM project. Table 8 describes values related to the term “voidable”. A value from this code list can be provided for a column or a whole table row, when no real value(s) can be provided, but when such a value or values may exist or may be measurable or computable in the real world. This table describes types of information which are stored in the M4EU database that may be of use in the context of ProSUM. The data type, in which the information is stored, is indicated in parenthesis. Lexicon is a value from a standard code list. Quantity is a numeric value and a unit of measure. Free text can be any text up to a certain length. Voidable is used where no information can be provided and a value from the voidable standard lexicon is provided e.g. unknown, unpopulated, withheld”, see Table 8.

Table 4 – Information stored in the M4EU database

Mining Waste Information
1. Waste Type *(lexicon, see* **2.** *Waste* **is also classified by the type of mining or processing undertaken to extract the ore (revised version based on the Mining Waste directive - 2006/21/EU and its vocabulary (2000/532/EC) - together with additional values defined by CGI.** Table **5 - Mining and processing classification** 3. *)*
4. *<voidable>* Storage Type *(lexicon, see table)*
5. *<voidable>* Environmental Impact *(lexicon, see table)*
6. *<voidable>* Waste Measure Amount *(quantity)* 7. *<voidable>* Waste Measure Grade *(quantity)*

8. *<voidable>* Waste Measure Density *(quantity)*
9. *<voidable>* Link to Rock Material a. Genetic Category *(lexicon)* b. Composition Category *(lexicon)* c. Consolidation Degree *(lexicon)* *d.* Lithology *(lexicon)* e. Colour *(lexicon)* 10. *<voidable>* Link to Mineral a. Mineral Name *(lexicon)* b. Colour *(lexicon)*
11. Spatial position and geometry (*geometry*)
12. *<voidable>* Link to Mining Activity (see below)
Mining Activity Information
1. Activity Start *(date)* 2. Activity Stop *(date)* 3. Activity Type *(lexicon)* 4. Processing Type *(lexicon)* 5. *<voidable>* Amount of ore processed *(quantity)*
6. *<voidable>* Link to Mine (see below)
Mine Information
1. Mine Name *(free text)*
2. Status Type *(lexicon)*
3. Spatial position and geometry (*geometry*)
4. *<voidable>* Begin Date *(date)*
5. *<voidable>* End Date *(date)*
6. *<voidable>* Link to Source reference a. Name *(free text)* b. *<voidable>* Date *(date)* c. *<voidable>* Hyperlink *(URL)* d. *<voidable>* Short Name *(free text)* e. *<voidable>* Specific Reference *(free text)*

Waste is also classified by the type of mining or processing undertaken to extract the ore (revised version based on the Mining Waste directive - 2006/21/EU and its vocabulary (2000/532/EC) - together with additional values defined by CGI.

Table 5 - Mining and processing classification

Code	EU code
wastes from mineral excavation	01 01
waste from mineral metalliferous excavation	01 01 01
waste from mineral non-metalliferous excavation	01 01 02
wastes from mineral dressing	01 02
wastes from the dressing of metalliferous minerals	01 02 01
cobbing waste	01 02 01 01 (CGI)
magnetic-separation tailings	01 02 01 02 (CGI)
wash tailings	01 02 01 03 (CGI)
flotation tailings	01 02 01 04 (CGI)
leach residues	01 02 01 05 (CGI)
wastes not otherwise specified	01 02 01 06 (CGI)
wastes from the dressing on non-metalliferous minerals	01 02 02
wastes from further physical and chemical processing of metalliferous minerals	01 03

tailings	01 03 01
dusty and powdery waste	01 03 02
red mud from alumina production	01 03 03
other sludges / muds / chemical liquid products than specified above	01 03 04 (CGI)
wastes not otherwise specified	01 03 99
wastes from further physical and chemical processing on non-metalliferous minerals	01 04
waste gravel and crushed rocks	01 04 01
waste sand and clays	01 04 02
dusty and powdery waste	01 04 03
waste from potash and rock-salt processing	01 04 04
waste from washing and cleaning of minerals	01 04 05
waste from stone cutting and sawing	01 04 06
waste not otherwise specified	01 04 99
drilling muds and other drilling wastes	01 05
oil-containing drilling muds and wastes	01 05 01
barite-containing drilling muds and wastes	01 05 02
chloride-containing drilling muds and wastes	01 05 03
fresh-water drilling muds and wastes	01 05 04
wastes not otherwise specified	01 05 99

Mining waste storage is also classified by how the wastes occur as stocks as shown in Table 6.

Table 6 - Storage classification

Code
covered
surface
underground
underwater

Environmental impacts are classified by the types of emissions and other risks to human health.

Table 7 - Environmental Impact Classification

Code
emission
particulate-emission
mineral-fiber-emission
dust
liquid-emission
aqueous-liquid-emission
subsurface-aqueous-liquid-discharge
surface-aqueous-liquid-discharge
mine-drainage
acid-mine-drainage
basic-mine-drainage
neutral-mine-drainage
runoff-water
non-aqueous-liquid-emission
gaseous-emission
odour

radioactive-emission
radiation
physical-impact
erosion
instability
subsidence
collapse
dam-failure
landslide
sedimentation
health-impact
heat
habitat-modification
visual-disturbance
vibration
noise

There are a number of reasons why no data is provided and the voidable field is used. Where a row or column is voidable an additional column is present to describe the reason as shown below, only values from this code list are added to the database.

Table 8- Voidable data

Code	description
unpopulated	The property is not part of the dataset maintained by the data provider. However, the characteristic may exist in the real world. For example when the elevation of the water body above the sea level has not been included in a dataset containing lake spatial objects, then the reason for a void value of this property would be 'Unpopulated'. The property takes this value from the data on all spatial objects in the spatial data set.
unknown	The correct value for the specific spatial object is not known, and not computable by the data provider. However, a correct value may exist. For example when the elevation of the water body above the sea level of a certain lake has not been measured, then the reason for a void value of this property would be 'Unknown'. This value is applied only to those spatial objects where the property in question is not known.
withheld	The characteristic may exist, but is confidential and not divulged by the data provider.

4.3. Composition of mining wastes

This section assumes that institutes and organisations that participated in Minerals4EU and are participating in ProSUM are able to provide data on mining wastes, particularly grades related to CRMs. Table 9 describes information that could be useful when classifying mining wastes as a mineral resource using the M4EU schema.

Table 9 - Comparable Mineral Resource Information

Mineral Resource Information
1. Spatial position and geometry (*geometry*)
2. Occurrence Type *(lexicon)*
3. <*voidable*> Deposit Type *(lexicon)*

4. Commodity
    a. Commodity Type *(lexicon)*
    b. <*voidable*> Rank *(ranking number)*
    c. <*voidable*> Importance *(lexicon)*
5. <*voidable*> Ore measure
    a. Classification method *(lexicon)*
    b. Date *(date)*
    c. Ore Amount *(quantity)*
    d. Source reference (see table**Error! Reference source not found.**)
    e. Commodity Measure
        i. <*voidable*> commodity amount *(quantity)*
        ii. <*voidable*> Cut-off grade *(quantity)*
        iii. <*voidable*> Grade *(quantity)*
    f. Reserve
        i. Category *(lexicon)*
    g. Resource
        i. Category *(lexicon)*
        ii. *Includes Reserves (True/False)*
    h. Endowment
        i. Includes Reserves *(True/False)*
        ii. Includes Resources *(True/False)*
    i. UNFC
        i. Category *(lexicon)*
6. <*voidable*> Mining Activity (see table)

If data for mining waste is available and associated with a specific deposit, the M4EU database can be reused to obtain this information. However, the present version of the Mining Waste table in the M4EU/INSPIRE database only stores and provides information about the amount, grade and density of waste material (see table). It does not include data on the presence of CRMs and consequently on the CRM amounts.

The Mining Waste model will be extended to link to commodities and grades directly. The idea is to link MiningWaste to a new concept WasteMeasure which will be quite similar to OreMeasure (used for primary resources) but adapted to waste specificity. This new WasteMeasure will be linked to another WasteCommodityMeasure. Again, this new concept WasteCommodityMeasure will be quite similar to CommodityMeasure, with some adjustment specific to waste. This new WasteCommodityMeasure will be then linked to the defined Commodity class.

Note that MiningWaste is linked to MiningActivity, itself linked to MineralOccurrence with a 0:1 cardinality. This means that a MiningActivity can be linked, or not, to a MineralOccurence and a MineralOccurence can have multiple MiningActivity, each of them generating none or several MiningWaste. Thanks to that, the Mining Waste is linked to a Mining Activity but can be independent of a Mineral Occurrence if the information is not known. Moreover, the MiningWaste gets its own(s) location(s) through the geometry property of the MiningFeatureOccurrence.

4.4. Mining Wastes in ProSUM

In WP4, mining wastes are being much more thoroughly described than has been done in previous projects. In order to improve the descriptions of mining wastes and particularly their reliability, two

new code lists are proposed which have been submitted to the IUGS/CGI/GTWG7 for international (worldwide) acceptance and then to the INSPIRE validation process. The code lists are shown in the tables below.

Table 10 - Methods for estimating the amount of mining waste

A: Methods for estimating the amount of mining waste		
1	**Drilling or trenching**	
1.1	*High density drilling or trenching*	Sampling by drilling or trenching with a sample density sufficient for a reliable geostatistical calculation of the amount of mining waste.
1.2	*Low density drilling or trenching*	Sampling by drilling or trenching with a sample density not sufficient for a reliable geostatistical calculation of the amount of mining waste.
2	**Production statistics**	
2.1	*Production statistics*	Amount of mining waste calculated from statistics on produced amount of waste rock, produced amount of tailings, ore input to concentrator minus quantity of produced concentrate or similar. For highest accuracy information on amount of recycled waste (backfill, reprocessed, as aggregates, etc.) is known.
2.2	*Ore production statistics*	Amount of mining waste estimated from data on the amount of ore produced and the knowledge of the ore type.
3	**Field measurement**	Estimate from direct measurements of the area of landfill and estimates of depths.
4	**Remote sensing**	Calculations from digital aerial photos, satellite images or similar
5	**Literature data**	Data from the literature without any information of methods
6	**Location of mine**	The mere presence of a mine or mineral processing plant means that mining waste is nearby. No information on amount though it can be estimated from knowledge of the mining activity.

Table 11 - Methods for estimating the composition of mining waste

B: Methods for estimating the composition of mining waste		
1	**Drilling or trenching**	
1.1	*Detailed sampling and analysis*	Sampling by drilling or trenching with a sample density and analytical quality sufficient for a geostatistical estimation to calculate the amount of material for a resource estimate acceptable for international reporting (ie the JORC code, NI 43-101, etc.)
1.2	*Sampling*	Random drilling or trenching with a sample density and analytical quality not sufficient for a proper geostatistical analysis.
1.3	*Random sampling*	One or very few locations sampled and analysed
2	**Production statistics**	
2.1	*Production statistics*	Calculations from known composition of produced waste rock, produced tailings, ore input to concentrator minus quantity of produced concentrate or similar.
2.2	*Ore production statistics*	Estimates from amount and composition of produced ore and estimates of recovery.

[7] http://www.cgi-iugs.org/tech_collaboration/geoscience_terminology_working_group.html. Proposal submitted during the Ispra meeting on October 29-30, 2015.

5. Products

5.1. Introduction

The classification of products is outlined in this chapter. Harmonised links are provided by grouping: EEE into UNU keys, UNU sub-keys and EEE device types; batteries into battery types divided into unique BAT keys; and vehicles by vehicle type, vehicle segment, vehicle engine power and vehicle weight class.

The sections below describe the existing UNU Key system for classifying EEE, and steps to expand it, proposes a new similar Key system for batteries and a new system for vehicles.

5.2. UNU keys, the classification for EEE

5.2.1. UNU keys

The classification of 'UNU keys' was developed by the United Nations University (UNU) and envelops all possible Electrical and Electronic Equipment (EEE). The UNU keys are constructed such that product groups share comparable average weights, material compositions, EOL characteristics and lifespan distributions see Figure 7. This classification list is divided into 54 categories by linking all possible W(EEE) items (about 700 products) to various conventional categorisations. In a similar manner, the link between statistical codes has been developed aligning the classifications applied in trade statistics (the Harmonised System) and WEEE directive (Baldé, 2015).

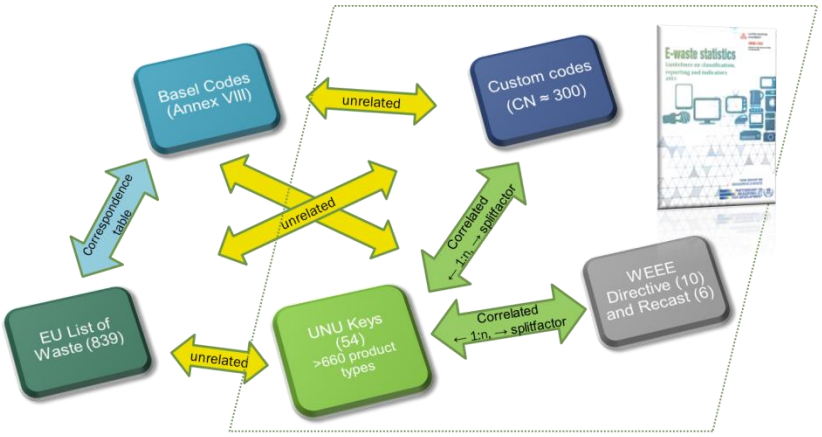


Figure 6 - UNU keys linkage to HS and WEEE directive

Moreover, the 54 categories of UNU keys can be grouped into 10 primary categories of original EU Waste Electrical and Electronic Equipment (WEEE) Directive (Annex II). The classification can also be linked to the new reporting categories for the recast of the WEEE Directive, which will come into effect in 2017 in the EU (Magalini et al., 2015). The UNU keys classification is ideal to serve as a link between the Recast WEEE Directive and the existing classifications. Likewise, all EEE follows the harmonised statistical coding of the international trade codes, the harmonised system (HS). The HS codes link to the Custom Procedure Codes (CPC) product classification. National statistical institutes or custom organisations document all commodities and economic activities in society. Independent of current WEEE registers; this data can provide consistent and harmonised sales figures for all products through historical years and serve as an alternative data-source for the estimation of WEEE generation. The list of UNU keys, and preliminary list of UNU_ sub-keys and EEEDeviceTypes is presented in the Correlation Tables in Annex 1.

On the waste related classifications (shown in Figure 6), there are linkages with the codes used for the Waste Shipment Regulation (the EU translation of the Basel Convention) in the List of Waste (LoW) used in most European countries for administrative purposes. The Basel/OECD Codes from Basel convention are not mapped yet. The Basel Codes and LoW codes, however, are difficult to

relate to the CN codes. This mainly comes from the fact that the CN nomenclature defines waste as the residual streams. The LoW and Basel codes are not linked to each other. As part of the CWIT Project Final Report (Huisman et al., 2015), it was recommended to establish correlation tables between the UNU keys (as the intended ultimate reference for the WEEE data model) and the LoW and Basel codes.

Table 12 - Selection of the UNU keys and the number of links with other classifications (UNU_key code list)

UNU Key	Description - Short	# of Subkeys	# of Device types	WEEE Dir. 2003 (10) 0 = out of scope	HS (6 digit)	WEEE Recast 2012 (6)	WEEE Forum Key Figures/ (Huisman et al. 2003)
0001	0001 Central Heating	5	9	0	2	IV	1A LHHA
0002	0002 PV Panels	1	1	0	1	IV	1A LHHA
0101	0101 PROF Heat & Vent.	3	18	1	2	IV	1A LHHA
0102	0102 Dishwashers	1	1	1	1	IV	1A LHHA
0103	0103 Kitchen	3	6	1	1	IV	1A LHHA
0104	0104 Washing Machines	2	2	1	4	IV	1A LHHA
0105	0105 Wash Dryers	2	2	1	3	IV	1A LHHA
0106	0106 HH Heat & Vent.	3	19	1	3	IV	1A LHHA
0108	0108 Fridges	3	3	1	4	I	1B C&F
0109	0109 Freezers	1	1	1	2	I	1B C&F
0111	0111 HH Aircons	3	13	1	3	I	1B C&F
0112	0112 Other Cooling	2	3	1	1	I	1B C&F
0113	0113 PROF Cooling	5	15	1	3	I	1B C&F
0114	0114 Microwaves	2	2	1	1	V	1C SLHA
0201	0201 Other Small HH	8	26	2	28	V	2 SHA
0202	0202 Food	6	56	2	3	V	2 SHA
0203	0203 Hot water	4	15	2	2	V	2 SHA
0204	0204 Vacuum Cleaners	2	4	2	4	V	2 SHA
0205	0205 Personal Care	8	28	2	6	V	2 SHA
0301	0301 Small IT	9	19	3	13	VI	3A IT
0302	0302 Desktops	1	1	3	3	VI	3A IT
0303	0303 Laptops	4	4	3	1	VI	3A IT
0304	0304 Printers	7	10	3	4	VI	3A IT
0305	0305 Telecom	3	7	3	10	VI	3A IT
0306	0306 Mobile Phones	3	3	3	4	VI	3A IT

UNU keys are also used in practice to collect statistical data on sales. This can be done via links to the consumer survey formats, and/or with links to available register data, which are in a few cases based on HS coding. In both cases, data on average weights might be needed to convert units to weight. The lifespans of the UNU keys are homogeneous, which enables the system to be used to determine WEEE generated. WEEE generation is based on a time-series of sales and the average lifespan of a product. Since the product composition of the products within a UNU key is homogeneous, the classification is also suitable for material flow analysis of the raw material components in EEE and WEEE.

5.2.2. UNU sub-keys

UNU keys (4 digits code) are split into UNU sub-key level (6 digits code) in order to provide greater granularity for product average weights and their lifetime profiles to forecast trends, sales and waste generation accordingly. However, some of the CN codes are not always un-ambiguous as they are by nature not specifying which devices types are covered under these codes. In practice, certain devices can and are declared in practice under multiple codes. Therefore, direct relations between sub-keys and CN codes can have scoping risks. An example of split factor is given in section 5.5. The current list of UNU sub-keys is still preliminary, it can contain inconsistencies and is subject to change since more and new devices are identified frequently.

5.2.3. Device types

A preliminary list of over 700 devices (8 digits code) confines them specifically into sub-keys and later to 54 categories of UNU keys. This top down clustering enables researchers to link further data manipulation in terms of components and material grouping directly linked to the device. An example of this is given for UNU key 0303 in Section 5.5.

The correlation tables for all device types are provided as a separate MS-Excel in Annex 1. This list covers the most important and highest prevalence appliance types on the market. However, it is not exhaustive for two reasons: new appliances types enter the market continually; and there are many inconsistencies in describing devices. Hence, the existing list will also be updated in the course of the project where key additional information is gathered. The development of the code lists is addressed in Deliverable 5.5 and the update protocols and required maintenance of the WEEE data models will be discussed in Deliverable 3.6.

5.3. BAT keys, the classification for batteries

Batteries are used in products or connected to products as uninterrupted power supplies. They can be sold separately, be embedded in vehicles and EEE, or within the EEE embedded in vehicles. Several classification approaches for batteries exist, depending on cell chemistry, hazardousness, chargeability, and area of application.

5.3.1. Classification of electrochemical cells

Based on expert knowledge on battery systems and the resources they contain, as well as an analysis of existing battery classifications, a preliminary version of the ProSUM battery classification of electrochemical cells was developed. The battery types cover the six current main electrochemical systems based on lithium, zinc, nickel-cadmium, nickel-metal hydride, lead and others.

5.3.2. The BAT keys

The six battery types are further divided into 16 BAT keys which will be used to consolidate data in a provider database. The keys are classified by chargeability type, the Battery Directive descriptions, battery recycling flows and other trade codes such as the EU List of wastes, ProdCom and CN, and the United Nations Committee of Experts on the Transport of Dangerous Goods.

The BAT keys are primarily based on the electrochemical subsystem.

Table 13 – The BAT keys based electrochemical subsystems (BAT_key code list)

BAT keys	Name	BatteryType	Name
BattLiCoO2	Lithium cobalt dioxide (LiCoO2)	BatteryLi	Battery, Li
BattLiFePO4	Lithium iron phosphate (LiFePO4)	BatteryLi	Battery, Li
BattLiMn	Lithium manganese (LiMn)	BatteryLi	Battery, Li
BattLiMnO2	Lithium manganese dioxide (LiMnO2)	BatteryLi	Battery, Li
BattLiCFx	Lithium carbon monofluoride (LiCFx)	BatteryLi	Battery, Li
BattLiNMC	Lithium nickel manganese cobalt (LiNMC)	BatteryLi	Battery, Li
BattLiSO2	Lithium sulfur dioxide (LiSO2)	BatteryLi	Battery, Li
BattLiSOCl2	Lithium thionyl chloride (LiSOCl2)	BatteryLi	Battery, Li
BattNiCdSealed	Nickel cadmium (NiCd), sealed	BatteryNiCd	Battery, NiCd
BattNiCdVented	Nickel cadmium (NiCd), vented	BatteryNiCd	Battery, NiCd
BattNiMHSealed	Nickel metal hydride (NiMH), sealed	BatteryNiMH	Battery, NiMH
BattNiMHVented	Nickel metal hydride (NiMH), vented	BatteryNiMH	Battery, NiMH

BattPbSealed	Lead-acid (Pb), sealed	BatteryPb	Battery, Pb
BattPbVented	Lead-acid (Pb), vented	BatteryPb	Battery, Pb
BattZn	Zinc	BatteryZn	Battery, Zn
BattOthers	Others	BatteryOther	Battery, other

An example on the use of the BAT keys is highlighted with real data in Annex 5 describing the chemical composition of batteries.

5.3.3. Relationship with other battery classifications

The battery charge type considers the chargeability type of batteries as referred to in Directive 2006/66/EC and is captured in the BattChargeType list.

Table 14 - BattChargeType list

ID	name
Non-rechargeable	Primary battery cells (non-rechargeable)
Rechargeable	Secondary battery cells (rechargeable)
unknown	unknown

The Battery Directive list covers the classification as referred to in Directive 2006/66/EC and is captured in the list BattDirType.

Table 15 - BattDirType list

ID	name	description
Portable	Portable batteries	'portable battery or accumulator' means any battery, button cell, battery pack or accumulator that: (a) is sealed; and (b) can be hand-carried; and (c) is neither an industrial battery or accumulator nor an automotive battery or accumulator [2006/66/EC]
Automotive	Automotive batteries	'automotive battery or accumulator' means any battery or accumulator used for automotive starter, lighting or ignition power;
Industrial	Industrial batteries	'industrial battery or accumulator' means any battery or accumulator designed for exclusively industrial or professional uses or used in any type of electric vehicle;

The correlation between the BAT keys and other existing battery classifications used for trade and logistics are shown for:

- Grouping of batteries in Annex III of the Battery Directive 2006/66/EC, for detailed treatment and recycling requirements (BattRecType)
- List of wastes (LoWType)
- PRODuction COMmunautaire (ProdComType)
- United Nations Committee of Experts on the Transport of Dangerous Goods (UNTransportType)
- Combined nomenclature trade codes (CNTradeCodesType)

5.3.4. Battery-containing products and devices

Batteries which are embedded and used in products are classified as shown in Table 16. The classification is linked to the classification of EEE by the UNU keys. The link between the classification of electrochemical cells and the classification of battery-containing products is an n:m relation, because one electrochemical battery system can be found in several products or

devices, and a product or device can be available on the market with a battery using one type or another of electrochemical cells (e.g. laptops can be powered with NiMH or Li-ion batteries).

Table 16 - Classification of products in which batteries are embedded and used

Key	Name	Product Group	UNU key	Classification Battery Directive
ProdSingleCell	Single cell batteries	Single cell batteries		Portable batteries
ProdPortPC	Portable PC	Electrical and electronic equipment (EEE)	0303	Portable batteries
ProdTablet	Tablets	Electrical and electronic equipment (EEE)	0303	Portable batteries
ProdCellPhone	cell phones	Electrical and electronic equipment (EEE)	0306	Portable batteries
ProdCameraGames	cameras/games	Electrical and electronic equipment (EEE)	0402	Portable batteries
ProdCordlessTool	cordless tools	Electrical and electronic equipment (EEE)	0601	Portable batteries
ProdOtherPort	others portable applications	Electrical and electronic equipment (EEE)	0201, 0202, 0205, 0301, 0302, 0305, 0401, 0402, 0406	Portable batteries
ProdMedical	medical	Electrical and electronic equipment (EEE)	0801, 0802	Portable batteries
ProdHEV	hybrid electric vehicles (HEV) and plug-in-electric vehicles (PHEV)	Vehicles		Industrial batteries
ProdEV	electric vehicles (EV)	Vehicles		Industrial batteries
ProdSLSBatt	SLI battery (starting, lighting, ignition)	Vehicles		Automotive batteries
ProdEBike	e- bikes	Vehicles	0703	Industrial batteries
ProdHandlingEq	Forklifts, handling equipment	Vehicles		Industrial batteries
ProdUPS	Uninterruptible power supply	Uninterruptible power supply		Industrial batteries
ProdTelecom	Telecom	Telecom		Industrial batteries
ProdSecuLighting	Security lighting	Security lighting		Industrial batteries
ProdGrid	Grid	Grid		Industrial batteries
ProdMilitarySpace	Military /space	Military /space		Industrial batteries
ProdOtherInd	other industrial	other industrial		Industrial batteries

5.4. ELV keys, the product classification for vehicles

5.4.1. Vehicle classification

In contrast to the classification of EEE, there is little previous work to build on for the classification of vehicles. The classification needs to be developed completely within the project. For efficiency, we have chosen a complete inclusion of vehicles addressed in the EU ELV Directive (vehicles below 3.5 tonnes) in combination with a mapping of 'hotspots' in which significant quantities of prioritised elements can be assumed to be found. The starting point for the classification of vehicles is to define types of vehicles, materials and components in such a way that high masses and/or mass fractions of prioritised elements can be captured. However, to allow for more exhaustive data to be inserted in the database, where available, other materials and components have also been added.

5.4.2. Product level lists

On the product level, vehicle type, vehicle powertrain and vehicle mass categories are defined based on existing regulations and statistical databases. Vehicle segment categories were further

defined in order to capture that vehicle material content based on the assumption that material use is strongly linked to equipment level and brand (Cullbrand and Olofsson, 2011). This segment classification is commonly used in the automotive industry, but not strictly defined and not used as a basis for any official statistics. The feasibility of using the segment classification will therefore be further explored in the project and taken as a matter of urgency in the ELV work scheduled for Deliverable 3.1 Product Stocks.

At the vehicle level, data can be classified in several different categories, allowing a range of end user queries to be answered. However, official statistics may not allow vehicle type, powertrain and mass categories to be readily interlinked, which is why it is expected that the possibility of combining various classification may be limited. Furthermore, the stock and flow modelling may have to be based on one selected category e.g., vehicle type.

An interim classification for testing has been developed describing all possible combinations of vehicle type, vehicle powertrain and vehicle weight classes, currently used in existing regulations and statistical databases, as well as a vehicle segment category, which is commonly used in the automotive industry. This approach allows a range of end user queries to be answered. However, in order to ultimately come to a similar classification as for EEE (UNU keys), further analysis of, for example, which selection of the main 'vehicle segments' and main 'powertrain' provides a workable and limited subset is still to be performed.

The vehicle type, vehicle segment, vehicle powertrain and vehicle mass categories are listed in the corresponding lists by VehicleType, VehicleSegmentType, VehiclePowertrain, VehicleWeightClass) of Annex 1.

Table 17 - ELV lists and relations

VehicleType_ID	VehicleType_Name	Description	ProductGroupType
PassengerCarsM1	Passenger cars (M1)		(EL)Vehicle
VansN1	Vans (N1)		(EL)Vehicle
3WheelVehicles	3 wheel vehicles		(EL)Vehicle

VehicleSegmentType_ID	VehicleSegmentType_Name	Description	ProductGroupType
SegmentA	Segment A: mini cars		(EL)Vehicle
SegmentB	Segment B: small cars		(EL)Vehicle
SegmentC	Segment C: medium cars		(EL)Vehicle
SegmentD	Segment D: large cars		(EL)Vehicle
SegmentE	Segment E: executive cars		(EL)Vehicle
SegmentF	Segment F: luxury cars		(EL)Vehicle
SegmentS	Segment S: sport coupés		(EL)Vehicle
SegmentM	Segment M: multi purpose cars		(EL)Vehicle
SegmentJ	Segment J: sport utility cars		(EL)Vehicle

VehicleMass_ID	VehicleMassClass_Name	Description	ProductGroupType
ELVless1000	Passenger cars, with unladen mass of less than 1000 kg	<1000 kg	(EL)Vehicle
ELV1000-1249	Passenger cars, with unladen mass of 1000 - 1249 kg	1000-1249 kg	(EL)Vehicle
ELV1250-1499	Passenger cars, with unladen mass of 1250 - 1499 kg	1250-1499 kg	(EL)Vehicle
ELVmore1500	Passenger cars, with unladen mass of more than 1500 kg	>1500 kg	(EL)Vehicle

VehiclePowertrainType_ID	VehiclePowertrainType_Name	Description	ProductGroupType
ELVPetroDiesel	Passenger cars, petroleum and/or diesel (can be further complemented by engine size)		(EL)Vehicle
ELVLPG	Passenger cars, LPG		(EL)Vehicle
ELVNaturalGas	Passenger cars, natural gas		(EL)Vehicle
ELVElectric	Passenger cars, electric (including hybrid)		(EL)Vehicle
ELVOther	Passenger cars, other		(EL)Vehicle

6. Components

6.1. Harmonising component descriptions

Complex products consist of a number of highly specialised components that differ due to their function in material and elemental composition. CRMs are often concentrated in specific components, so called hotspots. In addition to that, many components in the recycling economy are already traded as secondary raw materials with high relevance due to the high content of CRMs such as printed circuit board, batteries, cables etc.

ProSUM data is organised hierarchically by product types inside the three product groups and characterised by component compositions. The components can then be linked in tables with both compositional properties (discussed in Chapter 7) and other properties as shown in Figure 7 below. Existing classifications can be added (e.g. ProdCOM code list) in order to harmonise and consider the existing system and ease data harvesting and management.

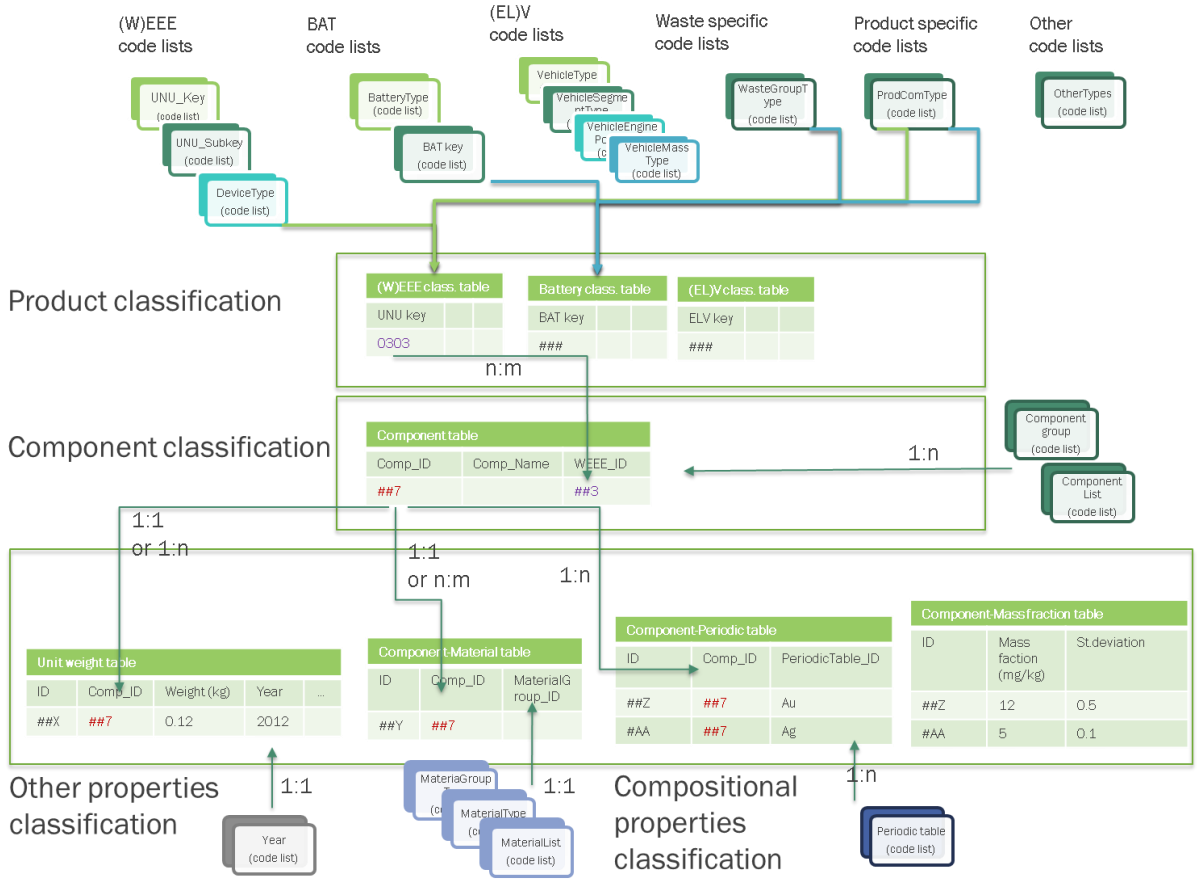


Figure 7 - Component linkages to products, composition and other properties

6.2. Component lists

Component lists aim at describing the consolidated product properties on a component level and identifying CRM hotspots. They are structured in a hierarchical way in order to allow the incorporation of higher aggregated data without losing more detailed information where available.

All components are product specific, but also include components occurring in more than one product group, which is denoted by linkages to the respective product group. These relational databases can be realised by creating tables which use the list entries as input.

6.2.1. Organisation of component data into lists

The hierarchy for the component classification is shown in Figure 8. The list ComponentGroupType aggregates all components entered in 'ComponentList' to a higher level of component groups,

whereas the aggregation is based on characteristics, application purposes, and composition. The ComponentList covers entries of various data sources from a product and waste point of view (see below).

More tables can be generated in order to sub-classify components of special interest, for example printed circuit boards (PCB), as they may contain a significantly different amount of CRM containing capacitors.

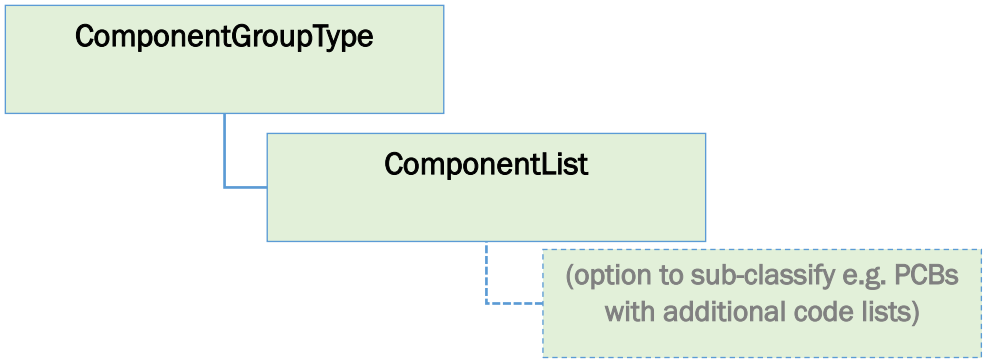


Figure 8 - Format for component lists

6.2.2. References for the component lists

The components were collected, collated, and harmonised from the references below:

Legislative references
Some legislation requires minimum treatment procedure for products. The WEEE Directive 2012/19/EU, for example, targets in Annex VII that components have to be removed from any separately collected WEEE.

Product data sheets
Product data sheets can provide information about components and parts included in products for equipment.

Treatment recommendations
Organisations provide information and dismantling procedure or terms of reference, like the German LAGA M31 “Anforderungen zur Entsorgung von Elektro- und Elektronik-Altgeräten”.

Projects and disassembly studies
Several projects already considered the componential composition of products or carried out disassembly studies. An exhaustive literature review and consultation of ProSUM partners supplemented the MaterialList.

7. Composition Properties

Products and their components need describing by their composition properties to correlate and aggregate information about mass flows with products to produce a quantified 'secondary raw material inventory' for the urban mine. Properties must allow for the correlation and aggregation of data for the databases and the presentation of data of relevance to potential users.

7.1. Taxonomy of the composition properties

Product composition can be described at various levels, as illustrated in Figure 9, where each level can be described a commodity or as a traded good.

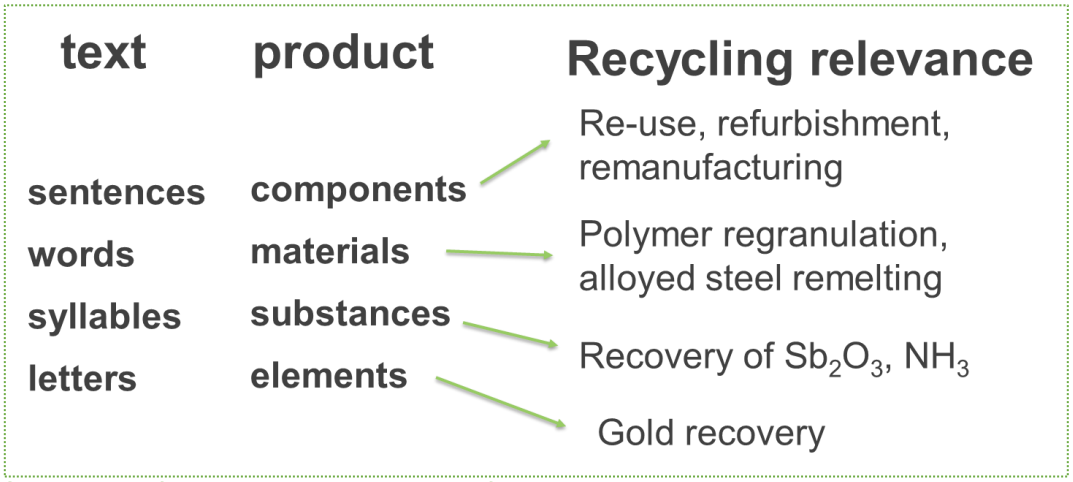


Figure 9 - Taxonomy of the composition property classification

In addition to the above, the choice of properties needs to match data availability both for products and the wastes.

'Components' are defined as uniquely identifiable parts or subunits of products. Components are usually mechanically removable in one piece and are considered indivisible for a particular function or use. A component can consist of other components as well (a printed circuit board with contains many electronic components) and a product can be a component in another product (a battery in a vehicle). Component classification is explained in chapter 6.

The term **'Materials'** as used here refers to 'engineered materials' that are composed, manufactured and processed to achieve intended properties. Material properties are determined by the chemical composition and strict processing conditions. Many materials like alloys, thermoplastics, glass, etc. can be reprocessed though melting and reshaping and are as such potential recycling commodities. The material classification allows for assessment of the main matrix where CRMs are incorporated and also allows, in some cases like alloys, to the direct assessment the CRM content. This information is important to quantify potential recycling commodities.

'Substances' are defined by (Brunner and Rechberger, 2004) as "any (chemical) element or compound composed of uniform units. All substances are characterised by a unique and identical constitution and are thus homogeneous." Substance classification is frequently used in full material declarations whilst waste characterisation rarely addresses a substance specification. "The most authoritative collection of disclosed chemical substance information, containing more than 102 million organic and inorganic substances and 66 million sequences" is the Chemical Abstracts Service (CAS)[8]. The CAS Registry Numbers are unique identifiers which consider next to substances, a collection of, inter alia, compounds, metals, alloys, minerals, and more. CAS

[8] https://www.cas.org/content/chemical-substances/faqs#q1

numbers are frequently used also in so-called Full Material Declarations (FMD) for instance used for declaring environmental compliance with various substance regulations.

The category **'Elements'** describes the elemental composition of products or components without considering their chemical speciation (see Elements code lists in Figure 11).

Within the ProSUM database, 'components', 'materials' and 'elements' are included but substances aren't since there are few complete data sets on substance level characterisation.

7.2. PropertyTypes

Compositional properties can be described on different aggregated levels. The basis for this is the periodic tables of elements. Based on internal as well as external end-user requirements, the composition of products or components will be described using the elemental or material composition, as appropriate. Therefore, correlation lists for both elements and materials have been defined. The list is provided in Annex 1.

7.3. Material lists

7.3.1. Organisation of material data

The material list allows for the characterisation of products from a recycling perspective by describing the macro or bulk material structure of a product part. This information is relevant to assess the accessibility of CRM elements in the material matrix and to assess the recovery potential of elements, in particular CRMs by material recycling.

Ashby et al. 2013 cluster engineered material in six families of which each has its own classification system. For each material family, international standardised material designation systems exist that classify material in classes and subclasses according to their chemical composition. All material designation systems follow a hierarchical approach which facilitates the integration of data sources with different aggregation levels.

The hierarchical format for the materials data is shown in Figure 10.

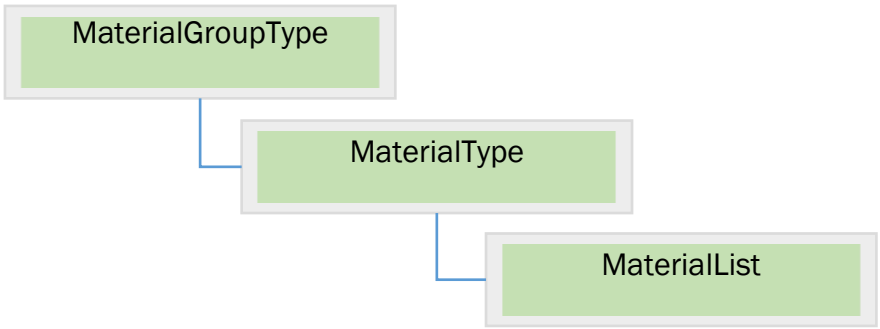


Figure 10 - Format for materials code lists

The material list has three levels aggregating the entries from the list of materials 'MaterialList' in higher levels. From a top-down perspective, the 'MaterialGroupType' defines the main categories in which materials can be clustered:

- Metals
- Polymers
- Ceramics
- Composites
- Biomass and Biomass Based Materials

7.3.2. References for the material data classification

The entries taken into account in producing the material list refer to different classification approaches as shown below.

Life cycle assessment (LCA) databases

LCA software uses information about substances, materials, processes to map mass flows for products or processes. The classification and extent of materials is often problem-related and not exhaustive and under a continental actualisation as well as expansion. A distinction between material, substance or chemical compounds is often not coherent or well-structured and consequently has to be adapted for the ProSUM scope. The data from Idemat 2015 (see www.idemat.nl/) are re-structured, clustered and have been inserted in the ProSUM MaterialList.

Minerals4EU Project

The Minerals4EU Project is "designed to meet the recommendations of the Raw Materials Initiative and will develop an EU Mineral intelligence network structure [and] provide data, information and knowledge on mineral resources around Europe"[9].

INSPIRE

Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). INSPIRE aims to "ensure that the spatial data infrastructures of the Member States are compatible and usable in a Community and transboundary context, the Directive requires that common Implementing Rules (IR) are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting)"[10]**.**

National and international standards

Organisations on national and international level, like the European Norm (EN) or International Organisation of Standardization (ISO), classify various materials by their composition and physical properties. For example, in the case of steel grades, reference to ISO/TS 4949:2003, EN 10027 or DIN standards can be made.

7.4. Elements list

The original intention was for this list to define the scope of raw materials to be addressed in the ProSUM project. This list was expanded to include chemical elements relevant for the products in the ProSUM scope. Given the dynamic character of some of the criteria used to determine the relevance of chemical elements, e.g. their 'criticality' or their relative use in the products under investigation, the element list may have to be re-evaluated periodically.

The following criteria have been applied to determine the relevance of chemical elements for ProSUM:

- Critical according to EC 2014: In line with the Waste 4c Horizon 2020 call scope and the ProSUM Grant Agreement, and independent of the other criteria, elements are considered relevant for ProSUM if the raw materials they can be extracted from are 'critical' according to the 2014 "Report on Critical Raw Materials for the EU" (EC 2014). Critical raw materials have a high economic importance to the EU combined with a high risk associated with their supply (EC 2014). It has to be kept in mind that the criticality of raw materials depends on the point in time of the evaluation (for example, tantalum was considered critical in the first criticality study of the EC in 2010, while it is not considered critical in the 2014 version) and of the scope of the study (criticality studies e.g. addressing the United States and not the EU come to different conclusions).
- Conflict mineral origin possible: Independent of the other criteria, elements are considered relevant for ProSUM, if the raw materials they could be extracted from originate from conflict

[9] http://www.minerals4eu.eu/
[10] http://inspire.ec.europa.eu/

regions. According to the United States Securities Exchange Commission (SEC) these are tantalum, tin and tungsten (the '3 T's') and gold (SEC 2014).

- Recovery driver: Independent of the other criteria, elements are considered relevant if they are drivers for the recovery of other elements (e.g. copper or gold).
- Challenge for recycling process: Independent of the other criteria, elements are considered relevant for ProSUM, if they can inhibit the recycling process. As this typically depends on the recycling process as well as on the macro properties of the material itself (e.g. the type of alloy), we included elements banned or restricted either by the REACH and RoHS (ECHA, 2015); Council Directive EC 2011, or by documents provided by producers in the scope of ProSUM (e.g. Ericsson 2014). The halogens Bromine, Chlorine and Fluorine, which can be found e.g. in plastics (brominated flame retardants, BFR) or in cooling agents (e.g. chlorinated fluorocarbons, CFC), were also included.
- Relative annual demand: Independent of the other criteria, elements are considered relevant for ProSUM, if their annual demand lies between 5-25% ('medium') or over 25% ('high') of the annual global for the raw material they are extracted from at least for one of the ProSUM product categories.

The application of these criteria results in the list provided in Annex 5, which is summarised in Figure 11. The list also contains some elements that do not fulfil any of the above mentioned criteria, either because they are known to be found in at least one specific application within the ProSUM scope (barium, caesium, the noble gases argon, helium, neon, krypton and xenon, strontium, thallium, titanium and zirconium - see for example Widmer et al., 2015), or because their use in specific applications within the ProSUM scope could not be excluded (hafnium, rhenium). Abundant elements such as calcium, hydrogen, nitrogen, potassium, oxygen or sodium were not included.

All elements highlighted in Figure 11 can also be found in the latest version of the M4EU code list (03 code list v0.7.0.2.xls, ObservedPropertyType), except graphitic carbon, fluorine, lithium and the noble gases. We plan to allow for output queries for these elements at least, provided that the necessary data are available.

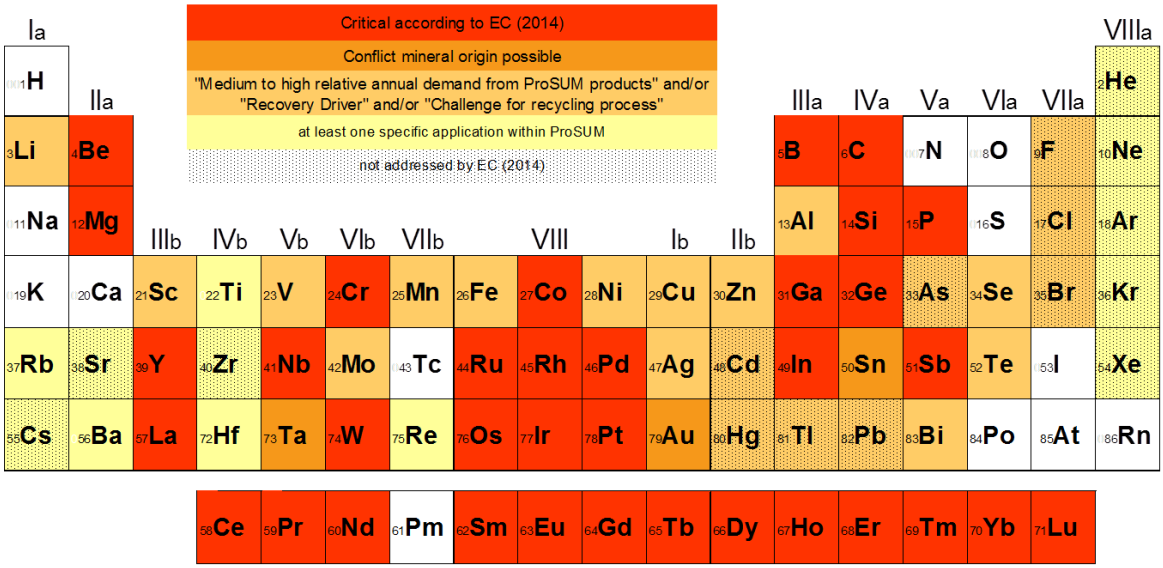


Figure 11 - Relevant elements for the product groups of ProSUM

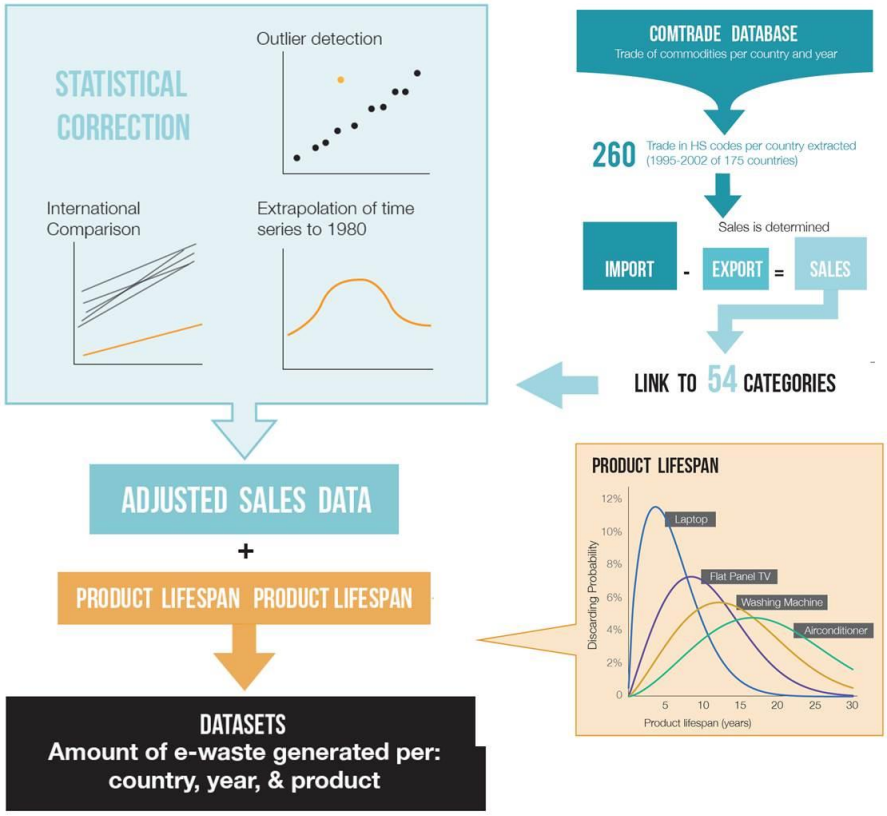
8. Stocks and flows section

Waste batteries, ELV and WEEE are fundamentally different from mining in terms of where the waste is generated in the economy. This also requires a different way to describe the most relevant items of the waste materials.

8.1. Harmonising stocks and flows descriptions

The measurement framework is based on empirical data, a model and statistical routines (Figure 12). To begin, EEE production and trade is tracked by selected code from Harmonised Commodity Description and Coding System (HS) followed by extraction of statistical data from the UN Comtrade database or Eurostat. This can serve as a critical and easily accessible data-source to calculate sales. Ideally, domestic production plus imports, minus exports (the 'apparent consumption method') equals the domestic sales in a country.

Figure 12 - Illustration of UNU stocks and flow model



After the equipment has been sold, for quite a while it stays in households or businesses. The equipment in households, businesses and public sector, is referred to as the 'stock' and ends up as WEEE. The stock information might be accessible for some countries depending on national statistical institute surveys on household EEE possession or penetration rate. The time the equipment spends at a household, businesses or the public sector is called the ''lifespan'' or ''residence time''. This timeframe includes the trading of second-hand equipment among households and businesses. The Weibull function, with parameters of scale and shape determines the lifetime of a product. The scale parameter, which is associated with the average life of EEE, provides the closest real life characteristics. The average age of household EEE stocks and the average age of discarded e-waste enabled the construction of lifetime profiles of products. This included the dormant time of electronic equipment on storage.

After a certain residence time, the good is disposed of, and it becomes waste. This is referred to as WEEE generated, calculated by 'Sales – Lifespan Distribution''. It is the annual supply of domestically generated WEEE prior to collection and without imports. WEEE can be classified into

three types of collection. The 'formal collection' activities are (largely) carried out by specialised WEEE treatment facilities. Those facilities might report to governments. The 'other recycling' channel comprises WEEE that is being collected and treated, but not reported as WEEE. Here, the WEEE may be recorded as scrap metal, and is mixed with the large bulk of other scrap metal. Finally, WEEE can also end up in non-separately collected waste (the waste bin). This waste is most likely incinerated or landfilled without material recycling, depending on the waste management infrastructure in a country.

8.2. Stocks and flows tables

Tables have been produced to provide harmonised data for the project provider database as shown in Figure 13.

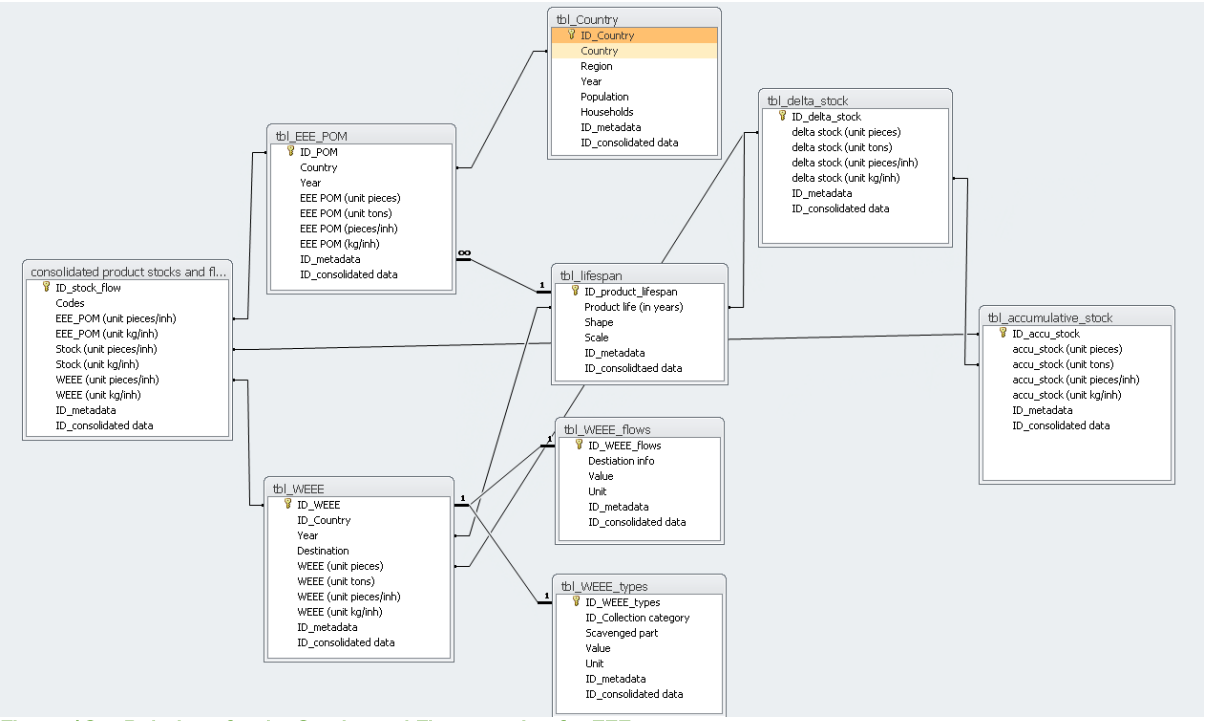


Figure 13 – Relations for the Stocks and Flows section for EEE

The classification system developed must be interoperable with existing statistical databases.

8.2.1. WEEE

The type of waste resembles how the waste is collected and recycled. These types of waste, link to products, in order to perform the necessary calculations for stocks and flows. As an example, the collection categories of the WEEE Recast Directive are displayed in the next table. See also Table 12 - for the relation to the UNU keys. Annex 1 displays the relation of WEEE to the UNU-KEYS.

Table 18 - Types of WEEE

Type of waste	Description
Cooling and Freezing	I As defined in the WEEE Recast Directive
Screens	II As defined in the WEEE Recast Directive
Lamps	III As defined in the WEEE Recast Directive
Large equipment	IV As defined in the WEEE Recast Directive
Small equipment	VAs defined in the WEEE Recast Directive
Small IT	VI As defined in the WEEE Recast Directive

For EEE all links and correlation tables can be found in Annex 1 and Annex 2.

8.2.2. Battery waste

The ProSUM classification for waste batteries is presented in Chapter 5.3. Due to data gaps, some categories of waste batteries may have to be merged to quantify the waste flows.

The battery recycling type considers the grouping of batteries in Annex III, 2006/66/EC, for detailed treatment and recycling requirements and is captured in the BattRecType.

Table 19 - BattRecType list

ID	name	description
BattRecPbA	lead-acid batteries and accumulators	2006/66/EC, Annex III
BattRecNiCd	nickel-cadmium batteries and accumulators	2006/66/EC, Annex III
BattRecOther	other waste batteries and accumulators	2006/66/EC, Annex III

The correspondences between the ProSUM battery classification and other existing classifications mentioned in chapter 5.3.3 (List of Waste, ProdCom, UN Transport, CN Trade Codes) are shown in the next table.

Table 20 - Correlation between the ProSUM battery classification of electrochemical cells and other existing classifications

Code	List of Waste	ProdCom	UN Transport	CN Trade Code
BattLiCoO2	16 06 05	27202300	UN 3480	85076000
BattLiFePO4	16 06 05	27202300	UN 3480	85076000
BattLiMn	16 06 05	27202300	UN 3480	85076000
BattLiMnO2	16 06 05	27201100	UN 3090	85065030
BattLiCFx	16 06 05	27201100	UN 3090	85065010, 85065030, 85065090
BattLiNMC	16 06 05	27202300	UN 3480	85076000
BattLiSO2	16 06 05	27201100	UN 3090	85065010, 85065030, 85065090
BattLiSOCl2	16 06 05	27201100	UN 3090	85065010, 85065030, 85065090
BattNiCdSealed	16 06 02*	27202300		85073020
BattNiCdVented	16 06 02*	27202300		85073080
BattNiMHSealed	16 06 04	27202300	UN 3496	85075000
BattNiMHVented	16 06 04	27202300	UN 3496	85075000
BattPbSealed	16 06 01*	27202200, 27202100		85072080, 85071080
BattPbVented	16 06 01*	27202200	UN 2794	85072020, 85071020
BattZn	16 06 05, 16 06 04	27201100		85061011, 85061018, 85061091, 85061098
BattOthers		27202300		

8.2.3. ELV waste

As for the other product categories in ProSUM, flows of generated waste will be captured up to the processing stage. For vehicles, this typically includes discarded vehicles to registered and unregistered depollution and dismantling. Registered vehicle waste types are based on the formats of the reporting requirements of the ELV directive. The same waste types are assumed for vehicles reaching unregistered depollution and dismantling.

Waste to registered treatment can be linked to official statistics, while waste flows to unregistered treatment may be calculated using the stock and flow model to be developed within the project.

The reporting requirements of the ELV directive include waste flows generated further down in the ELV recycling chain. These waste flows are outside the main scope of the project and will not be included in the stock and flow modelling. In order to allow for a place to insert data on such waste streams, which is known to be available, the classification is provided based on the ELV directive reporting. The waste flows can be coded with European List of Waste codes in combination with type of treatment ('destination') according to List of Wastes (LOW) and EWC-Stat codes.

The vehicle waste classification is listed in the table below in Annex 1 (VehicleWasteType, VehicleWasteList).

Table 21 - Types of ELV waste

Type of waste	Description
Batteries	As defined in the ELV Directive
Liquids (excluding fuel)	As defined in the ELV Directive
Oil filters	As defined in the ELV Directive
Other materials arising from de-pollution (excluding fuel)	As defined in the ELV Directive
Catalysts	As defined in the ELV Directive
Metal components	As defined in the ELV Directive
Tyres	As defined in the ELV Directive
Large plastic parts	As defined in the ELV Directive
Glass	As defined in the ELV Directive
Other materials arising from dismantling	As defined in the ELV Directive
Total dismantled mass	As defined in the ELV Directive
Ferrous scrap	As defined in the ELV Directive
Non-ferrous materials	As defined in the ELV Directive
Shredder Light Fraction	As defined in the ELV Directive
Other shredded materials	As defined in the ELV Directive
Total shredded material output	As defined in the ELV Directive

For vehicles and ELV, links to statistical databases are shown in the VehicleType, VehicleSegmentType, VehiclePowertrainType and VehicleWeightClass correlation tables in Annex 1. No such links are available for VehicleSegmentType or at the component level.

8.3. System flows diagrams and potential data sources

In Annex 7.d, the system flow diagram representing the main data sources per flow and position in the product life-cycle are displayed.

9. User defined output lists

Output queries will allow for the retrieval of information on products or components placed on the market (POM) and the resultant waste fractions, in particular their composition, and related stocks and flows. End users may wish to access this information in different ways dependent upon their data needs. Therefore, the harmonisation approach we define needs to provide for the presentation of collated data in additional ways. Elemental composition is reported in line with the periodic table of elements which is standard. However, for commodities and materials consideration needs to be given to both the complexity of gathering data from the 'bottom up' and presenting it in a way which is meaningful. For instance, a recycler may need to know more than that an element is present, he/she will want to know the physical and chemical format in which it is present to determine if it is recyclable. (See Deliverable 5.1 for more information on end user requirements.

For the elemental and material composition, the end-user will be guided by the element and material related lists provided in Figure 11 and in the tabs MaterialGroupType, MaterialType and MaterialList in Annex 1, as well as by Metadata parameter lists (including e.g. parameters such as 'relative mass fraction in %'). To check if the search options provided by these lists are meaningful to the end-users, they will need to be reviewed by selected end-users at a later stage of the project. If considered necessary by the end-users, a list of commodities (similar to the CommodityType list developed in the Minerals4EU project, i.e. materials of economic interest for the end users) will be provided based on correlation and aggregation from the element and material lists.

Regarding the stocks and flows information, possible outputs may include figures of in-use stocks for specific products over a selected period of time.

For components, queries should allow for retrieval of data on elemental and material composition. Accordingly, the user may search for the elements and materials defined in the element list shown in Annex 5, by MaterialGroupType, MaterialType, MaterialList, and possibly a list of commodities extending the INSPIRE compliant commodity list used in the Minerals4EU project.

Depending on data availability, some queries may not be allowed by the consortium, e.g. in the case where data are incomplete and data completeness would be a prerequisite to answer a query, or in the case where it is not possible to aggregate sets of data from different sources.

10. Metadata

10.1. Harmonising the metadata fields

Available data (literature, reports, existing open source databases, etc.) will be screened for CRM data related to WEEE, ELV and BAT. In order to do so transparently, this data will be catalogued using fields based on Dublin core descriptors (http://www.dublincore.org/documents/usageguide/elements.shtml). Importantly, the metadata descriptors need harmonising within the consortium to describe the consolidated data in the databases and in the sharing of bibliographical files. However, because of the expected multitude, variety and complexity of the data-sources, additional fields have been added to build, maintain and manage a ProSUM bibliography (which captures and details the data screening process). Additionally, the descriptions provided by Dublin Core are in some cases open to interpretation, therefore, a more precise description of the Dublin core descriptors is presented in this section with specific instructions for completing the fields in the ProSUM bibliography.

10.2. Selected metadata fields for the ProSUM Bibliography

In order to be able to scan the available data using Dublin Core and other metadata descriptors, an interactive bibliography file has been created containing all available data-sources for CRM from mainly scientific publications. This is an essential step to be able to manage the potentially large number of data sources in a transparent way.

For laptops alone, there are over 300 reference reports form which data and information will be reviewed and screened. Examples of reports from which data will be utilised include:

1. Oguchi M, Murakami S, Sakanakura H, Kida A, Kameya T. A preliminary categorization of end-of-life electrical and electronic equipment as secondary metal resources. Waste Manag 2011;31(9–10):2150–60, http://dx.doi.org/10.1016/j.wasman.2011.05.009.
2. Huisman J, Magalini F, Kuehr R, Maurer C, Ogilvie S, Poll J, et al. 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE) – Final report [Internet]. Comm. by Eur. Comm. Contract No. 07010401/2006/442493/ETU/G4. United Nations University; 2007. p. 1–347, Available from: http://ec.europa.eu/environment/waste/weee/pdf/final rep unu.pdf
3. Chancerel P, Meskers CEM, Hagelüken C, Rotter VS. Assessment of precious metal flows during preprocessing of waste electrical and electronic equipment. J Ind Ecol [Internet] Wiley Online Library 2009;13(5):791–810, Available from: http://doi.wiley.com/10.1111/j.1530-9290.2009.00171.x
4. EC. Critical raw materials profiles. Report of the ad hoc working group on defining critical raw materials [Internet]. European Commission, DG Entr; 2014a, Available from: http://ec.europa.eu/enterprise/policies/raw-materials/critical/index en.htm

The Bibliography could be maintained for use by the Information Network.

The bibliography has been created using the EndNote software, where a custom ProSUM reference type is generated containing the 'Dublin core' descriptors, as expanded by for instance 'Data Quality' and 'CRM parameter'.

Table 22 – Standard fields from the Dublin-core and additional fields

Standard Dublin-core fields	
1Title	Input/Copy-paste full title of data-source *Specification of this descriptor is quite straightforward.*
2 Subject	Input/Copy-paste key-words of data-source including at least 1 from term-list 'Subject' (Products and Component composition/Stocks&Flows/Waste/General) *Copying the key-words of the data-source will allow a keyword search as well as compiling a list of all key-words in the*

	bibliography for this field. Additionally, 1 term is deemed mandatory from the term-list 'subject' in order to enable WP-leaders to quick-scan bibliography entries of relevance to their WP.
3 Description (Abstract)	Input/Copy-paste abstract or summary of data-source *Specification of this descriptor is quite straightforward. Copying the abstract or summary enables an expanded key-word search.*
4 Type	Select one or more from term-list 'Type' (text/image/etc.) *Specification of this descriptor is quite straightforward.*
5 Source	Specify origin of data-source *Specifying the source of the actual data on CRM's, is intended with this descriptor.*
6 Relation	Select from term-list 'Relation'(Original/Secondary/Compiled) *Specifying 'relation' is chosen to be defined as the internal relation to other documents of a specific data-source: Is it original data, or is based on other data-sources, directly or indirectly. Important references from the reference list may be inserted here as well.*
7 Coverage (Geo)	Select one or more country codes from term list ISO 3166 - alpha 3 for the geographical location of the actual data on CRM's *For ProSUM, geographic information for the data-source itself is irrelevant. It is deemed more useful if this descriptor is used for geographical information of the CRM's.*
8 Creator (Author)	Input/Copy-paste corresponding author *Specification of this descriptor is quite straightforward.*
9 Publisher/Journal /Institution	Input/Copy-paste publisher of data-source (leave blank if confidential) *Specification of this descriptor is quite straightforward.*
10 Contributor (Co-Authors)	Input/Copy-paste contributing authors *Specification of this descriptor is quite straightforward.*
11 Rights	Select from term-list (Copyright, conf., internal use only, etc.) *Specification of this descriptor is quite straightforward.*
12 Date	Input year of publication of data-source *This descriptor refers to the publishing date of the data-source, not the actual CRM data, since a separate descriptor is created for that purpose, see 'years covered' descriptor.*
13 Format	Select from term-list (PDF/WORD/EXCEL/ACCESS/OTHER) *Specification of this descriptor is quite straightforward.*
14 Identifier (DOI/ISBN/URL)	Input/Copy-paste *Specification of this descriptor is quite straightforward. In Endnote, there are three fields for the Identifier descriptor: (DOI/ISBN/URL)*
15 Language	Select from term-list European Language + Jap & CHN *For this descriptor, a short-list of languages is created, being the EU languages expanded with Japanese and Chinese. If another language were to be encountered, manual input is required.*
Additional fields for ProSUM	
16 Data quality	Select from term-list 'Data Quality'. Use 'Data Quality checklist' to determine level of quality. *See section 10 for further explanation*
17 Key (UNU/BAT/ELV/MIN)	Select from term-list Key *Specify all Keys that are represented in the data-source for all 4 categories*
18 Sub-Key	Select from term-list Sub-Key *Specify all Sub-Keys that are represented in the data-source for all 4 categories*

19 Device Type	Select from term-list Sub-Sub-Key *Specify all Sub-Sub-Keys that are represented in the data-source for all 4 categories*
20 Years covered	Input year or year range for actual data on CRM's *Specify the covered years for the context of CRM's within each data-source. This item was added to separate the date of publication and the dates related to actual CRM data*
21 Components	Select from term-list 'Components'
22 Materials	Select from term-list 'Materials'
23 Elements	Select from term-list 'Elements'
24 CRM Parameters	Specify the CRM parameters used in the data-source. The CRM Parameter is defined as: *'measurable factors characterizing products and components on a compositional level with relation to CRM's in (W)EEE'*

25 Stock flow modelling type	Select from following term-list
	• Disposal related analysis
	• Group comparison analysis
	• Time series analysis
	• Factor/correlation models
	• Input-Output Analysis with subtypes:
	  ○ Time Step model
	  ○ Market Supply models
	  ○ Stock and Lifespan model
	  ○ The leaching model.
	
	(Other names are in use in practice)
	• Material Flow Analysis (MFA)
	• Substance Flow analysis (SFA)

26 Flows	Select from term-list 'Flows' for WEEE and BAT: • Reported (in assigned compliance schemes/ national statistics) • Waste Bin • Export for Reuse • Non-compliant Treatment • Scavenged parts For ELV (simplified list, more details in Annex 4): • New vehicles POM • New components POM • Second hand vehicles and components, imported • (note: 2nd hand domestic vehicles and components regarded as maintained in stock) Outflows: • Reported ELV for recovery, domestic (note: can be further divided into recycling, reuse, energy recovery and landfill) • Reported ELV for recovery, exported • Unreported ELV • Reported second hand vehicles and components, exported • Unreported second hand vehicles and components, exported
27 Follow up (optional for internal use in EndNote)	*Input name and action required* *Here it is chosen to have a specific descriptor to enable specific follow-ups for team-members. It is likely that one assessor comes across an interesting data-source relevant for another assessor's work package. This field can thus be searched on actions required by name.*

To harmonise input, term-lists have been created for many descriptors. Not all descriptors are suited for using a term-list, since they require highly variable input, such as ‘title’. The term-lists are provided in Annex 4. One metadata descriptor added for the ProSUM project deserves additional attention: the data quality descriptor. In the early stages of the project, data quality and data accuracy were added to enable the selection of data-sources on quality and accuracy. Progressive insight has led to merging the two, since accuracy is but one parameter of data quality as a whole. The next section dives deeper into the complexity of the data quality descriptor.

A manual has been created to ensure all data input providers classify their data-sources in a similar way, see Annex 4.

11. Data consolidation and data quality

11.1. Harmonising data consolidation steps

Structured Data Consolidation is an essential process for generating useful, trustworthy and transparent information for the users of the EU-UMKDP: data consolidation refers to the collection and integration of multiple data-sources into a single destination facilitating effective data analysis (Techopedia Dictionary, 2010). Multiple data-sources will need to be consolidated into 'single' data points for each of the required outputs, for which data quality assessments are required, filtering out the 'best available' data-sources for each data point. This is a 'one-off' exercise performed during the project to produce structured data. This procedure will be undertaken by experts.

After data quality assessments have been performed the data will consolidated for the databases feeding the EU-UMKDP. For transparency and updating, it is proposed to create separate code lists containing all documents describing each and every data consolidation step. This process of data consolidation will be described through a comprehensive set of rules to ensure internal harmonisation and transparency of the information presented in the EU-UMKDP.

11.2. Data Quality

Since it is expected that multiple assessors will take part in this process, a standardised method of assessing data quality is required. The process for coming to a robust and unbiased assessment of data quality for all relevant data sources has been approached as follows:

1. Define initial categories for data quality

The checklist for assessing data quality is still under development, a preliminary proposal is provided below:

Table 23 – Proposed data quality assessment

	Data quality assessment
1	Data from original experiment?: Yes = +3, No =0
	Data compiled from original experiments?: Yes = +2, No =0
	Data compiled from mixed sources?: Yes = +1, No =0
2	Methodology appropriate and described extensively?: Yes = +2, No =0
	Methodology appropriate?: Yes = +1, No =0
3	Data specified to component, material and element level?: Yes= +3 No= 0
	Data specified to component and material level?: Yes = +2, No =0
	Data specified to component level?: Yes = +1, No =0
4	Are the product and components well specified?: Yes = +2, No =0
5	Is the product well specified?: Yes = +1, No =0
6	Data presented as range?: Yes = +2, No =0
7	Data presented with standard deviation?: Yes = +1, No =0

Here the max nr. of points is 21. This could lead to a pre-selection of high quality data scoring 16-21, and dubious data scoring 0-5, for example:
16-21=HIGHLY CONFIDENT
11-15= CONFIDENT
6-10= LESS CONFIDENT
0-5= DUBIOUS

The checklist above should describe the 'ideal data-source' for the ProSUM project, if all are scored to a maximum. Further work is necessary to finalise this checklist.

2. Appoint (at least two) fully separate and independent assessors that will apply the 'set of rules' to each data source to determine their assessment of data quality.

3. Evaluate all data sources

This is the lengthy process where each and every data-source in the bibliography is evaluated by the assessors.

4. Compare the results of the data quality assessment

To minimise bias, the assessors' results are compared on the score given for data quality. Only if scores are 'far apart', will it require further discussion. Otherwise the initial combined assessment is approved.

5. Assign uncertainties (distributions) to each of the data quality categories

6. Perform Monte Carlo simulations

Data quality is defined as "characteristics of data that relate to their ability to satisfy stated requirements" [ISO 14044]. Data quality evaluates whether the accompanying characteristics are in accordance with the objective: time-related, geographical and technology coverage, precision, completeness, consistency, reproducibility, sources of data and uncertainty (Biemann et al., 2013).

:

12. Conclusions

12.1. Conclusions

Deliverable 5.3 on data harmonisation describes the classification system and the correlation tables that will be used to develop harmonised and standardised data. It provides the foundations of the harvesting system, identifying how the different data/datasets will be integrated in the system depending on their origin (extraction of structured data from an existing provider, compilation and synthesis of scattered raw data), the role of the correlation tables in the ETL process, and the additional data models which it will be necessary to develop. All these data models will allow for the definition of the **ProSUM data organisation** which be used for building the Central Harvesting and Diffusion DBs. This is important preliminary work which will serve to finalise the specifications of the EU-UMKDP and start the development of the platform.

A classification system for each part of the urban mine part, except for ELV and for the compositional properties, has been developed as described. The classification of components and composition properties will be determined and finalised based on the work in later deliverables resulting from Work Package 2 and 4 (Task 2.2, M24 and Task 4.2, M24).

This report sets out the process for correlating and classifying different data sources. Deliverable 5.5 will contain the final code lists and describe the data models which will be built in addition to the existing one (the UNU-based WEEE data model related to EEE products and stocks) to provide data to the EU-UMKDP.

12.2. Recommendations and outlook

A challenge in producing the final code lists and the overall classification system is that products, their flows, composition and materials change over time. This is a key challenge between the Data Platforms for primary and secondary materials. The code lists are constructed to have sufficient flexibility to allow for the inclusion of additional information. Moreover, whereas the MKDP can be updated easily with national reports and statistics, much of the data produced for the UMKDP will be as part of a 'one off' exercise. A further consideration is some parts of the correlation tables will require some form of maintenance e.g. when the CN or PRODOM codes change. This needs considering in Task 6.1.2 to develop a business plan for maintaining and updating the EU-UMKDP. Additional work is required to finalise the classification system for ELVs and components to ensure that development of the detailed code lists and data models are not delayed. This work will be completed by finalising the Deliverables 2.2, 3.1 and 4.1.

The code lists developed for the project will need to go through the IUSG/CGI/GTWG for international validation and acceptance. This process is already under way for the new vocabularies suggested for improving the characterisation section of the mining wastes data model (both new features and new vocabularies).

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Annex 1 ProSUM Detailed Classification Tables

The accompanying Excel file 'Annex_D5 3 1 ProSUM_Classifications.xlsx' contains extra tables, figures and examples used to prepare the classification system. Some are too big to be listed here and others are still under construction and will be updated at a later stage. The following data is present:

- List of UNU keys
- List of UNU sub-keys
- List of Device types
- Link UNU keys to devices
- WasteGroupType codelist
- BatteryType codelist
- BatteryTypeType codelist (this is the ProSUM BAT codelist with correlation of codes to List of Wastes, ProdCom, UN and CNtrade codes)
- BatteryChargeabilityType codelist
- Product (Battery classification linked to UNU keys and ELV keys)
- ProductGroup codelist
- ClassificationBatteryDir (battery directive classification)
- ClassificationLoW (for batteries)
- ClassificationCNTradeCodes (for batteries)
- ClassificationProdCOM (for batteries)
- ClassificationUNTransport (for batteries)
- Vehicles (Vehicle classification)
- ComponentGroupType
- ComponentList
- Link component to device
- MaterialGroupType
- MaterialType
- MaterialList
- Flows WEEE (flow diagram)
- Flows Batteries (flow diagram)
- Flows ELV (flow diagram)
- Elements(rawmaterials)list
- Periodictablerepresentation
- Snapshot of materials list

Annex 2 Classification for WEEE

UNU keys with descriptions and linkage to Original and Recast WEEE Directive (Annex I and III).

Table 24 - List of UNU-Keys and linkage to waste categories

UNU-KEY	Description	Original WEEE Directive Annex I	Recast WEEE Directive Annex III
0001	Central Heating (household installed)	Large Household appliances	large equipment
0002	Photovoltaic Panels (incl. inverters)	Consumer equipment	large equipment
0101	Professional Heating & Ventilation (excl. cooling equipment)	Large Household appliances	large equipment
0102	Dishwashers	Large Household appliances	large equipment
0103	Kitchen (e.g. large furnaces, ovens, cooking equipment)	Large Household appliances	large equipment
0104	Washing Machines (incl. combined dryers)	Large Household appliances	large equipment
0105	Dryers (wash dryers, centrifuges)	Large Household appliances	large equipment
0106	Household Heating & Ventilation (e.g. hoods, ventilators, space heaters)	Large Household appliances	large equipment
0108	Fridges (incl. combi-fridges)	Large Household appliances	temperature exchange equipment
0109	Freezers	Large Household appliances	temperature exchange equipment
0111	Air Conditioners (household installed and portable)	Large Household appliances	temperature exchange equipment
0112	Other Cooling (e.g. dehumidifiers, heat pump dryers)	Large Household appliances	temperature exchange equipment
0113	Professional Cooling (e.g. large air conditioners, cooling displays)	Large Household appliances	temperature exchange equipment
0114	Microwaves (incl. combined, excl. grills)	Large Household appliances	small equipment
0201	Other Small Household (e.g. small ventilators, irons, clocks, adapters)	Small Household appliances	small equipment
0202	Food (e.g. toaster, grills, food processing, frying pans)	Small Household appliances	small equipment
0203	Hot Water (e.g. coffee, tea, water cookers)	Small Household appliances	small equipment
0204	Vacuum Cleaners (excl. professional)	Small Household appliances	small equipment
0205	Personal Care (e.g. tooth brushes, hair dryers, razors)	Small Household appliances	small equipment
0301	Small IT (e.g. routers, mice, keyboards, external drives & accessories)	IT and telecommunications equipment	small equipment
0302	Desktop PCs (excl. monitors, accessoires)	IT and telecommunications equipment	small equipment
0303	Laptops (incl. tablets)	IT and telecommunications equipment	screens and monitors (referred to as screens)

0304	Printers (e.g. scanners, multi functionals, faxes)	IT and telecommunications equipment	small IT and telecommunication equipment with an external dimension of less than 50 cm
0305	Telecom (e.g. (cordless) phones, answering machines)	IT and telecommunications equipment	small IT and telecommunication equipment with an external dimension of less than 50 cm
0306	Mobile Phones (incl. smartphones, pagers)	IT and telecommunications equipment	small IT and telecommunication equipment with an external dimension of less than 50 cm
0307	Professional IT (e.g. servers, routers, data storage, copiers)	IT and telecommunications equipment	large equipment
0308	Cathode Ray Tube Monitors	IT and telecommunications equipment	screens and monitors (referred to as screens)
0309	Flat Display Panel Monitors (LCD, LED)	IT and telecommunications equipment	screens and monitors (referred to as screens)
0401	Small Consumer Electronics (e.g. headphones, remote controls)	Consumer equipment	small equipment
0402	Portable Audio & Video (e.g. MP3, e-readers, car navigation)	Consumer equipment	small equipment
0403	Music Instruments, Radio, Hi-Fi (incl. audio sets)	Consumer equipment	small equipment
0404	Video (e.g. Video recorders, DVD, Blue Ray, set-top boxes)	Consumer equipment	small equipment
0405	Speakers	Consumer equipment	small equipment
0406	Cameras (e.g. camcorders, photo & digital still cameras)	Consumer equipment	small equipment
0407	Cathode Ray Tube TVs	Consumer equipment	screens and monitors (referred to as screens)
0408	Flat Display Panel TVs (LCD, LED, Plasma)	Consumer equipment	screens and monitors (referred to as screens)
0501	Small lighting equipment (excl. LED & incandescent)	Lighting equipment	small equipment
0502	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)	Lighting equipment	lamps
0503	Straight Tube Fluorescent Lamps	Lighting equipment	lamps
0504	Special Lamps (e.g. professional mercury, high & low pressure sodium)	Lighting equipment	lamps
0505	LED Lamps (incl. retrofit LED lamps)	Lighting equipment	lamps
0506	Household Luminaires (incl. household incandescent fittings & household LED luminaires)	Lighting equipment	small equipment
0507	Professional Luminaires (offices, public space, industry)	Lighting equipment	small equipment
0601	Household Tools	Electrical and electronic tools (with the exception of	small equipment

	(e.g. drills, saws, high pressure cleaners, lawn mowers)	large-scale stationary industrial tools)	
0602	Professional Tools (e.g. for welding, soldering, milling)	Electrical and electronic tools (with the exception of large-scale stationary industrial tools)	large equipment
0701	Toys (e.g. car racing sets, electric trains, music toys, biking computers)	Toys, leisure and sports equipment	small equipment
0702	Game Consoles	Toys, leisure and sports equipment	small IT and telecommunication equipment with an external dimension of less than 50 cm
0703	Leisure (e.g. large exercise, sports equipment)	Toys, leisure and sports equipment	large equipment
0801	Household Medical (e.g. thermometers, blood pressure meters)	Medical devices (with the exception of all implanted and infected products)	small equipment
0802	Professional Medical (e.g. hospital, dentist, diagnostics)	Medical devices (with the exception of all implanted and infected products)	large equipment
0901	Household Monitoring & Control (alarm, heat, smoke, excl. screens)	Monitoring and control instruments	small equipment
0902	Professional Monitoring & Control (e.g. laboratory, control panels)	Monitoring and control instruments	large equipment
1001	Non Cooled Dispensers (e.g. for vending, hot drinks, tickets, money)	Automatic dispensers	large equipment
1002	Cooled Dispensers (e.g. for vending, cold drinks)	Automatic dispensers	temperature exchange equipment

The UNU keys are subdivided into smaller groups to identify products subgroups. These UNU sub-keys are listed in the accompanying Excel file. See Annex 1.

Annex 3 Mining wastes in the M4EU database and INSPIRE V3.0 data model and code lists

Introduction

In Minerals 4EU, the INSPIRE mineral resources core (version 3.0) and extension model (version 2.0) (http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_MR_v3.0rc3.pdf) for the characterization of mining waste are used. This model is compliant with the Earth Resource ML Version 2 (http://www.earthresourceml.org/earthresourceml/2.0/doc/ERML_HTML_Documentation/).

This model includes information about the geographic position and shape of the waste, waste type, storage type, environmental impact, and the measure of the waste (grade, volume, density). In addition the waste can be linked to information about mining activities that caused the formation of the waste and the material that the waste consists of.

INSPIRE Codelist values were taken from C. Schubert et al. (2014) and for units of measure common SI units were used.

INSPIRE UML model of Mining Waste

The UML model is built up using class inheritance by extension. A generic *MiningFeatureOccurrence* from the INSPIRE core model is extended in the *MiningWaste* class with specific attributes related to mining waste. An instance of *MiningWaste* would contain attribute and associations related to both. It would contain an INSPIRE identifier, a shape, waste type, and other attributes related to mining waste if these data are available. The UML model also shows that each mining activity can produce multiple instances of mining waste, which then should be associated to each other.

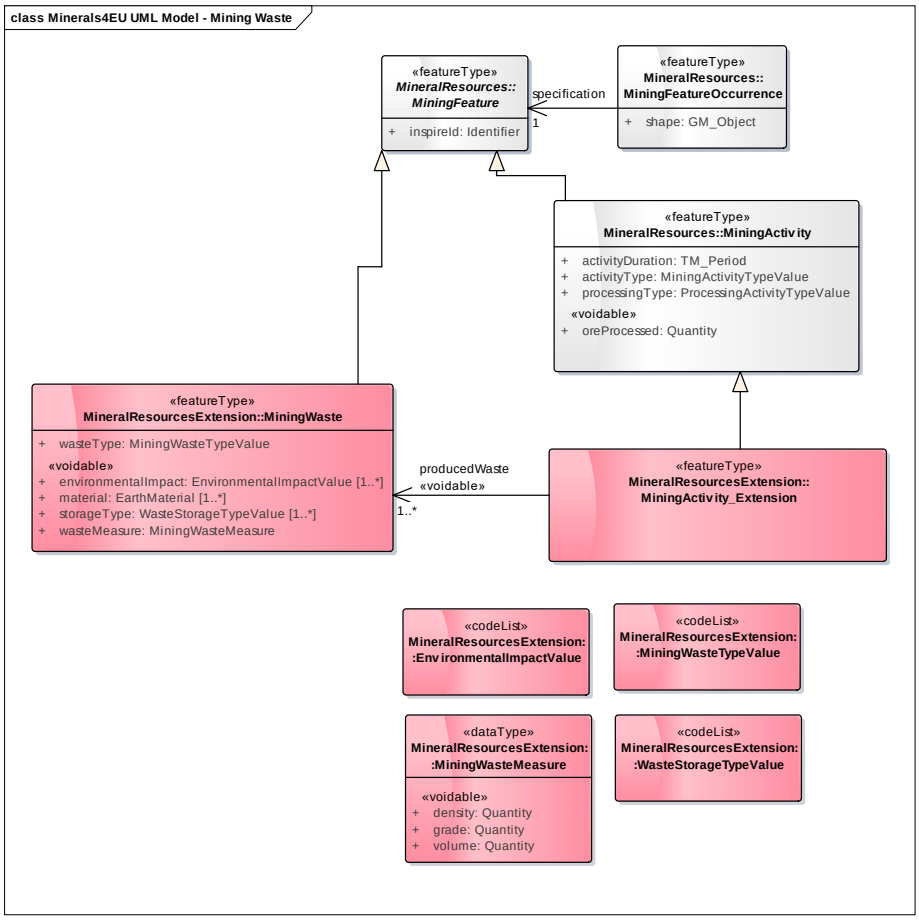


Figure 14- INSPIRE UML model of Mining Waste and related classes.

Code lists in the UML model are postfixed with “Value”, whereas we use “Type” in the database model. Grey classes are from mineral resources core model and red classes are from the mineral resources extension model.

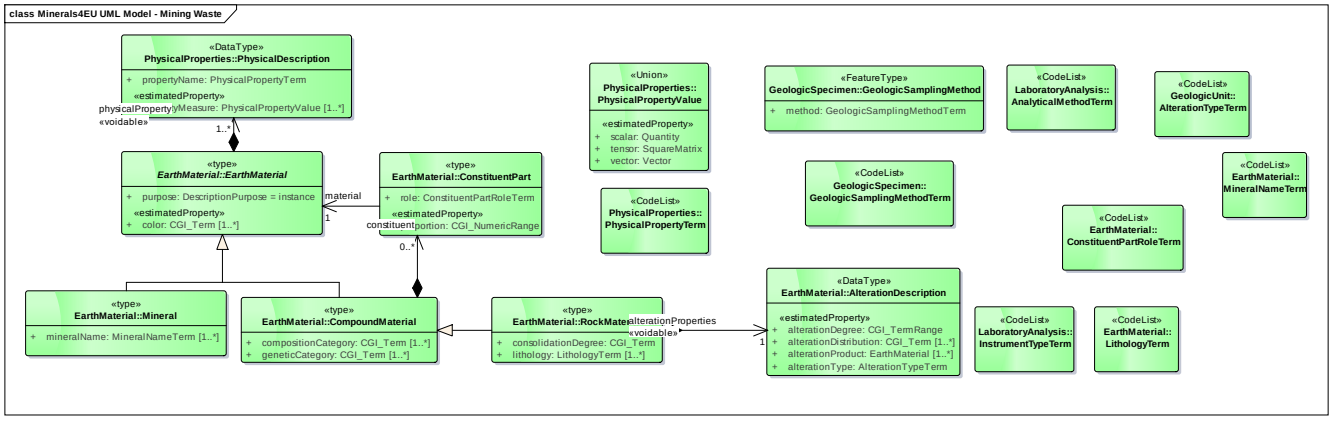


Figure 15- GeoSciML model of Earth Material, which is used to describe the mining waste material.

M4EU database model

In the relational database the tables have the same name as the UML classes. In the model, the *MiningFeature* class is mapped to the *MiningFeatureOccurrence* table which therefore has the columns related to the *InspireId*. A row in the *MiningActivity* table or *MiningWaste* table should

therefore have a row in the *MiningFeatureOccurrence* table. Attributes with the “VoidReason” postfix are related to a particular attribute or relation. For example the *MiningActivity.oreProcessed* attribute has an associated *MiningActivity. oreProcessedVoidReason* attribute. The latter may be filled with a value from the *VoidReasonType* codelist when no data can be provided about the amount of material processed.

The *EarthMaterial* table links to the tables described in Figure 17.

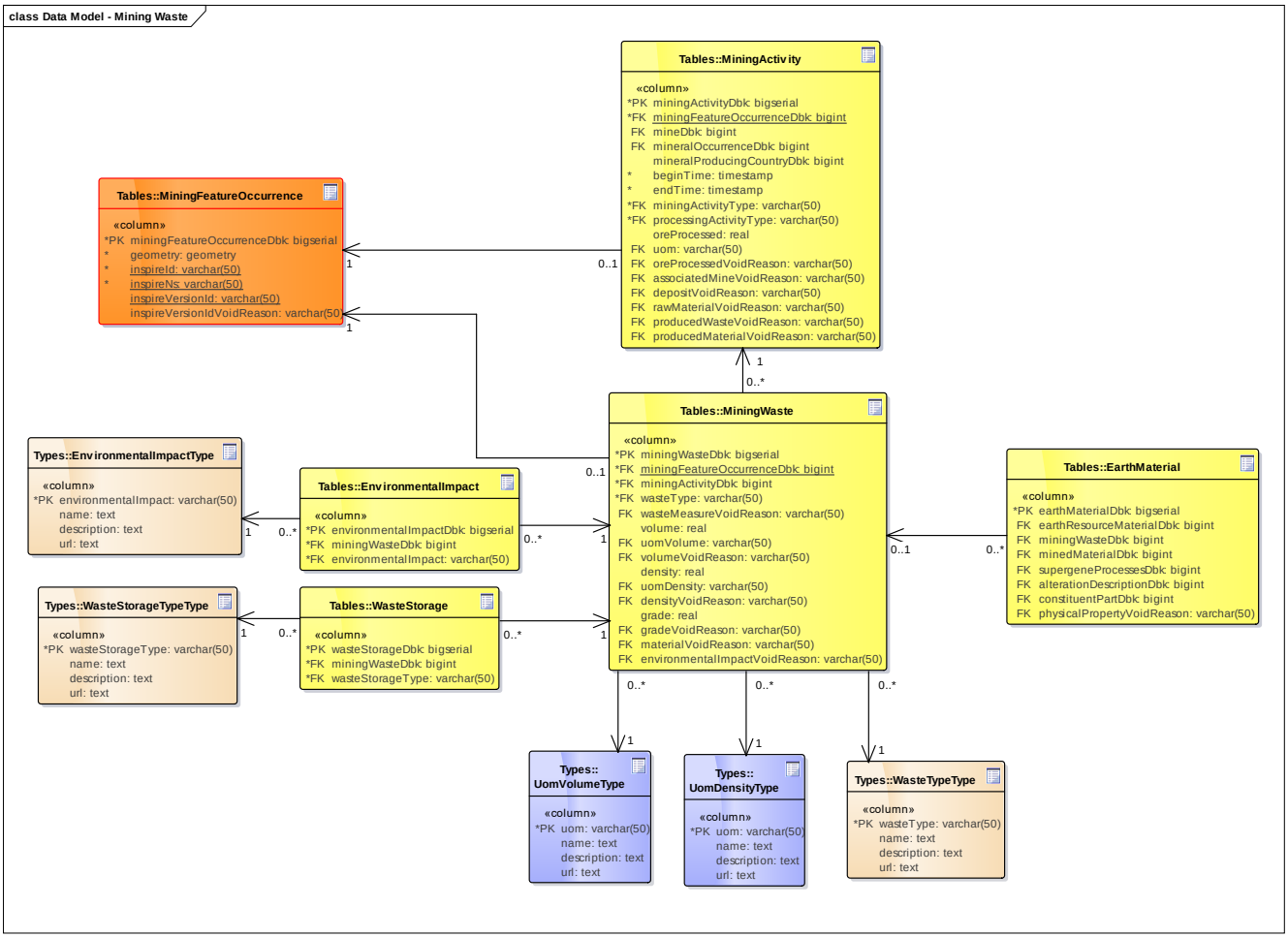


Figure 16 - Mining Waste Database model from the M4EU database modelled after the INSPIRE UML model

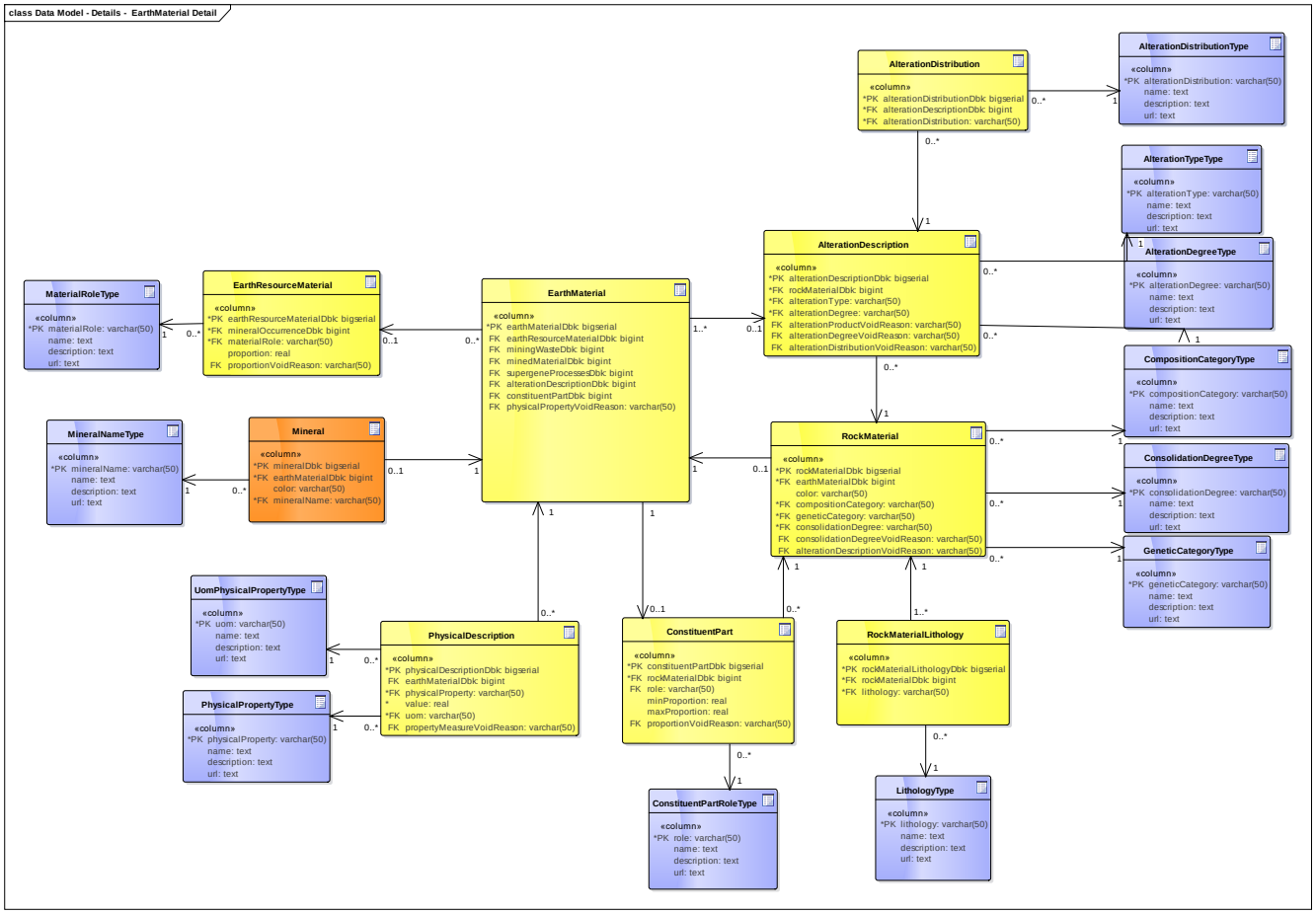


Figure 17- Database model of the Earth material type

Mapping between UML model and Database model

To give more detailed information on the mapping between the UML model and the Database model Table 1 has further details.

Table 25 - Mapping table between INSPIRE UML model and M4EU relational database model for mining waste

UML Class	UML attribute	M	V	Database table	Database attribute	N	Restrictions
MiningWaste (MW)							
MineralResources:: MiningFeature	inspireId	1		MiningWaste	inspireId	x	
		1		MiningWaste	inspireNs	x	
		0-1	x	MiningWaste	inspireVersionId		
MineralResourcesExtension:: MiningWaste	wasteType	1		MiningWaste	wasteType		
MineralResourcesExtension:: MiningWaste	storageType	1-*	x	*WasteStorage*			
MineralResourcesExtension:: MiningWaste	material	1-*	x	*EarthMaterial*			Material is implemented as a RockMaterial or Mineral
MineralResourcesExtension:: MiningWaste	wasteMeasure	1	x	MiningWaste	volume		

				MiningWaste	uomVolume	
				MiningWaste	density	
				MiningWaste	uomDensity	
				MiningWaste	grade	Uom is constant ('percentage')
MineralResourcesExtension::MiningWaste	environmentalImpact	1-*	x	*EnvironmentalImpact*		
MiningFeatureOccurence (MFO)						
MineralResources::MiningFeatureOccurrence	shape	1		MiningFeatureOccurrence	geometry	

M = multiplicity, V = voidable, N = Nullable. No mapping is given for the EarthMaterial table and related tables.

Code lists

Apart from the code lists mentioned in the UML model (see section X2 above), the database also includes code lists for units of measure, which currently hold values from common SI units (*UomVolumeType*, *UomDensityType*) waste measure grade is currently taken to be in (%). The *VoidReasonType* codelist (see section X2) is used to map the voidable stereotype to. In INSPIRE it is recommended to provide reasons why certain data cannot be provided.

Table 26 - Unit of measure for volume

UomVolumeType	http://www.minerals4eu.eu/codeList/UomVolumeType/		
Code	Name	description	url
km3	km3		http://www.minerals4eu.eu/codeList/UomVolumeType/km3
m3	m3		http://www.minerals4eu.eu/codeList/UomVolumeType/m3

Table 27 - units of measure for density of mining waste

UomDensityType	http://www.minerals4eu.eu/codeList/UomDensityType/		
Code	Name	description	url
gcm3	g/cm3		http://www.minerals4eu.eu/codeList/UomDensityType/gcm3
kgm3	kg/m3		http://www.minerals4eu.eu/codeList/UomDensityType/kgm3
tm3	t/m3		http://www.minerals4eu.eu/codeList/UomDensityType/tm3

Annex 4 Metadata descriptors and term-lists

This section introduces the 15 mandatory Dublin Core descriptors selected for the project. The descriptions in this section are taken from www.dublincore.org. Specific use of these metadata descriptors for the ProSUM project is explained in chapter 10, since some Dublin Core descriptors are quite open to interpretation.

Metadata definitions

1. Title

The name given to the resource. Typically, a Title will be a name by which the resource is formally known.

2. Subject

The topic of the content of the resource. Typically, a Subject will be expressed as keywords or key phrases or classification codes that describe the topic of the resource.

3. Description

An account of the content of the resource. Description may include but is not limited to: an abstract, table of contents, reference to a graphical representation of content or a free-text account of the content.

4. Type

The nature or genre of the content of the resource. Type includes terms describing general categories, functions, genres, or aggregation levels for content. Recommended best practice is to select a value from a controlled vocabulary (for example, the DCMIType vocabulary). To describe the physical or digital manifestation of the resource, use the FORMAT element.

5. Source

A Reference to a resource from which the present resource is derived. The present resource may be derived from the Source resource in whole or part. Recommended best practice is to reference the resource by means of a string or number conforming to a formal identification system.

6. Relation

A reference to a related resource. Recommended best practice is to reference the resource by means of a string or number conforming to a formal identification system.

7. Coverage

The extent or scope of the content of the resource. Coverage will typically include spatial location (a place name or geographic co-ordinates), temporal period (a period label, date, or date range) or jurisdiction (such as a named administrative entity). Recommended best practice is to select a value from a controlled vocabulary (for example, the Thesaurus of Geographic Names [Getty Thesaurus of Geographic Names, http://www.getty.edu/research/tools/vocabulary/tgn/]). Where appropriate, named places or time periods should be used in preference to numeric identifiers such as sets of co-ordinates or date ranges.

8. Creator

An entity primarily responsible for making the content of the resource. Examples of a Creator include a person, an organization, or a service. Typically the name of the Creator should be used to indicate the entity.

9. Publisher

The entity responsible for making the resource available. Examples of a Publisher include a person, an organization, or a service. Typically, the name of a Publisher should be used to indicate the entity.

10. Contributor
An entity responsible for making contributions to the content of the resource. Examples of a Contributor include a person, an organization or a service. Typically, the name of a Contributor should be used to indicate the entity.

11. Rights
Information about rights held in and over the resource. Typically a Rights element will contain a rights management statement for the resource, or reference a service providing such information. Rights information often encompasses Intellectual Property Rights (IPR), Copyright, and various Property Rights. If the rights element is absent, no assumptions can be made about the status of these and other rights with respect to the resource.

12. Date
A date associated with an event in the life cycle of the resource. Typically, Date will be associated with the creation or availability of the resource. Recommended best practice for encoding the date value is defined in a profile of ISO 8601 [Date and Time Formats, W3C Note, http://www.w3.org/TR/NOTE- datetime] and follows the YYYY-MM-DD format.

13. Format
The physical or digital manifestation of the resource. Typically, Format may include the media-type or dimensions of the resource. Examples of dimensions include size and duration. Format may be used to determine the software, hardware or other equipment needed to display or operate the resource.
Recommended best practice is to select a value from a controlled vocabulary (for example, the list of Internet Media Types [http://www.iana.org/ assignments/media-types/] defining computer media formats).

14. Identifier
An unambiguous reference to the resource within a given context. Recommended best practice is to identify the resource by means of a string or number conforming to a formal identification system. Examples of formal identification systems include the Uniform Resource Identifier (URI) (including the Uniform Resource Locator (URL), the Digital Object Identifier (DOI) and the International Standard Book Number (ISBN).

15. Language
A language of the intellectual content of the resource. Recommended best practice for the values of the Language element is defined by RFC 3066 [RFC 3066, http://www.ietf.org/rfc/ rfc3066.txt] which, in conjunction with ISO 639 [ISO 639, http://www.oasis- open.org/cover/iso639a.html]), defines two- and three-letter primary language tags with optional subtags. Examples include ‘en’ or ‘eng’ for English, ‘akk’ for Akkadian, and ‘en-GB’ for English used in the United Kingdom.

1. Title

Label: Title
Element Description: The name given to the resource. Typically, a Title will be a name by which the resource is formally known.

Guidelines for creation of content:
If in doubt about what constitutes the title, repeat the Title element and include the variants in second and subsequent Title iterations. If the item is in HTML, view the source document and make sure that the title identified in the title header (if any) is also included as a Title.

Examples:
Title=‘A Pilot's Guide to Aircraft Insurance’
Title=‘The Sound of Music’

Title='Green on Greens'
Title='AOPA's Tips on Buying Used Aircraft'

2. Subject

Label: Subject and Keywords

Element Description: The topic of the content of the resource. Typically, a Subject will be expressed as keywords or key phrases or classification codes that describe the topic of the resource. Recommended best practice is to select a value from a controlled vocabulary or formal classification scheme.

Guidelines for creation of content:
Select subject keywords from the Title or Description information, or from within a text resource. If the subject of the item is a person or an organization, use the same form of the name as you would if the person or organization were a Creator or Contributor.

In general, choose the most significant and unique words for keywords, avoiding those too general to describe a particular item. Subject might include classification data if it is available (for example, Library of Congress Classification Numbers or Dewey Decimal numbers) or controlled vocabularies (such as Medical Subject Headings or Art and Architecture Thesaurus descriptors) as well as keywords.

When including terms from multiple vocabularies, use separate element iterations. If multiple vocabulary terms or keywords are used, either separate terms with semi-colons or use separate iterations of the Subject element.

Examples:
Subject='Aircraft leasing and renting'
Subject='Dogs'
Subject='Olympic skiing'
Subject='Street, Picabo'

3. Description

Label: Description

Element Description: An account of the content of the resource. Description may include but is not limited to: an abstract, table of contents, reference to a graphical representation of content or a free-text account of the content.

Guidelines for creation of content:
Since the Description field is a potentially rich source of indexable terms, care should be taken to provide this element when possible. Best practice recommendation for this element is to use full sentences, as description is often used to present information to users to assist in their selection of appropriate resources from a set of search results.

Descriptive information can be copied or automatically extracted from the item if there is no abstract or other structured description available. Although the source of the description may be a web page or other structured text with presentation tags, it is generally not good practice to include HTML or other structural tags within the Description element. Applications vary considerably in their ability to interpret such tags, and their inclusion may negatively affect the interoperability of the Metadata.

Examples:

Description='Illustrated guide to airport markings and lighting signals, with particular reference to SMGCS (Surface Movement Guidance and Control System) for airports with low visibility conditions.'

Description='Teachers Domain is a multimedia library for K-12 science educators, developed by WGBH through funding from the National Science Foundation as part of its National Science Digital Library initiative. The site offers a wealth of classroom-ready instructional resources, as well as online professional development materials and a set of tools which allows teachers to manage, annotate, and share the materials they use in classroom teaching.'

4. Type

Label: Resource Type

Element Description: The nature or genre of the content of the resource. Type includes terms describing general categories, functions, genres, or aggregation levels for content. Recommended best practice is to select a value from a controlled vocabulary (for example, the DCMIType vocabulary). To describe the physical or digital manifestation of the resource, use the FORMAT element.

Guidelines for content creation:
If the resource is composed of multiple mixed types then multiple or repeated Type elements should be used to describe the main components.

Because different communities or domains are expected to use a variety of type vocabularies, best practice to ensure interoperability is to include at least one general type term from the DCMIType vocabulary in addition to the domain specific type term(s), in separate Type element iterations.

Examples:
Type='Image'
Type='Sound'
Type='Text'
Type='simulation'

Note: The first three values are taken from the DCMI Type Vocabulary, and follow the capitalization conventions for that vocabulary. The last value is a term from an unspecified source.

The item described is an Electronic art exhibition catalog:
Type='Image'
Type='Text'
Type='Exhibition catalog'

Note: The first two values are taken from the DCMI Type Vocabulary, and follow the capitalization conventions for that vocabulary. The last value is a term from an unspecified source.

The item described is a Multimedia educational program with interactive assignments:
Type='Image'
Type='Text'
Type='Software'
Type='InteractiveResource'

Note: All values in this example are taken from the DCMI Type Vocabulary, and follow the capitalization conventions for that vocabulary.

5. Source

Label: Source

Element Description: A Reference to a resource from which the present resource is derived. The present resource may be derived from the Source resource in whole or part. Recommended best practice is to reference the resource by means of a string or number conforming to a formal identification system.

Guidelines for content creation:
In general, include in this area information about a resource that is related intellectually to the described resource but does not fit easily into a Relation element.

Examples:
Source='RC607.A26W574 1996' [where 'RC607.A26W574 1996' is the call number of the print version of the resource, from which the present version was scanned]

Source='Image from page 54 of the 1922 edition of Romeo and Juliet'

6. Relation

Label: Relation

Element Description: A reference to a related resource. Recommended best practice is to reference the resource by means of a string or number conforming to a formal identification system.

Guidelines for content creation:
Relationships may be expressed reciprocally (if the resources on both ends of the relationship are being described) or in one direction only, even when there is a refinement available to allow reciprocity. If text strings are used instead of identifying numbers, the reference should be appropriately specific. For instance, a formal bibliographic citation might be used to point users to a particular resource.

Because the refined terms used with Relation provide significantly more information to a user than the unqualified use of Relation, implementers who are describing heavily interrelated resources might choose to use qualified Dublin Core.

Examples:
Title='Reading Turgenev'
Relation='Two Lives' [Resource is a collection of two novellas, one of which is 'Reading Turgenev']
[Relationship described is IsPartOf.

[Part/Whole relations are those in which one resource is a physical or logical part of another]

Title='Candle in the Wind'
Subject='Diana, Princess of Wales'
Date='1997'
Creator='John, Elton'
Type='sound'
Description='Tribute to a dead princess.'
Relation='Elton John's 1976 song Candle in the Wind'
[Relationship described is IsVersionOf.

[Version relations are those in which one resource is an historical state or edition, of another resource by the same creator]

Title='Electronic AACR2'
Relation='Anglo-American Cataloging Rules, 2nd edition'

[Relationship described is IsFormatOf]

Title='Landsat TM dataset of Arnhemland, NT, Australia'
Relation='arnhem.gif'
[Relationship described is HasFormat]

[Format transformation relations are those in which one resource has been derived from another by a reproduction or reformatting technology which is not fundamentally an interpretation but intended to be a representation.]

Title='Morgan's Ancient Society'
Relation='Engels' Origin of the Family, Private Property and the State'
[Relationship described is IsReferencedBy]

Title='Nymphet Mania'
Relation='References Adrian Lyne's 'Lolita''
[Relationship described is References]

[Reference relations are those in which the author of one resource cites, acknowledges, disputes or otherwise make claims about another resource.]

Title='Peter Carey's novel Oscar and Lucinda'
Relation='1998 movie Oscar and Lucinda'
[Relationship described is IsBasisFor]

Title='The movie My Fair Lady'
Relation='Shaw's play Pygmalion'
[Relationship described is IsBasedOn]

[Creative relations are those in which one resource is a performance, production, derivation, adaptation or interpretation of another resource.]

Title='Dead Ringer'
Relation='Gemstar e-book'
[Relationship described is Requires]

[Dependency relations are those in which one resource requires another resource for its functioning, delivery, or content and cannot be used without the related resource being present.]

7. Coverage

Label: Coverage

Element Description: The extent or scope of the content of the resource. Coverage will typically include spatial location (a place name or geographic co-ordinates), temporal period (a period label, date, or date range) or jurisdiction (such as a named administrative entity). Recommended best practice is to select a value from a controlled vocabulary (for example, the Thesaurus of Geographic Names [Getty Thesaurus of Geographic Names, http://www.getty.edu/research/tools/vocabulary/tgn/]). Where appropriate, named places or time periods should be used in preference to numeric identifiers such as sets of co-ordinates or date ranges.

Guidelines for content creation:
Whether this element is used for spatial or temporal information, care should be taken to provide consistent information that can be interpreted by human users, particularly in order to provide interoperability in situations where sophisticated geographic or time-specific searching is not supported. For most simple applications, place names or coverage dates might be most useful. For

more complex applications, consideration should be given to using an encoding scheme that supports appropriate specification of information, such as DCMI Period, DCMI Box or DCMI Point.

Examples:
Coverage='1995-1996'
Coverage='Boston, MA'
Coverage='17th century'
Coverage='Upstate New York'

8. Creator

Label: Creator

Element Description: An entity primarily responsible for making the content of the resource. Examples of a Creator include a person, an organization, or a service. Typically the name of the Creator should be used to indicate the entity.

Guidelines for creation of content:
Creators should be listed separately, preferably in the same order that they appear in the publication. Personal names should be listed surname or family name first, followed by forename or given name. When in doubt, give the name as it appears, and do not invert.

In the case of organizations where there is clearly a hierarchy present, list the parts of the hierarchy from largest to smallest, separated by full stops and a space. If it is not clear whether there is a hierarchy present, or unclear which is the larger or smaller portion of the body, give the name as it appears in the item.

If the Creator and Publisher are the same, do not repeat the name in the Publisher area. If the nature of the responsibility is ambiguous, the recommended practice is to use Publisher for organizations, and Creator for individuals. In cases of lesser or ambiguous responsibility, other than creation, use Contributor.

Examples:
Creator='Shakespeare, William'
Creator='Wen Lee'
Creator='Hubble Telescope'
Creator='Internal Revenue Service. Customer Complaints Unit'

9. Publisher

Label: Publisher

Element Description: The entity responsible for making the resource available. Examples of a Publisher include a person, an organization, or a service. Typically, the name of a Publisher should be used to indicate the entity.

Guidelines for content creation:
The intent of specifying this field is to identify the entity that provides access to the resource. If the Creator and Publisher are the same, do not repeat the name in the Publisher area. If the nature of the responsibility is ambiguous, the recommended practice is to use Publisher for organizations, and Creator for individuals. In cases of ambiguous responsibility, use Contributor.

Examples:
Publisher='University of South Where'
Publisher='Funky Websites, Inc.'
Publisher='Carmen Miranda'

10. Contributor

Label: Contributor

Element Description: An entity responsible for making contributions to the content of the resource. Examples of a Contributor include a person, an organization or a service. Typically, the name of a Contributor should be used to indicate the entity.

Guideline for content creation:
The same general guidelines for using names of persons or organizations as Creators apply here. Contributor is the most general of the elements used for 'agents' responsible for the resource, so should be used when primary responsibility is unknown or irrelevant.

11. Rights

Label: Rights Management

Element Description: Information about rights held in and over the resource. Typically a Rights element will contain a rights management statement for the resource, or reference a service providing such information. Rights information often encompasses Intellectual Property Rights (IPR), Copyright, and various Property Rights. If the rights element is absent, no assumptions can be made about the status of these and other rights with respect to the resource.

Guidelines for content creation:
The Rights element may be used for either a textual statement or a URL pointing to a rights statement, or a combination, when a brief statement and a more lengthy one are available.

Examples:
Rights='Access limited to members'
Rights='http://cs-tr.cs.cornell.edu/Dienst/Repository/2.0/Terms& quot;

12. Date

Label: Date

Element Description: A date associated with an event in the life cycle of the resource. Typically, Date will be associated with the creation or availability of the resource. Recommended best practice for encoding the date value is defined in a profile of ISO 8601 [Date and Time Formats, W3C Note, http://www.w3.org/TR/NOTE- datetime] and follows the YYYY-MM-DD format.

Guidelines for content creation:
If the full date is unknown, month and year (YYYY-MM) or just year (YYYY) may be used. Many other schemes are possible, but if used, they may not be easily interpreted by users or software.

Examples:
Date='1998-02-16'
Date='1998-02'
Date='1998'

13. Format

Label: Format

Element Description: The physical or digital manifestation of the resource. Typically, Format may include the media-type or dimensions of the resource. Examples of dimensions include size and duration. Format may be used to determine the software, hardware or other equipment needed to display or operate the resource.

Recommended best practice is to select a value from a controlled vocabulary (for example, the list of Internet Media Types [http://www.iana.org/ assignments/media-types/] defining computer media formats).

Guidelines for content creation:
In addition to the specific physical or electronic media format, information concerning the size of a resource may be included in the content of the Format element if available. In resource discovery size, extent or medium of the resource might be used as a criterion to select resources of interest, since a user may need to evaluate whether they can make use of the resource within the infrastructure available to them.

When more than one category of format information is included in a single record, they should go in separate iterations of the element.

Examples:
Title='Dublin Core icon'
Identifier='http://purl.org/Metadata/dublin_core/images/dc2.gif& quot;
Type='Image'
Format='image/gif'
Format='4 kB'

Subject='Saturn'
Type='Image'
Format='image/gif 6'
Format='40 x 512 pixels'
Identifier='http://www.not.iac.es/newwww/photos/images/satnot.gif '

Title='The Bronco Buster'
Creator='Frederic Remington'
Type='Physical object'
Format='bronze'
Format='22 in.'

14. Identifier

Label: Resource Identifier

Element Description: An unambiguous reference to the resource within a given context. Recommended best practice is to identify the resource by means of a string or number conforming to a formal identification system. Examples of formal identification systems include the Uniform Resource Identifier (URI) (including the Uniform Resource Locator (URL), the Digital Object Identifier (DOI) and the International Standard Book Number (ISBN).

Guidelines for content creation:
This element can also be used for local identifiers (e.g. ID numbers or call numbers) assigned by the Creator of the resource to apply to a particular item. It should not be used for identification of the Metadata record itself.

Examples:
Identifier='http://purl.oclc.org/Metadata/dublin_core/& quot;
Identifier='ISBN:0385424728'
Identifier='H-A-X 5690B' [publisher number]

15. Language

Label: Language

Element Description: A language of the intellectual content of the resource. Recommended best practice for the values of the Language element is defined by RFC 3066 [RFC 3066, http://www.ietf.org/rfc/ rfc3066.txt] which, in conjunction with ISO 639 [ISO 639, http://www.oasis- open.org/cover/iso639a.html]), defines two- and three-letter primary language tags with optional subtags. Examples include 'en' or 'eng' for English, 'akk' for Akkadian, and 'en-GB' for English used in the United Kingdom.

Guidelines for content creation:
Either a coded value or text string can be represented here. If the content is in more than one language, the element may be repeated.

Examples:
Language='en'
Language='fr'
Language='Primarily English, with some abstracts also in French.'
Language='en-US'

Table of Metadata descriptors for ProSUM

Table 28 - Table of Metadata descriptors for ProSUM

1Title	Input/Copy-paste full title of data-source *Specification of this descriptor is quite straightforward.*
2 Subject	Input/Copy-paste key-words of data-source including at least 1 from term-list 'Subject' (Products and Component composition/Stocks&Flows/Waste/General) *Copying the key-words of the data-source will allow a keyword search as well as compiling a list of all key-words in the bibliography for this field. Additionally, 1 term is deemed mandatory from the term-list 'subject' in order to enable WP-leaders to quick-scan bibliography entries of relevance to their WP.*
3 Description (Abstract)	Input/Copy-paste abstract or summary of data-source *Specification of this descriptor is quite straightforward. Copying the abstract or summary enables an expanded key-word search.*
4 Type	Select one or more from term-list 'Type' (text/image/etc.) *Specification of this descriptor is quite straightforward.*
5 Source	Specify origin of data-source *Specifying the source of the actual data on CRM's, is intended with this descriptor.*
6 Relation	Select from term-list 'Relation'(Original/Secondary/Compiled) *Specifying 'relation' is chosen to be defined as the internal relation to other documents of a specific data-source: Is it original data, or is based on other data-sources, directly or indirectly. Important references from the reference list may be inserted here as well.*
7 Coverage (Geo)	Select one or more country codes from term list ISO 3166 - alpha 3 for the geographical location of the actual data on CRM's *For ProSUM, geographic information for the data-source itself is irrelevant. It is deemed more useful if this descriptor is used for geographical information of the CRM's.*
8 Creator (Author)	Input/Copy-paste corresponding author *Specification of this descriptor is quite straightforward.*
9 Publisher/Journal/Institution	Input/Copy-paste publisher of data-source (leave blank if confidential) *Specification of this descriptor is quite straightforward.*
10 Contributor (Co-Authors)	Input/Copy-paste contributing authors *Specification of this descriptor is quite straightforward.*
11 Rights	Select from term-list (Copyright, conf., internal use only, etc.) *Specification of this descriptor is quite straightforward.*
12 Date	Input year of publication of data-source

	This descriptor refers to the publishing date of the data-source, not the actual CRM data, since a separate descriptor is created for that purpose, see 'years covered' descriptor.
13 Format	Select from term-list (PDF/WORD/EXCEL/ACCESS/OTHER) *Specification of this descriptor is quite straightforward.*
14 Identifier (DOI/ISBN/URL)	Input/Copy-paste *Specification of this descriptor is quite straightforward. In Endnote, there are three fields for the Identifier descriptor: (DOI/ISBN/URL)*
15 Language	Select from term-list European Language + Jap & CHN *For this descriptor, a short-list of languages is created, being the EU languages expanded with Japanese and Chinese. If another language were to be encountered, manual input is required.*
16 Data quality	Select from term-list 'Data Quality'. Use 'Data Quality checklist' to determine level of quality. *See section 10 for further explanation*
17 Key (UNU/BAT/ELV/MIN)	Select from term-list Key *Specify all Keys that are represented in the data-source for all 4 categories*
18 Sub-Key	Select from term-list Sub-Key *Specify all Sub-Keys that are represented in the data-source for all 4 categories*
19 Sub-sub-Key/Device Type	Select from term-list Sub-Sub-Key *Specify all Sub-Sub-Keys that are represented in the data-source for all 4 categories*
20 Years covered	Input year or year range for actual data on CRM's *Specify the covered years for the context of CRM's within each data-source. This item was added to separate the date of publication and the dates related to actual CRM data*
21 Components	Select from term-list 'Components'
22 Materials	Select from term-list 'Materials'
23 Elements	Select from term-list 'Elements'
24 CRM Parameters	Specify the CRM parameters used in the data-source. The CRM Parameter is defined as: *'measurable factors characterizing products and components on a compositional level with relation to CRM's in (W)EEE'*
25 Stock flow modelling type	Select from term-list 'Stock flow modelling type' • A. Time Step Model • B.i. Market Supply Model (distribution delay) • B. ii. Market Supply Model (simple delay) • B. iii. Market Supply Model (Carnegie Mellon Method) • C. Stock and Lifespan Model • D. Leaching Method *(Other names are in use in practice)*
26 Flows	Select from term-list 'Flows' for WEEE and BAT: • Reported • Waste Bin • Export for Reuse • Non-compliant Treatment • Scavenged parts For ELV (simplified list, more details in Annex 4): • New vehicles POM • New components POM • Second hand vehicles and components, imported • (note: 2nd hand domestic vehicles and components regarded as maintained in stock) Outflows: • Reported ELV for recovery, domestic (note: can be further divided into recycling, reuse, energy recovery and landfill) • Reported ELV for recovery, exported

	• Unreported ELV • Reported second hand vehicles and components, exported • Unreported second hand vehicles and components, exported
27 Follow up	Input name and action required *Here it is chosen to have a specific descriptor to enable specific follow-ups for team-members. It is likely that one assessor comes across an interesting data-source relevant for another assessor's work package. This field can thus be searched on actions required by name.*

Term-list Type

- Text
- Image
- Audio
- Video
- Presentation

Term-list Relation

- Original
- Secondary
- Compiled
- See reference (Specify number)

Term-list Coverage

See alpha-3 country code list in other properties.

Term-list Rights

- Copyright
- Internal Use Only
- Confidential

Term-list Format

- Word
- Excel
- Access
- PDF
- Other

Term-list Language

BG	DE	ET	HR	LT	NO	SK
CS	EL	FI	HU	LV	PL	SL
CN	EN	FR	IT	MT	PT	SV
DA	ES	GA	JA	NL	RO	

Term-list Data Quality

- HIGHLY CONFIDENT
- CONFIDENT
- LESS CONFIDENT
- DUBIOUS

Term-list Key (UNU)

See UNU_key code list in Annex 1

Term-list Key (ELV)

See ELV_key code list in Annex 1

Term-list Key (BAT)

See BAT_key code list in Annex 1

Term-list Key (MIN)

See Chapter 4.

Term-list Components

See component code lists in Annex1

Term-list Composition Properties

See composition properties code lists in Annex 1

Term-list Elements

See elements list in Annex 1 and Annex 5.

Term-list CRM Parameters

- CRM Content
- Speciation
- Product Residence Time

Term-list Stock Flow Modelling Type

- Time Step Model
- B.i. Market Supply Model (distribution delay)
- ii. Market Supply Model (simple delay)
- iii. Market Supply Model (Carnegie Mellon Method)
- Stock and Lifespan Model
- Leaching Method

Term-list Flows

- Reported
- Waste Bin
- Export for Reuse
- Other Recycling
- Scavenged parts

Specific term list for ELV:

Main inflows to stock

- New vehicles POM, domestic
- New vehicles POM, imported
- New components POM, domestic
- New components POM, imported
- Second hand vehicles, imported
  (note: 2nd hand domestic vehicles regarded as maintained in stock)
- Second hand components, imported
  (note: 2nd hand domestic components regarded as maintained in stock)

Main outflows from stock

- Reported ELV for recovery, domestic
  (note: this can be further divided into recycling, reuse, energy recovery and landfill)
- Unreported ELV for recovery, domestic
- Unreported ELV illegal dumping, domestic
- Reported ELV for recovery, exported
- Unreported ELV for recovery, exported
- Reported second hand vehicles, exported
- Unreported second hand vehicles, exported
- Reported second hand components, exported
- Unreported second hand components, exported
- (note: legally hibernated vehicles, i.e. garaged, are regarded as part of stock and not included in list)

Example for the metadata in EndNote:

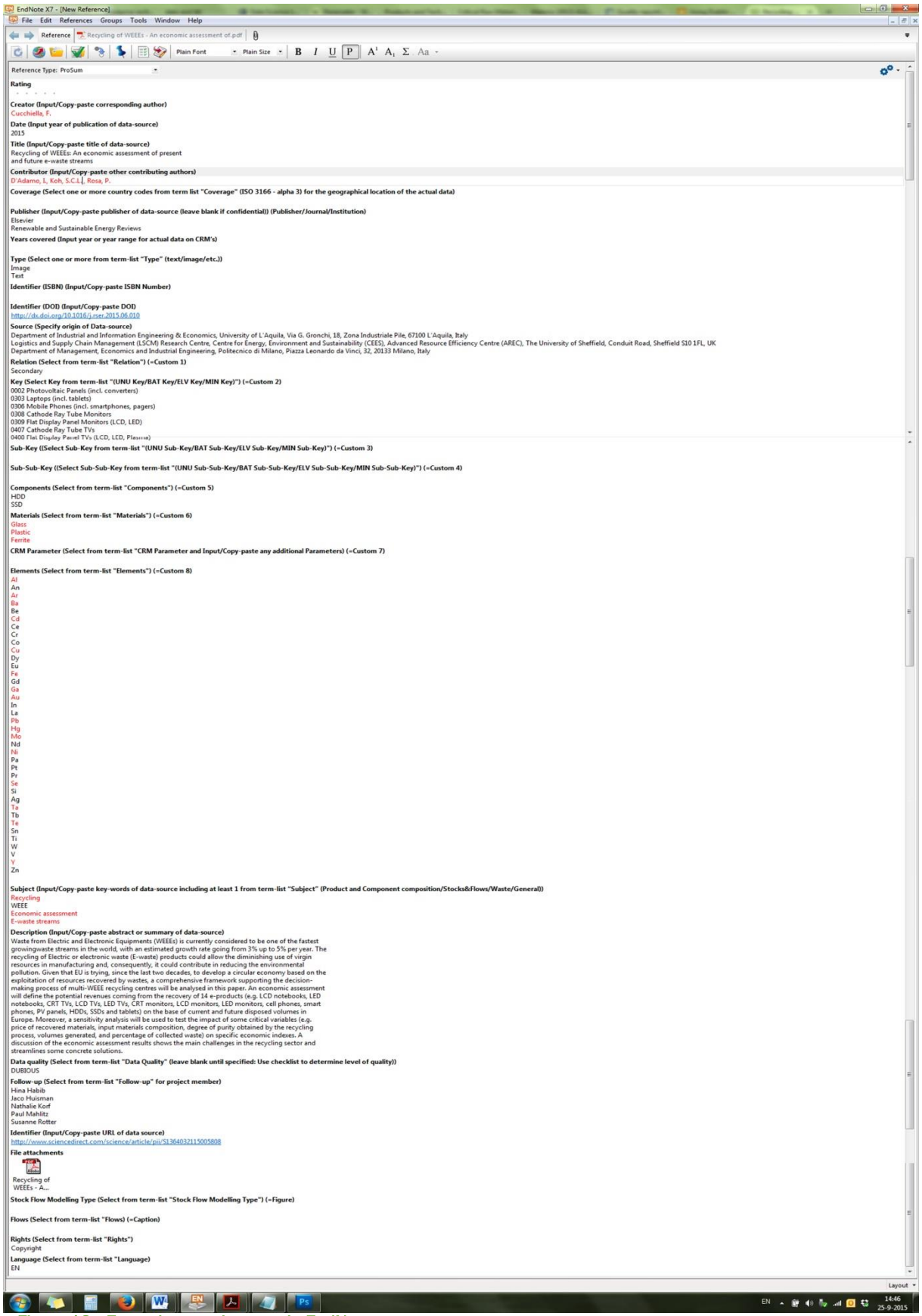


Figure 18 –Example metadata use in EndNote

Annex 5 List of most relevant elements in the ProSUM product scope

Table 29 - List of most relevant elements in the ProSUM product scope

Element (raw material)	Chemical symbol	Family/group	Evaluation/selection criteria						
							Relative annual demand [1)]		
			Critical according to EC 2014	Conflict mineral origin possible	Recovery driver	Challenge for recycling process	*batteries*	*EEE/WEEE*	*vehicles/ELV*
Aluminium	Al		N	N	Y		Low	Medium	High
Antimony	Sb		Y	N		Y	High	Low	High
Argon	Ar		N	N					
Arsenic	As		N	N		Y			
Barium	Ba		N	N			Low	Low	Low
Beryllium	Be		Y	N		Y	Low	High	Low
Bismuth	Bi		N	N		Y			
Boron (Borates)	B		Y	N			Low	Low	Low
Bromine	Br					Y			
Cadmium	Cd		N	N		Y			
Carbon (Natural graphite)	C		Y	N			Medium	Low	Medium
Cerium	Ce	LREE	Y	N			Low	Low	Medium
Cesium	Cs								
Chlorine	Cl					Y			
Chromium	Cr		Y	N		Y (CrVI)	Low	Low	Medium
Cobalt	Co		Y	N	Y		High	Medium	Medium
Copper	Cu		N	N	Y		Low	High	Medium
Dysprosium	Dy	HREE	Y	N			Low	High	High
Erbium	Er	HREE	Y	N			Low	Medium	Low
Europium	Eu	HREE	Y	N			Low	High	Low
Fluorine	Fe					Y			
Gadolinium	Gd	HREE	Y	N			Low	High	Medium
Gallium	Ga		Y	N			Low	High	Medium
Germanium	Ge		Y	N			Low	High	Low
Gold	Au	precious metal	N	Y	Y		Low	Medium	Low
Hafnium	Hf		N	N			Low	Low	Low
Helium	He		N	N					
Holmium	Ho	HREE	Y	N					
Indium	In		Y	N			Medium	High	Low
Iridium	Ir	PGM, precious metal	Y	N			Low	Medium	Low
Iron	Fe		N	N	Y		Low	Low	Medium
Krypton	Kr		N	N					
Lanthanum	La	LREE	Y	N			High	Low	High
Lead	Pb		N	N		Y			
Lithium	Li		N	N			High	Low	Low

Lutetium	Lu	HREE		Y	N					
Magnesium	Mg			Y	N	Y		Low	Low	Medium
Manganese	Mn			N	N			Low	Low	Medium
Mercury	Hg			N	N		Y			
Molybdenum	Mo			N	N			Low	Low	Medium
Neon	Ne			N	N					
Neodymium	Nd	LREE		Y	N			Low	High	High
Nickel	Ni			N	N	Y	Y	Low	Medium	Medium
Niobium	Nb			Y	N			Low	Low	High
Osmium	Os	PGM, metal	precious	Y	N					
Palladium	Pd	PGM, metal	precious	Y	N			Low	Medium	High
Phosphorus (Phosphate rock)	P			Y	N			Low	Low	Low
Platinum	Pt	PGM, metal	precious	Y	N			Low	Medium	High
Praseodymium	Pr	LREE		Y	N			Low	High	High
Rhenium	Re			N	N			Low	Low	Low
Rhodium	Rh	PGM, metal	precious	Y	N			Low	Low	High
Rubidium	Rb			N	N					
Ruthenium	Ru	PGM, metal	precious	Y	N			Low	High	Low
Samarium	Sm	LREE		Y	N			Low	High	High
Scandium	Sc			N	N			Low	Medium	Low
Selenium	Se			N	N			Low	Medium	Low
Silicon (Silicon metal)	Si			Y	N			Low	Medium	High
Silver	Ag	precious metal		N	N	Y		Low	High	Low
Strontium	Sr			N	N					
Tantalum	Ta			N	Y			Low	High	
Tellurium	Te			N	N			Low	High	Low
Terbium	Tb	HREE		Y	N			Low	High	Low
Thallium	Tl			N	N		Y			
Thulium	Tm	HREE		Y	N					
Tin	Sn			N	Y	Y		Low	High	Low
Titanium	Ti			N	N			Low	Low	Low
Tungsten	W			Y	Y			Low	Low	Low
Vanadium	V			N	N			Low	Low	High
Ytterbium	Yb	HREE		Y	N					
Yttrium	Y	HREE		Y	N			Low	High	Low
Xenon	Xe			N	N					
Zinc	Zn			N	N	Y				
Zirconium	Zr			N	N					

1) according to the critical and non-critical raw materials profiles included in the report on critical raw materials for the EU (EC 2014)

N: No; Y: Yes

HREE: Heavy Rare Earth Elements; LREE: Light Rare Earth Elements; PGM: Platinum Group Metals

Low: <5% of annual global demand for raw material

Medium: 5-25% of annual global demand for raw material

High: > 25% of annual global demand for raw material

no known specific application within ProSUM scope

Annex 6 Alternative schemes for assessing data quality

Alternative example, the PEF Guide (JRC, 2012)

The PEF guide defines 6 data quality criteria to be rated from 1 (best) to 5 (very poor): technological representativeness (TeR), geographical representativeness (GeR), time-related representativeness (TiR), completeness (C), precision/uncertainty (P), and methodological appropriateness and consistency (M). In the PEF guide, the data quality rating (DQR) is calculated as follows:

$$DQR = \frac{TiR + TeR + GR + C + P + M}{6}$$

Based on these data quality criteria, a semi-quantitative assessment of the overall data quality of the dataset used by the applicant for all relevant processes shall be calculated summing up the achieved quality rating for each of the quality criteria, divided by the total number of criteria. The rating of 1 to 5 (table xx) will define data quality of data-source.

Data Accuracy

In statistics, accuracy is the closeness of results of observations to the true values or values accepted as being true. In ProSUM, data accuracy can include on basic statistics analysis provided with data sets. It includes mean, standard deviation, relative standard deviation, coefficient of variation and confidence limits of a measurement. Data accuracy should provide reliability of published data-sources.

Table 30 - Example of quality level and rating for datasets used in the context ProSUM (EC JRC 2012)

Quality level	Quality rating	C	TiR	P	TeR	GR	Method
Very good	1	All 15 PEF Impact Categories, and all categories include the most relevant elementary flows as identified in the PEFCR	None of the data is older than 1 year	≤ 10%	The technology modelled is exactly the one used by the company	The processes included in the dataset are fully representative for the geography where the specific processes take place	Attributional + all methodological requirements listed in Table 6
Good	2	14 PEF Impact Categories, including all 10 categories classified I or II in ILCD are included and with all 14 categories include the most relevant elementary flows as identified in the PEFCR	None of the data is older than 2 years	10% to 20%	The technology modelled is very similar to the one used by the company	The processes included in the dataset are well representative for the geography where the specific processes take place	Attributional + 7 out of 8 criteria listed in Table 6
Fair	3	12-13 PEF Impact Categories, including all 10 categories classified I or II in ILCD are included[6] and with all 12-13 categories include the most relevant elementary flows as identified in the PEFCR	None of the data is older than 3 years	20% to 30%	The technology modelled is representative of the average technology used for similar processes	The processes included in the dataset are sufficiently representative for the geography where the specific processes take place	Attributional + 6 out of 8 criteria listed in Table 6
Poor	4	10-11 PEF Impact Categories, including all 10 categories classified I or II in ILCD are included[6] and with all 10-11 categories include the most relevant elementary flows as identified in the PEFCR	None of the data is older than 5 years	30% to 50%	The technology modelled present several relevant differences compared to the one used by the company	The processes included in the dataset are only partly representative for the geography where the specific processes take place	Attributional + 5 out of 8 criteria listed in Table 6
Very poor	5	Less than 10 PEF Impact Categories and all categories include the most relevant elementary flows as identified in the PEFCR	There are data older than 5 years	> 50%	The technology modelled is not representative of the one used by the company	The processes included in the dataset are not representative for the geography where the specific processes take place	Attributional

Table 31 - Aspects covered by the data quality criteria (EC JRC, 2012)

TiR	**Degree to which the dataset reflects the specific conditions of the system being considered regarding time/age of the data, and including background datasets, if any.**
TeR	Degree to which the dataset reflects the true population of interest regarding technology, including background datasets, if any.
GR	Degree to which the dataset reflects the true population of interest regarding geography, including background datasets, if any.
P	Qualitative expert judgment or relative standard deviation.
M (Method)	

Annex 7 Case study: example of the data organisation for products

Disclaimer: the example below illustrates how data is organised using a laptop case study including its batteries. This numbers presented should not be interpreted as a result of the project.

a. Introduction

This example lists the main steps of data collection and analysis related to the stocks and flows (as shown in Figure 19) of UNU key 0303 IT-Laptops (including notebooks and tablet). Presently, confidential data is only available for the Netherlands with respect to precise share of laptops and tablets for UNU key 0303 which need to be calculated for remaining EU countries upon availability of accurate data.

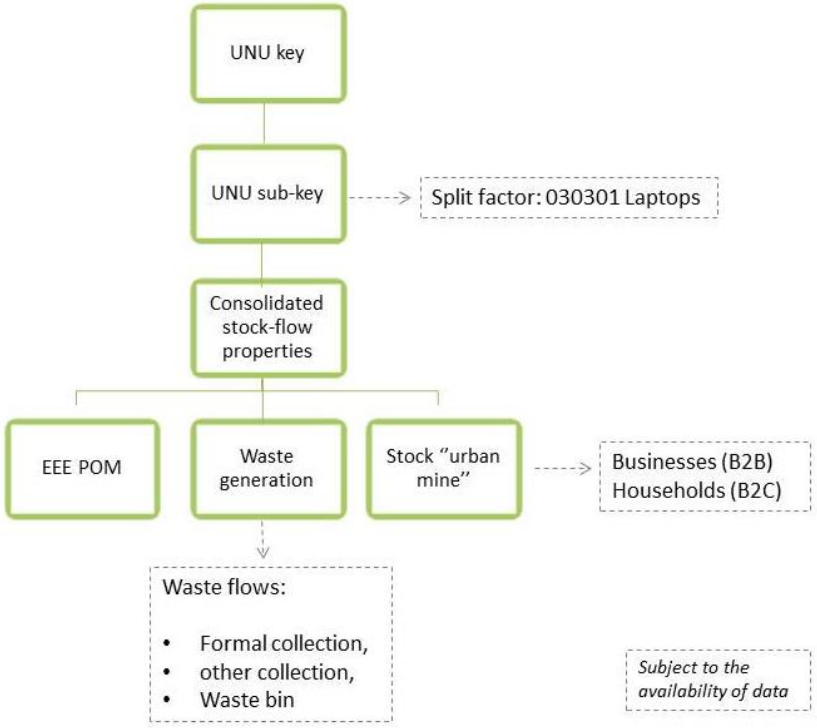


Figure 19 – Structure of laptop case study

b. Product classifications for EEE in practice

A vital check on the device characterisation is whether it works across product diversity and compositional attributes. In this regard, in particular a very CRM rich but also rapidly changing device type of portable computing equipment, including laptops and tables, is taken as an example. The respective UNU key 0303 is further divided in sub-keys, with sub-key 030301 is classified according to compositional characteristics, whereas 030302 is classified according to product diversity alongside their varying type, respectively.

From chapter 5, the product classification is illustrated for EEE. Split factors have been introduced in the data to enable the use of both classifications as outlined. As an example for the UNU keys, UNU sub-keys and EEEDeviceTypes, the following is used to illustrate the harmonisation effort. It takes into consideration the effect of a split on the total number of product units in order to compare and to better understand their share in the main key in terms of market input, technological trend and material composition.

Table 32 - Example top down hierarchy of Product section represents by UNU categories

UNU key	Key description	UNU sub-key	Sub-key description	DeviceTypeCode	Device type
0303	IT Laptop PC's	030301	Laptops	03030101	Laptops (SSD)
				03030102	Laptops (HHD)
				03030103	Laptop computers general (Drive not specified)
		030302	Tablets	03030201	Tablets: Slate (w/o physical keyboard)
				03030202	Tablets: Mini tablets (w/o physical keyboard)
				03030203	Tablets: Phablet (w/o physical keyboard)
				03030204	Tablets: Booklet (w/o physical keyboard)
				03030205	Tablets: Traditional Hybrid (w/ physical keyboard)
				03030206	Tablets: Laplet (w/ physical keyboard)
				03030207	Tablets: Convertible (w/ physical keyboard)
				03030208	Tablets: Gaming tablet (w/ physical keyboard)
				03030209	Tablets: Hybrid (removable physical keyboard)
		030303	Notebooks	03030301	notebook computers
		030304	Other laptops, palmtops	03030401	palm tops

b. Example of the classifications for product stocks and waste generations

United Nations University (UNU) has developed a statistical model that estimates the quantity of EEE put on the market (POM) and WEEE generated, by taking into account their data of sales, stock and lifespan profiles. The estimation structure as illustrated in Figure 20 begins with sales of EEE. After the equipment has been sold, it remains with users for some time. The time the equipment stays with user called the product's 'lifetime' or 'residence time'. This includes the exchange of second hand equipment between households and businesses. After a certain residence time (depending on their sale year and lifetime profile) the product is disposed of (becomes waste). This is referred to as 'e-waste generated' (Baldé et al., 2015).

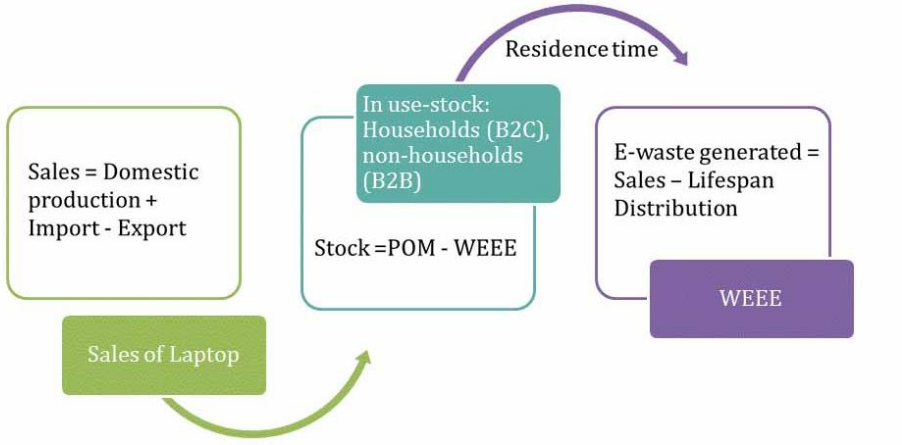


Figure 20 - Illustration of Sales-stock-lifespan model

Sales data has been collected from UNU study on Article 7 of the Recast Directive (study on collection rates of waste electrical and electronic equipment, (Magalini et al., 2015) which comprises of national statistics and compliance scheme registers. Subsequently, a time sequence is made of the quantities of laptops put on the market from 1995 to 2012 for EU28+2 (Figure 21). The quantities of laptops are expressed in million units. The general trends provide a steady increase in the both pieces and tons, with 2.6 to 62 million pieces units from 1995 to 2012. The steady increase in quantity depicts an overview of boom in information technology.

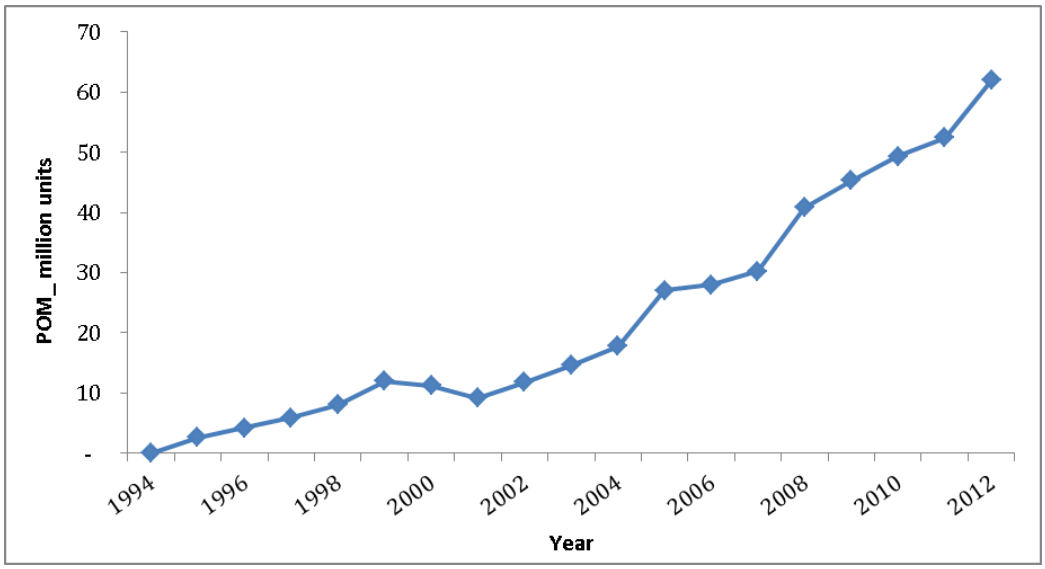


Figure 21 - Historic Laptop POM for EU28+2

To provide more insight knowledge, the above figure of POM has been grouped into seven regions. The regions are: (i) Benelux + FRA (incl. Belgium, Netherlands, Luxemburg and France); (ii) DACH (incl. Germany, Austria and Switzerland); (iii) Bulgaria, Romania and Croatia; (iv) Eastern + Central EU (incl. Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovakia and Slovenia); (v) Nordic countries (incl. Denmark, Finland, Norway and Sweden); (vi) Southern EU (incl. Cyprus, Spain, Greece, Italy, Malta and Portugal); (vii) United Kingdom and Ireland. In Figure 22, the size of the national EEE market is represented by EEE put on market (unit kg/inh). In 2012, the top regions with the highest laptops POM in relative quantities are Nordic countries (0.58 kg/inh) and DACH (0.46 kg/inh). However, Bulgaria, Romania and Croatia block shows only 0.01 kg/inh.

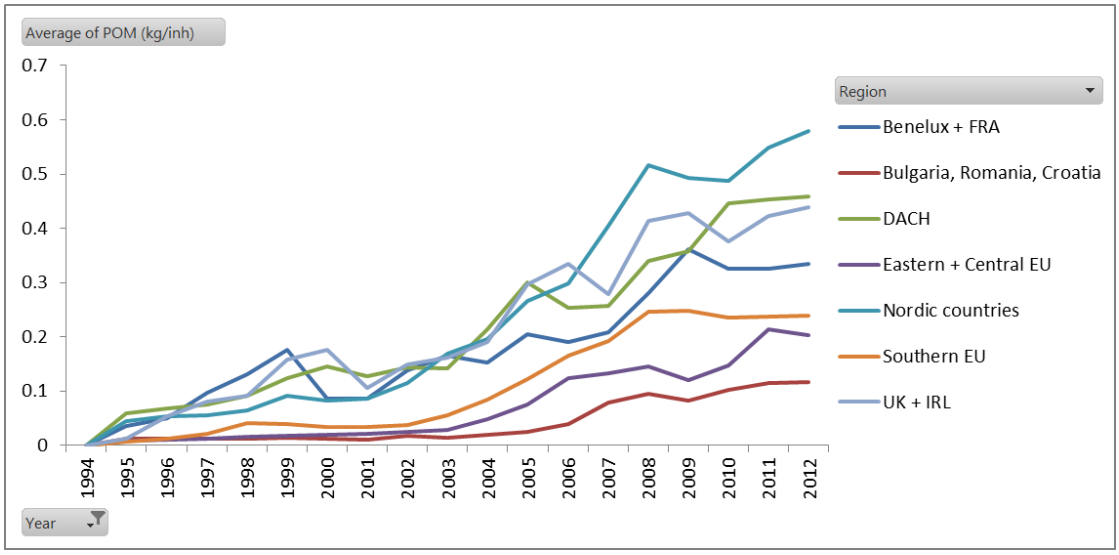


Figure 22 - EEE Put on Market laptops (kg/inh) for EU28+2

UNU Key 0303 has been split into the UNU sub-keys 030301 and 030302 that cover laptops and tablets respectively. Data from one specific country with very detailed information is used as to determine split factors. The introduction of light weight and compact tablets in 2012 with an average weight of around 0,450 kg, reduces the share of the predominant laptops since then. Laptops and tablets share 53% and 47% pieces placed for sale in 2012. Likewise, their weight share corresponds to 83% and 17%. This helps to update overall 0303 average weight and lifetime profile.

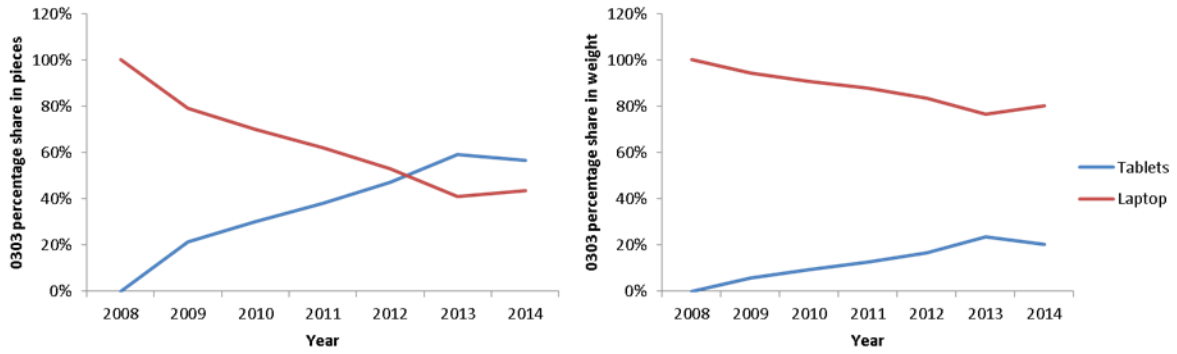


Figure 23 - 0303 split factor depicting pieces and weights percentage

The lifespan of devices is used for forecasting the replacement market. Statistical method, the Weibull function with parameters of scale and shape has been used to calculate lifespan. The average age of laptop stock and the average age of discarded laptops facilitate the construction of lifespan profiles (Baldé et al., 2015).

Lifespan of laptops can be distinctive per country. However, for this study the 'lifespan' is acquired from the average lifespan of laptops from Article 7 (Table 33). Moving from 2005 to 2012, the average weights of laptops is declining due to more compact nature of electronics alongside the introduction of notebooks and tablets in 2007 and 2012 respectively. This trend is expected to continue for prophesied future technology and sales as well. Meanwhile, more data points are required to calculate historic lifespan profile.

Table 33 - Average lifespan and product weight of Laptops from 2005-2012

Sales Year	Weibull parameters		Average Lifespan	Average POM product weight
	Shape	Scale	(median, in years)	(in kg/pc)
2005	1.66	6.80	5.45	3.68
2006				3.59
2007				3.50
2008				3.41
2009				3.32
2010				3.23
2011				3.23
2012				3.23

The equipment in households, businesses and public sector, is referred to as the 'stock'. This is destined to become e-waste in the future and is also called the 'urban mine' (Baldé et al., 2015). In the sales-stock-lifespan model, stocks are differentiated between dynamic (in-use stocks from past, present, and future material use) and accumulative stock (tending to be accumulate). The laptop stock is based on their sales and lifetime profiles. In 2012, Nordic countries represent stocks of 2.5 kg/inh for UNU Key 0303 (Figure 24). Here, accumulative stock represents the total

stock in households and businesses which needed to be split between business to consumers (B2C) and business to business (B2B) to provide detailed calculations in the future.

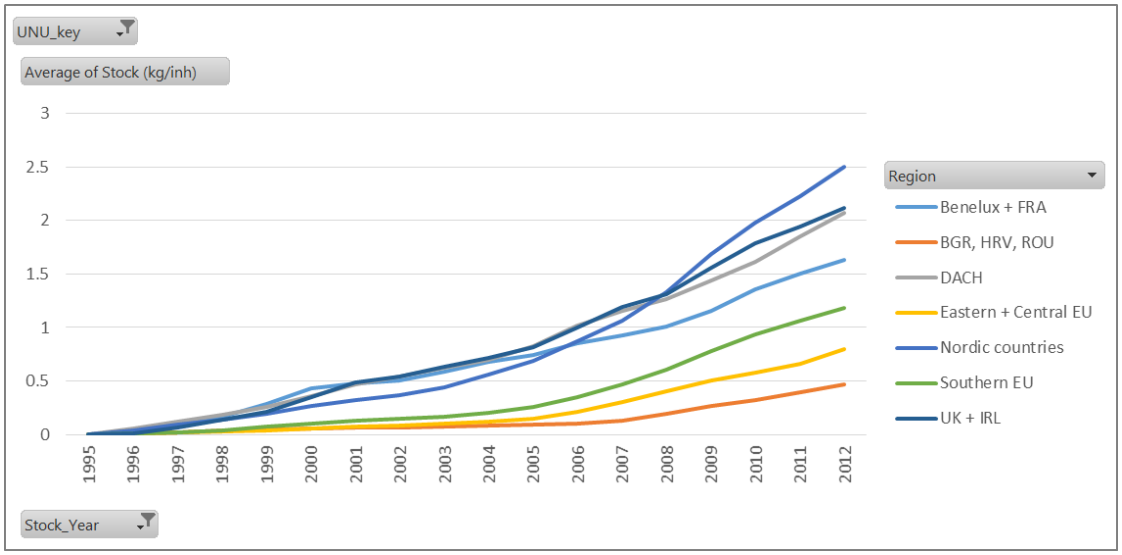


Figure 24 – Accumulative laptops stocks for EU28+2 (1994-2012)

Laptops after a certain period of their sale will become waste depending on their sale year and lifetime profile. It is the amount of waste generated before any collection and treatment. WEEE generated (kg/inh) represents the size of national WEEE market. It is necessary to collect data (product sales, stocks, and lifespans and average weights) to reach reliable estimates of waste amounts. With increase in laptop sales between 1995 to 2012 and the average age of 5.45 years the amount of waste is rapidly increasing, where Nordic countries ranked maximum on the chart followed by United Kingdom and Ireland by having 0.32 and 0.28 kg/inh respectively in 2012.

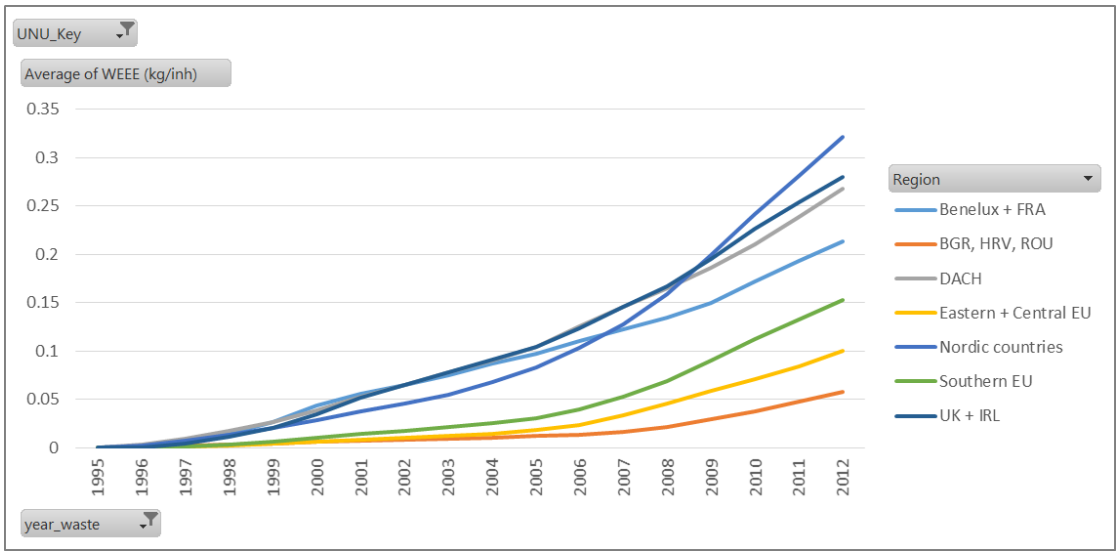


Figure 25 - WEEE laptops for EU28+2, kg/inh

This study can further continue to complementary WEEE flows. For this purpose, CWIT (countering WEEE illegal Trade) will be a helpful source (Huisman et al., 2015) by providing an insight of WEEE flows within and outside Europe.

c. Example data quality assessment for EEE stocks and flows

In addition to ILCD and PEF data quality guide, the following specific checklist for W(EEE) stocks and flows is also being proposed concentrating on POM, stock, lifespan profiles and item weights with a specific end goal to fine tune the data evaluation. It should be noted, that in later deliverables a more definitive choice on harmonising data quality assessment for all parts, including the various stocks and flows model will be developed.

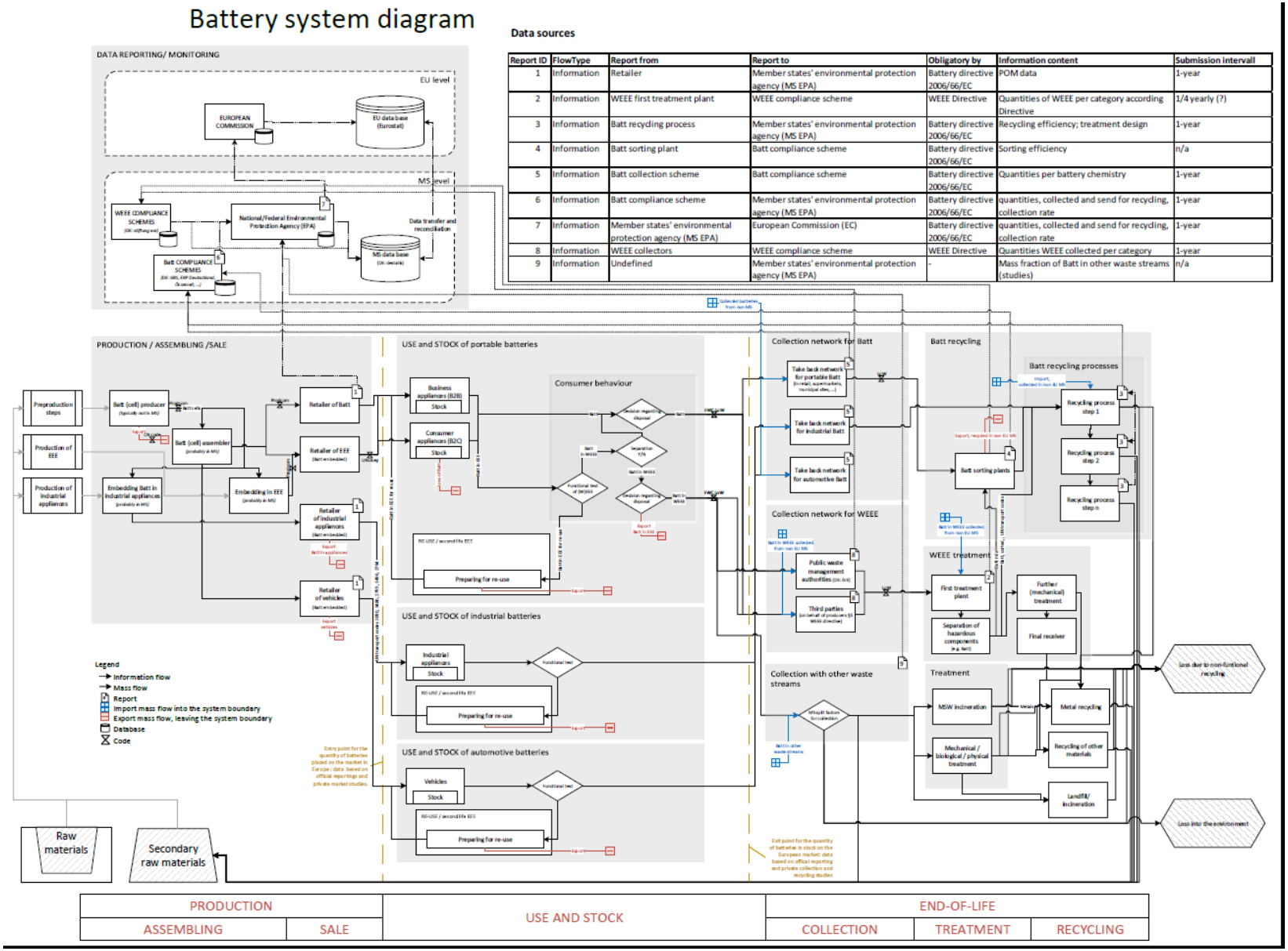
Table 34 - Checklist for evaluating data quality on waste electrical and electronic equipment (Wang et al., 2013)

A: Product put on the market (POM)	
1	Clear and consistent product scoping
2	Number of POM sources
3	Data match among different POM sources
4	Continuous data on historical years
5	Including all producers, retailers and importers
B: Stock	
1	Stock data available in both households and business channels
2	Continuous stock data on historical years
3	Measured data using a statistically robust sampling method ; Representative survey in sample size, demography, regions, income etc.
C: Lifespan profiles	
1	Clear and consistent definition of lifespan among different data sources
2	Measured data using a statistically robust sampling method ; Representative survey in sample size, demography, regions, income etc.
3	Lifespan profiles available in both households and business channels
4	Source of lifespan profile: consumer survey, Delphi method, waste sampling etc.
5	Sufficient data points from stock measurement
6	Sum of squares disposal
7	Sum of squares stock age
8	Lifespan profiles available over time
9	Availability of lifespan distribution or only average lifespan
10	Lifespan data validated by different methods and data
D: Product Weight	
1	Standard deviation of weight distribution available
2	Product weight data available over time
3	Source of product weight information: producer registers, waste sampling, literature etc

d. System flow diagrams and data sources

On the next pages, the system flow diagrams for BAT, ELV and WEEE are displayed as referred to in Chapter 8.3.

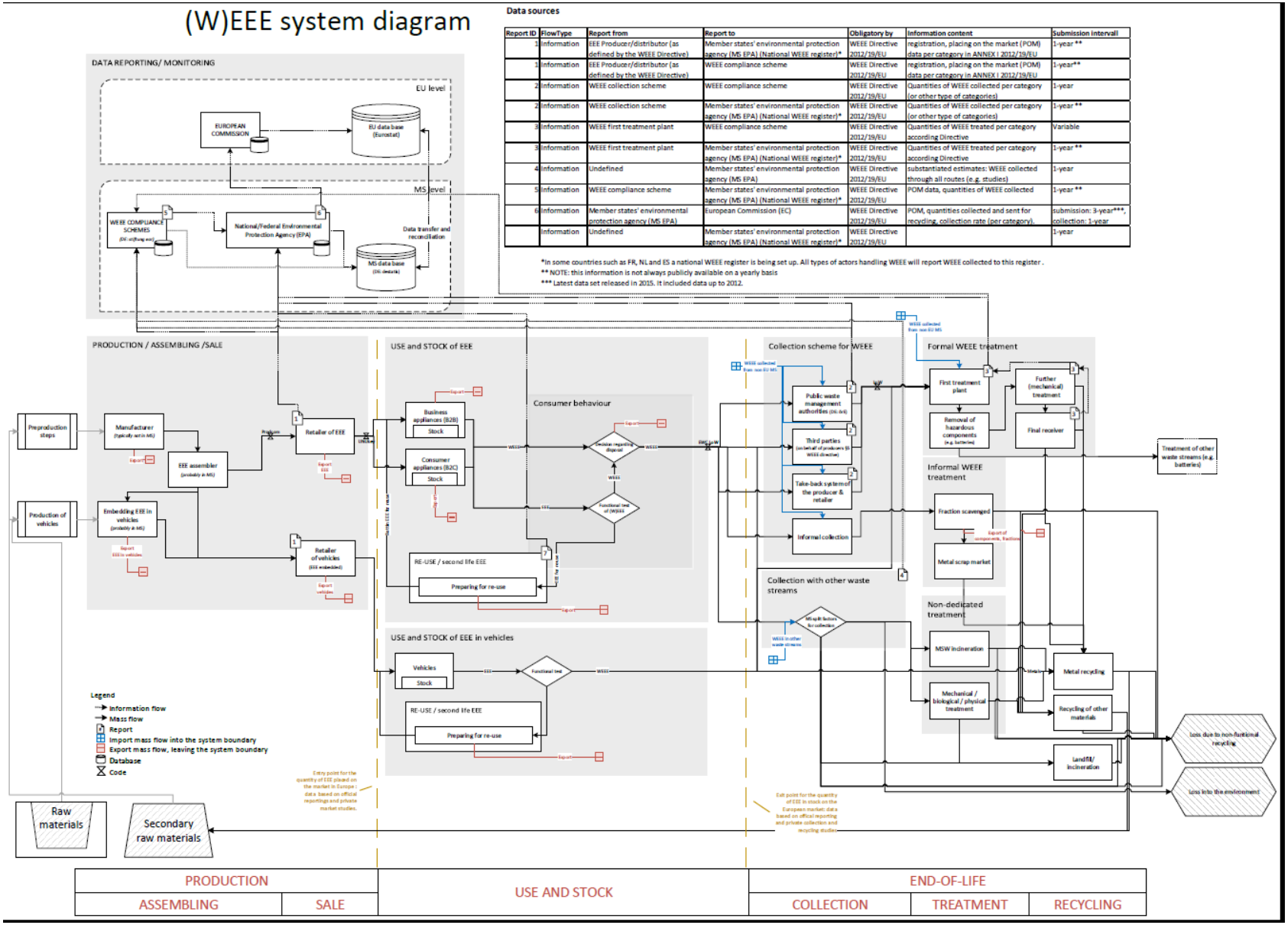
Battery system diagram



Data sources

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

(W)EEE system diagram

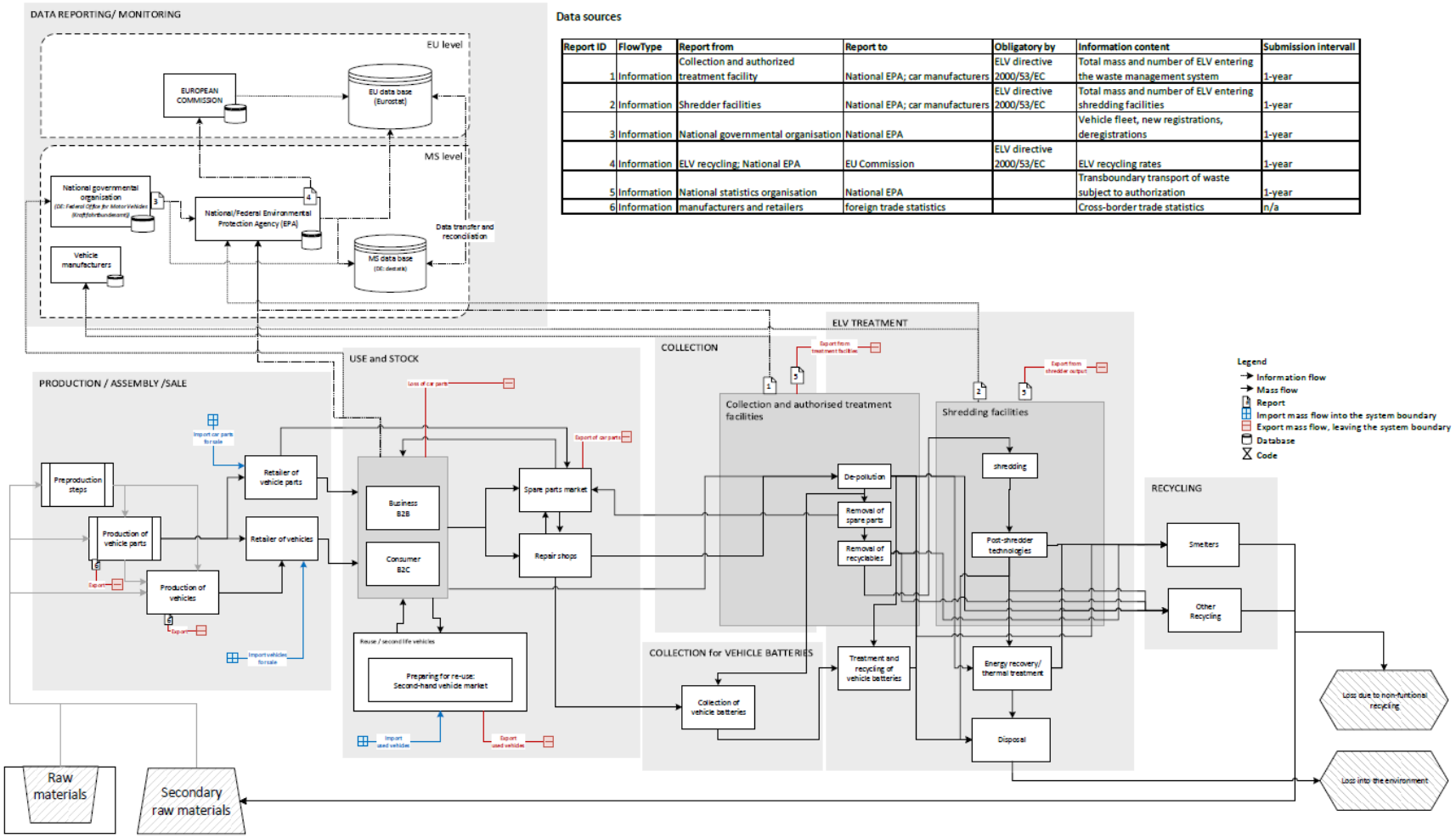


Data sources

Report ID	FlowType	Report from	Report to	Obligatory by	Information content	Submission interval
1	Information	EEE Producer/distributor (as defined by the WEEE Directive)	Member states' environmental protection agency (MS EPA) (National WEEE register)*	WEEE Directive 2012/19/EU	registration, placing on the market (POM) data per category in ANNEX I 2012/19/EU	1-year **
1	Information	EEE Producer/distributor (as defined by the WEEE Directive)	WEEE compliance scheme	WEEE Directive 2012/19/EU	registration, placing on the market (POM) data per category in ANNEX I 2012/19/EU	1-year**
2	Information	WEEE collection scheme	WEEE compliance scheme	WEEE Directive 2012/19/EU	Quantities of WEEE collected per category (or other type of categories)	1-year
2	Information	WEEE collection scheme	Member states' environmental protection agency (MS EPA) (National WEEE register)*	WEEE Directive 2012/19/EU	Quantities of WEEE collected per category (or other type of categories)	1-year **
3	Information	WEEE first treatment plant	WEEE compliance scheme	WEEE Directive 2012/19/EU	Quantities of WEEE treated per category according Directive	Variable
3	Information	WEEE first treatment plant	Member states' environmental protection agency (MS EPA) (National WEEE register)*	WEEE Directive 2012/19/EU	Quantities of WEEE treated per category according Directive	1-year **
4	Information	Undefined	Member states' environmental protection agency (MS EPA)	WEEE Directive 2012/19/EU	substantiated estimates: WEEE collected through all routes (e.g. studies)	1-year
5	Information	WEEE compliance scheme	Member states' environmental protection agency (MS EPA) (National WEEE register)*	WEEE Directive 2012/19/EU	POM data, quantities of WEEE collected	1-year **
6	Information	Member states' environmental protection agency (MS EPA)	European Commission (EC)	WEEE Directive 2012/19/EU	POM, quantities collected and sent for recycling, collection rate (per category).	submission: 3-year***, collection: 1-year
	Information	Undefined	Member states' environmental protection agency (MS EPA) (National WEEE register)*	WEEE Directive 2012/19/EU		1-year

*In some countries such as FR, NL and ES a national WEEE register is being set up. All types of actors handling WEEE will report WEEE collected to this register .
** NOTE: this information is not always publicly available on a yearly basis
*** Latest data set released in 2015. It included data up to 2012.

(EL)Vehicle system diagram



Data sources

Report ID	FlowType	Report from	Report to	Obligatory by	Information content	Submission intervall
1	Information	Collection and authorized treatment facility	National EPA; car manufacturers	ELV directive 2000/53/EC	Total mass and number of ELV entering the waste management system	1-year
2	Information	Shredder facilities	National EPA; car manufacturers	ELV directive 2000/53/EC	Total mass and number of ELV entering shredding facilities	1-year
3	Information	National governmental organisation	National EPA		Vehicle fleet, new registrations, deregistrations	1-year
4	Information	ELV recycling; National EPA	EU Commission	ELV directive 2000/53/EC	ELV recycling rates	1-year
5	Information	National statistics organisation	National EPA		Transboundary transport of waste subject to authorization	1-year
6	Information	manufacturers and retailers	foreign trade statistics		Cross-border trade statistics	n/a

PRODUCTION		USE AND STOCK	END-OF-LIFE		
ASSEMBLING	SALE		COLLECTION	TREATMENT	RECYCLING