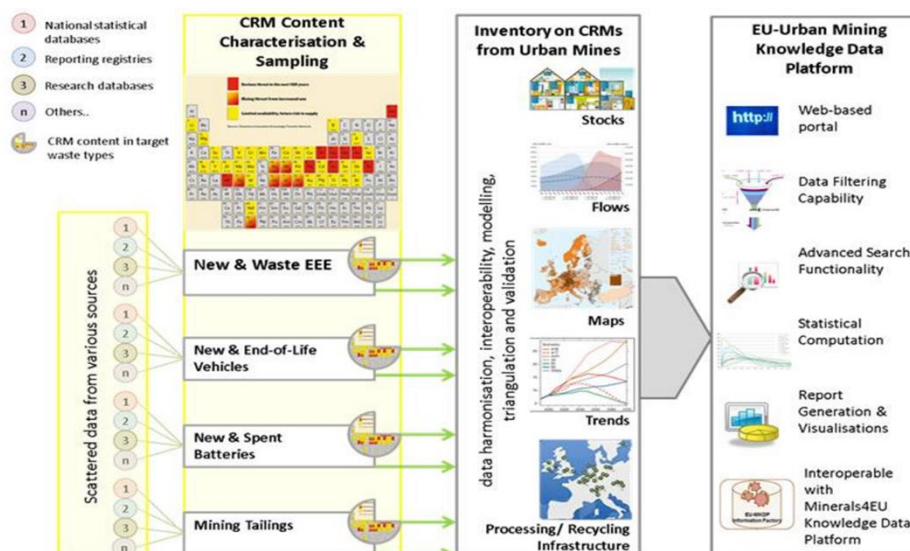


# Historic and Current Stocks

## Deliverable 3.1



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<b>Author</b>	Jaco Huisman UNU, Hina Habib UNU, Vera Susanne Rotter TUB, Paul Maehlitz TUB, Nathalie Korf TUB, Perrine Chancereel TUB, Duncan Kushnir Chalmers, Maria Ljunggren Söderman Chalmers, Amund Loevik Empa, Kees Baldé CBS, Vincent van Straalen, CBS
<b>Reviewed by</b>	Project Management Team
<b>E-mail</b>	Huisman@unu.edu Dr Jaco Huisman, Scientific Advisor, UNU – ViE SCYCLE
<b>Scientific Coordinators</b>	Nikolaos Arvanitidis, Chair of the EGS Mineral Resources Expert Group Huisman@unu.edu
<b>E-mail</b>	Nikolaos.Arvanitidis@sgu.se

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## Document Control

<b>Project Coordinator:</b>	WEEE Forum
<b>Work Package Leader:</b>	Jaco Huisman
<b>Deliverable leader</b>	United Nations University
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## PURPOSE

The purpose of this report is to describe the results of the assessment of the amount (stocks and flows) of products in households and businesses. Task 3.1 takes an inventory of the data sources available in line with, and structured according to, the classifications and harmonisation produced in Deliverable 5.3 “Review and Harmonisation of Data”. Since data on stocks and flows is often from various diverse sources, the classification system developed in D5.3 is essential in structuring all available data sources. In addition to this, geographic and demographic information has been reviewed from EU wide statistical databases. The inventory has been produced by screening data from publicly available sources, and specific national sources and studies e.g. published academic literature, technical reports, national producer registries, and consumer surveys indicating stock levels for products present in households and businesses. Furthermore, data from other EU projects, other quantification studies like those performed in the Ecodesign Directive (for Energy related/ using Products) studies, commercially available market research data (where available and affordable) plus information from EU wide associations such as: CECED and Digital Europe for EEE; Recharge/Eucobat for batteries; and the European Automobile Manufacturer’s Association (ACEA) for vehicles.

Based on above data gathering, all data is structured into one bibliographic overview in EndNote where all meta data is kept and stored in harmonised formats for future replication. The data sources are further described and evaluated in an Excel file which is also aligned with the simultaneous deliverables D2.2 and D4.1. Combined, the total inventory forms the project Milestone 4 ‘Existing Data Inventory’.

**For a glossary of terms and definitions used, see Annex 5.**

## EXECUTIVE SUMMARY

The main result of this Deliverable 3.1 is the development of the data inventory of stocks and flows information for EEE, BATT and vehicles following and further developing the common approach for harmonising and structuring data from Deliverable 5.3. The shared bibliography in EndNote allows different researchers in the ProSUM project to store and track data in a harmonised manner, including those describing stocks and flows. For this deliverable, the data analysis included roughly 140 of the most relevant references regarding market input, stocks and flows being analysed and stored out of 336 processed references in the current ProSUM bibliography altogether. The majority of sources comprised of study reports and academic journal articles. Some specific datasets and confidential sources are also available but are not stored in Endnote for obvious reasons. The majority of data sources concern EEE.

A second result is the selection of data and the expansion of the stock and flows models. For EEE and BATT a sales–lifespan approach is applied to determine stocks and flows. For vehicles, a stock-lifespan approach is used. Existing EEE modelling undertaken by UNU in other projects and studies has been significantly expanded and advanced through the ProSUM project. New market input data for 2013 and 2014 data has been included and the data for 2011 and 2012 has been improved, following updated trade statistics. In addition, EEE stocks are calculated for the EU for the first time. Compared with the BATT and vehicle stock and flow modelling, data availability and reliability is not good for all UNU keys. In particular, for some of the smaller and less commonly used equipment types, data reliability and availability remains an issue. The same issue is seen for goods codes with particular description or average weight issues. This will be addressed as the project delivers. Clear specifications for key stock and flow parameters are reviewed and included in Chapter 2. This includes the average weights and lifespan parameters for all UNU keys, where distribution and reliability can be improved with the additional sources now identified and stored in EndNote.

Similar to EEE, the expected year of arisings of waste batteries after being put on the market is initially calculated based on the modelling of the residence time distribution. Further work will be undertaken to improve the modelling of data concerning batteries which arise as part of WEEE.

Due to the nature of vehicle registration and regulation, more (accurate) comprehensive data on EU vehicles vehicle stocks and flows is available as the fleet sizes in Europe are well monitored. The availability of stocks information in the form of vehicle fleets information is crucial and allows a stock-lifespan approach to determine waste generation. The nature of available data on vehicle stocks in the EU will allow high confidence in estimating aggregated flows and reasonable confidence in calculating distributions over the chosen vehicle keys.

It should be noted, however, that there will be substantial concern and difficulty in finding vehicle keys that are CRM-relevant. All vehicle statistics are designed for traffic and transport economy, fuel demand and air emission purposes and not for their CRM composition, or trends affecting these CRM parameters. The same applies to EEE and BATT: the challenge in the next steps will be the connection of the product stocks and flows information with the detailed and often very product composition.

This deliverable will also inform the final mathematical approach and common methodology on the stocks and flows by M24 for D3.3. Moreover, the developed ProSUM bibliography set up in EndNote now is functioning well internally first. It specifically allowed to categorise, filter and manage the continuously growing knowledge base covering 336 relevant documents, likely to be converted via an XML export, to become the basis for the EU-Urban Mine Knowledge Data Platform currently in development. Proper scrutiny of all data sources in a uniform manner is an important step now successfully completed and forming the basis for further expansion in the project as more sources becoming available will continuously be added.

# 1 Introduction

## 1.1 Aim and scope of the Deliverable

The aim of this deliverable is the identification and description of all data sources related to market input (product sales), stocks (equipment in use and hibernated at households and businesses) and output (generated waste and, for vehicles, also exported second hand vehicles). Secondly, it is to provide an inventory as complete and harmonised as possible according to the classification developed in Deliverable 5.3. The scope of this deliverable is the **product market inputs and stocks** of appliances for EEE, BATT and vehicles leading to **waste generation**. At the same time, the scope of parallel Deliverable 2.2 is on available CRM data for **components in these products and stocks**, whereas the scope of parallel Deliverable 4.1 is from the point of **waste generation** towards available **waste flow studies**. A single inventory has been developed as multiple sources may have multiple data points for these 3 flows, and data used in WP2, 3 and 4 needs to be linked carefully.

The system boundary is the EU28+2 countries for all waste types. Data for 1980-2015 are used for market input information for Electric and Electronic Equipment (EEE) and for vehicles, and when referring to generated waste and 2000-2015 for batteries (BATT). From this, historic market inputs and stocks are calculated. Where possible, the waste generation amounts are determined and include the 2015 – 2030 time frame. The reliability of this calculation up to 2020 will be sufficient especially for products with a relatively long residence time. After 2020, the waste generated will become more dominated by newer products which is increasingly unpredictable. Vehicle waste generation, due their relatively longer lifespan of around 15-20 years, will be relatively more predictable up to 2030.

The focus of this deliverable is on producing an inventory of existing data sources and readily available stock and flow modelling results. In the later deliverables D3.3 and D3.4, further harmonisation, elaboration and updating of this work will be done. The EndNote library (the ProSUM bibliography) developed in task T2.1.1, will be continuously expanded with new references and data as they become available. The ProSUM bibliography is specifically set-up to be able to categorise, filter and manage the continuously growing knowledge base behind the EU-Urban Mine Knowledge Data Platform.

Figure 1 shows the position of this deliverable in relation to other deliverables.

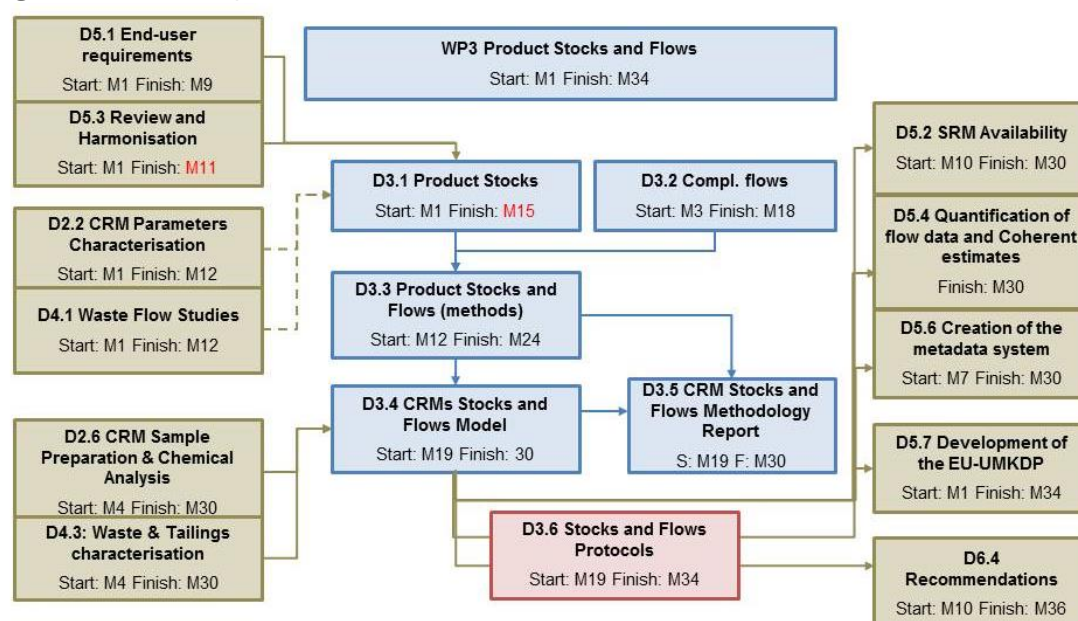


Figure 1. Pert chart positioning D3.1 in WP3 and other work packages

The following linkages are important:

1. D3.1 takes into account the data harmonisation and classification from D5.3 (including related data sources) focusing on the product **stocks and waste generation based on available and consolidated age information**.
2. D3.1 takes into account the end user requirements and Table 6 in D5.1 concerning the scope of product stocks. The end-user requirements have been further developed and evaluated by the Project Consortium in January 2016 since the completion of D5.1.
3. D3.1 includes data sources identified in D2.1 and D4.1 and the bibliography in order to create one aligned inventory of information **in Annex 2** of this document.
4. D3.1 delivers the first estimates of waste generation (to be fine-tuned in D3.3) as a starting point for the D3.2 on complementary flows.
5. D3.1 provides the data inventory for more sophisticated Stock-Flow modelling in D3.3, which includes data on **actual product flows** (D3.2), and **specific age information from WP4 (for validation purposes** where for instance age information in the return streams can be used as feedback on the determination of the product stocks). This should result in the final mathematical approach and common methodology on the stocks and flows by M24 for D3.3. It is relevant to note that the approaches for EEE are already more advanced and will be harmonised and built upon for modelling the BATT and vehicle stocks and flows.
6. D3.1 and the subsequent D3.3 will feed D3.4 where product stocks (D3.1) and flows (D3.2) and the modelling (D3.3) will be combined with **CRM content in these flows**. The final approach will also describe **data quality** and steps for validation of the results in D3.4.
7. The combined/updated information from D3.1 to D3.4 will then provide all parameters and **datasets** (to D5.2) for the methodology that will feed WP5, including specific **data structure** (D5.5) that allows WP5 to provide the **mapping of the urban mine** D5.4.
8. Finally in D3.6, information will be provided to improve harmonisation and updating of the CRM stocks and flows information for the **EU-UMKDP** by means of developing specific updating protocols (D5.7)

## 1.2 Classification and data formats (approach extended from D5.3)

It is important to note that following the classification work in deliverable D5.3, together with careful inventory of the potentially available information, the classification system is being used and thoroughly tested in harmonised formats with the available information. In addition to this, clear specification of the scope and approach of data collation is required to avoid misalignments. Although the classification of EEE, BATT and vehicles is by definition imperfect due to the complexity and differences in reporting on product and wastes, it must be sufficiently robust to construct the stock and flow models. Without this approach, there is a risk that the entire stock and flow modelling needs to be redone, or even worse, the analysis of all data fed to these models, has to be reconfigured and recalculated again in later stages in the project. Hence, the reiteration of the systems agreed upon in deliverable D5.3 below to test and improve the classification system.

### 1.2.1 Classification and formats for WEEE (extended from D5.3)

The construction of the UNU keys envelops product groups with similar applications, comparable average weights, material compositions, End-of-Life (EoL) characteristics and lifespan distributions. The data in this format have been used to quantify the waste generation based on the product sales over all historical years with their respective lifespan distribution in the evaluation year. The following scope, approach, formats and classifications are used:

- Product sales data are determined through the *apparent consumption approach*. Based on correlation tables, all international trade codes are linked to the 54 UNU keys, the old 10 and the new 6 EU WEEE Recast Directive categories, and data formats for the volumes are both in kg's, (kilo)tons (kt), as well as pieces (pcs), where necessary also

normalised in kg per inhabitant (kg/inh) pieces per inhabitant (pcs/inh) or per household (kg/HH, pcs/HH).

- The geographical area is the EU28+2.
- Average product weight over time is determined from various sources including the statistical data itself for those goods codes that have both tonnage and pieces specified. The average weight evolves over time and is displayed in kg/pc.
- Weibull distribution parameters are currently one set per UNU key and are linked to the year of market input (sales) and specify the chance in all following evaluation years of the products becoming waste. There are two parameters per UNU key used: one scale parameter specifying the 'length' of the disposal distribution curve and one 'scale' parameter specifying how 'steep' versus how 'flat' the disposal curve is (Wang et al., 2013).
- The years covered for product sales are 1980-2014, from 2015 extrapolations are made per UNU key based on observed market trends. The waste generation years coverage currently include 1995-2020 and likewise for stock data. For the years beyond 2020 until 2030, the assessment of product and component parameters influencing CRM amounts will take place in D2.3 and D2.4. Here also the introduction and market expectance of very new types of equipment like 3D printers and drones need to be forecasted and included as scenarios to the Stock and Flow modelling.
- For stock data, agreed representation includes pieces per inhabitant, but also conversions based on data sources with a different type of specification like penetration rate or items per (hundred) household are documented.

### 1.2.2 Classification and formats for BATT (extended from D5.3)

Basically, the data on stocks and flows of batteries have five dimensions (Figure 2):

- The electrochemical systems as reflected in the BATT keys.
- The product groups in which portable, automotive and industrial batteries are embedded or that mention that the battery is sold separately if it is the case.
- The geographical area (countries in the EU28+2).
- The year (data published by Avicenne, 2015) batteries are put on the market are available for the years 2000-2014.
- The stock or flow considered.

The units used for describing the data are very similar to those of WEEE in kg's, (kilo)tons (kt), as well as pieces (pcs), where necessary also normalised in kg per inhabitant (kg/inh) pieces per inhabitant (pcs/inh) or per household (kg/HH, pcs/HH).

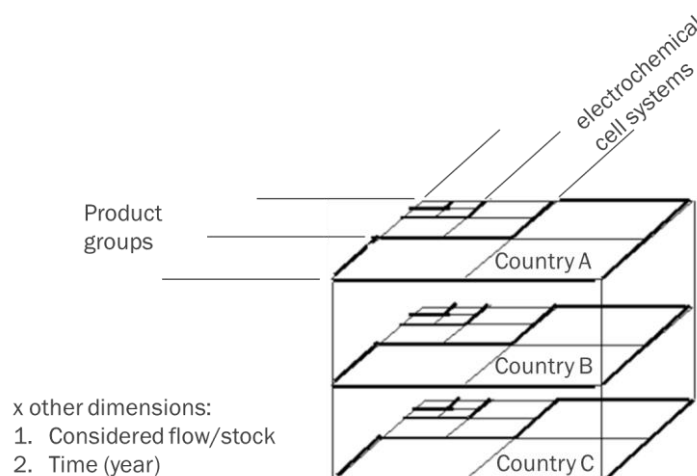


Figure 2. Dimensions of the structure of data on batteries

The data on volumes of batteries in various sources are available with different units: megawatt-hours (MWh), million dollars, units (number of batteries) and mass (tons). The industrial

association Recharge developed and uses conversion tables to link the units and be able to compare the data. Table 1 shows units and classifications in terms of electrochemical systems, product groups and geographical areas were used from different data sources focusing on different flows (batteries put on the market, collected) and stocks. The differences show that the way of reporting the data on battery flows is not harmonised, which will create challenges for the data consolidation.

**Table 1. Units and classifications used to report data on stocks and flows of batteries**

Data source	Unit	Electro-chemical systems	Product groups	Geographical granularity
EPBA	Tons and units	5 x Single use; 4 x Rechargeable; 6 x lead + other, vehicle propulsion and automotive starter	Portable (including „share embedded“), Industrial, Automotive	Detailed EU, aggregated country analysis
Eucobat	tons, units and g/inh	8 categories	Portable, Industrial	Countries (members)
Avicenne	MWh, units, million dollars	Li-ion, NiCd, NiMH, lead	Many categories	Countries
Eurobat	Units	Ind: 2V Cells+Mono-blocks/ sealed+vented Automotive: HCV; Cars+LCV	Industrial, Automotive	EU + shares for main countries
Eurostat	Tons	No categorisation	No categorisation	Countries
ProdCom	Units	No categorisation	No categorisation	Production, import, export from/to countries
CN trade	Kg	21 categories little compatible with ours	No categorisation	Import and export from/to countries
Bebat	Units	7 chemical families	Portable	Belgium

### 1.2.3 Classification and formats for ELV (extended from D5.3)

The Vehicle Keys include classifiers for vehicle type, vehicle weight, drivetrain type, and cylinder size. While the other classifiers have relatively obvious utility, the inclusion of cylinder size is useful because the data is available, and it is assumed to be the best available proxy for ‘equipment level’, which is an important consideration when mapping vehicle numbers to material content. A vehicle of any given weight class with a larger engine is likely to contain more enhancing electronics and control systems.

ACEA and Eurostat report numbers for each key classification directly. The sub-categorisations are presented in the Table 2.

**Table 2. Sub classification of ELVs**

	Type		Weight		Motor energy		Cylinder capacity
00	unknown	00	unknown	00	unknown	00	unknown
01	car	01	< 1000 kg	01	petrol	01	< 1400 cm3
02	van	02	1000-1249 kg	02	diesel	02	1400-1999 cm3
		03	1250-1499 kg	03	LPG	03	> 2000 cm3
		04	> 1500 kg	04	natural gas	04	no cylinder (only for

			05	electric		alternative fuels)
			06	other		

### 1.3 Classification of Stock and Flow models

The following are available methodologies used for stocks and flows characterisation in literature (Wang et al., 2013).

- *Disposal related analysis* uses e-waste figures obtained from collection channels, treatment facilities and disposal sites. It usually requires empirical data from parallel disposal streams to estimate the overall generation (Walk, 2004).
- *Group/comparative analysis* of qualitative and quantitative variables gathered from the different strategies within the scope of the study, i.e, compare with different regions, countries and appliances. This approach is not used for the three waste groups, rather the reverse: after waste generation determination, these amounts become the starting point for the further waste flows (see also deliverable D4.1 and the upcoming deliverable D3.2).
- *Time series analysis (projections model)* forecast the trend of e-waste generation by extrapolating historical data into the future. It can be also applied to fill in the gap of past unknown years from available datasets. This approach is not chosen either. Similar to above, however, after determining waste generation numbers, interpolation for countries, or UNU or BATT keys may happen based on cases with relatively complete data to cover instances of no or incomplete data.
- *Factor/correlation models* are based on hypothesised causal relationships between exogenous factors like population size and income level versus e-waste generation (Huisman et al., 2008; Huisman, 2010). With developing more advanced IOA approaches, also this approach is not preferred over mass balance based approaches.
- *Input-Output Analysis (I/O)*, often also referred to as Mass Flow Analysis (MFA), quantitatively evaluates the sources, pathways and final sinks of material flows. Material Flow Analysis (MFA) is 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.).
- Different versions of I/O model or MFA models include:
  - Time step mode (I/O) the change of stock within a period in a system equals the difference between the total inflows and outflows (Araújo et al., 2012).
  - Market supply mode(I/O) Market Supply models estimate e-waste generation from product sales in all historical years with their respective obsolescence rates in evaluation year (Streicher-Porte et al., 2005; Jain and Sameer, 2006; Oguchi et al., 2008; Dwivedy and Mittal, 2010).
  - Stock and lifespan model (I/O) combines time-series stock data with lifespan distributions of products can also estimate e-waste generation (Binder et al., 2001; Müller et al., 2009; Walk, 2009).
  - The leaching model (I/O) calculates the e-waste generation as a fixed percentage of the total stock divided by the average product lifespan (van der Voet et al., 2002; Robinson, 2009; Chung et al., 2011; Araújo et al., 2012)
  - Multivariate Sales-Stock-Lifespan model is an advanced and flexible method, which can be used when multiple datasets are available. It was developed for the Dutch Future Flows study (Huisman, 2012) and it links product sales, stock and lifespan data to construct mathematical relationships between various data points, based on best available data to calculate WEEE generated. By applying method, the data consolidation steps facilitate the production of more comprehensive time series

datasets from the available datasets, which increases the reliability of WEEE estimates (Wang et al., 2013; Magalini et al., 2016).

Data sources in literature and various options for stock and flow estimation methods, in particular input output analysis methods (also called mass flow analysis methods), have been reviewed. For these IOA methods, in simple terms, at least two parameters must be known, estimated, or otherwise defined to determine the waste generation: that means two data points from sales, stocks and lifespan as the three main parameters (Wang et al., 2013). A summary list is available in Table 4. A more detailed data inventory is available in Annex 2.

**Table 3. (W)EEE literature overview of main IOA models (Wang et al., 2013)**

Estimation Model	Variables and data requirements						Key references
	Sales Cont.*	Dis.*	Stock cont.	Dis.	Lifespan age distribution	Average lifespan	
A. Time Step Model		✓	✓				Oguchi et al., 2008; Yu et al., 2010; Araújo et al., 2012
B1. Market Supply Model (Distribution Delay)	✓				✓		Melo, 1999, Yang et al., 2008, NemaNord, 2009
B2. Market Supply Model (Simple Delay)		✓				✓	van der Voet et al., 2002
B3. Market Supply Model (Carneige Mellon method)	✓					✓	Kang and Schoenung, 2006; Peralta and Fontanos, 2006; Dwivedy and Mittal, 2010; Steubing et al., 2010
C. Stock and Lifespan model			✓		✓		Müller et al., 2009; Walk, 2009; Zhang et al., 2011
D. Leaching model			✓			✓	van der Voet et al., 2002; Robinson, 2009; Chung et al., 2011; Araújo et al., 2012
E. Multivariate Sales-Stock-Lifespan model	✓		✓		✓	✓	Wang et al., 2013
Note: "Cont." means that continuous datasets in the current and all historical years are required for calculation; "Dis" means that discrete data (mainly in the current evaluation year) are sufficient for calculation.							

The above different methods for characterising stocks and flows have been analysed in order to determine the appropriate choice for the model type and sophistication level in relation to the data availability and quality for ProSUM. From past experience, UNU developed the advanced specific method (E) that can handle different data sources when multiple sources for all three key parameters are available. This allows, including judgement of the multiple data sets and advanced solving, the evaluation of the most plausible solutions when considering different data sources with different data qualities. For EEE, for the detailed country studies, this Multivariate Sales-Stock-Lifespan method (E) was used. This detailed analysis method, which only functions for multiple and high quality data available in some countries, enables the derivation of key parameters like lifespans, split factors, estimates and correlations. These in turn are used in the more simplified methods A – D to analyse future data in a more streamlined manner for future years, for all EU28+2 countries and for all three product groups. In section 3.1, these parameters are used in the method B1 in the table above. The stocks and flows model is built using a unified and robust mathematical approach following a common modelling methodology for all product groups. The same approach is used for BATT stock and flow modelling. In the case of ELV, the stock-lifespan approach (method C) is more suitable. In particular since relatively reliable data is available on the vehicle fleet size in Europe.

## 2 Data sources for product market input and stocks

### 2.1 Demographic information

Demographic data, in particular, population and households numbers are included. Population data has been taken from the IMF database (IMF, 2015) and individual country population consensus. The EU28+2 historic population data (1995-2020) is provided in Annex 1a. Likewise, household data has been taken from Eurostat (2005-2014). For Sweden, data is missing from 2005-2008. Also, there is no Swiss or Norway household data available in Eurostat. Here, the United Nations Economic Commission for Europe (UNECE) data has been taken for CHE and NOR for 2005-2011 and 2005-2012, respectively. Annex 2b covers the demographic data in the EU28+2.

### 2.2 Data sources for EEE Placed on the Market and in stock

#### 2.2.1 WEEE Directive Article 7 report as common methodology

The recently published Article 7 study by (Magalini et al., 2016) established a common methodology for the market input and WEEE generation, containing a time series of POM (Placed on the market) developed by Statistics Netherlands from 1980 to 2012 per UNU key. The method involves the following steps:

- *Part 1- Estimating ProdCom confidential data:* This is needed in addition to the publicly available CN information because some data points in the ProdCom statistics are not published due to confidentiality. A detailed overview of ProdCom statistics is given in Annex 3.
- *Part 2- Apparent consumption approach:* This step calculates a first version of POM based on the production and trade statistics (CN) into the classification for EEE: the UNU keys.
- *Part 3- Checks and corrections of POM:* The data from Part 2 still has missing data points and it can have outliers due to incorrect registration of the production and trade. They are corrected in this part. It involves automatic corrections by comparing the data between years of the same country, automatic corrections by comparing data for the same year between similar countries, corrections by using a few other data sources and some manual corrections based on information from experts. Also the calculation of POM for years before data was structurally registered is done by using overall percentages over the statistical data.

As part of the ProSUM project this recently published dataset has now been enlarged to include the years 2013 and 2014. For most countries the first year with data from statistics was 1995. For some others (Bulgaria, Estonia, Croatia, Hungary, Lithuania, Latvia, Poland and Romania), this is a few years later. Results from 1980 until the first year that data was available have been extrapolated by deducting 2 per cent each year starting from the first real statistical results. The impact of this extrapolation on the current stocks and waste generation is very minimal.

#### 2.2.2 ProdCom statistics and International trade statistics

Foreign trade (import and export) statistics for each product are registered under the Harmonized Commodity Description and Coding System (HS codes) developed by the World Customs Organization. In Europe, a more detailed and fully compatible coding system named Combined Nomenclature (CN codes) is used, in which the first six digits correspond with the HS codes with the seventh and eighth digits relating to EU specific subheadings (Eurostat, 2015). In parallel, domestic production is registered under the Community Production system (ProdCom codes). In most cases, one ProdCom code corresponds to one or more CN codes, and a linkage table with coding details is available annually in the EU Ramon database (Eurostat, 2015).

There are around 4000-6000 ProdCom codes and 8000-9000 CN codes for all commodities per year. From this, there are around 160-250 ProdCom codes to be regarded as EEE relevant,

according to their literal descriptions. Meanwhile, descriptions that refer to parts of EEE were excluded, as it would create double counting. By using the linkage tables, the corresponding CN codes can be traced from EEE-related ProdCom codes. A database containing annual changes and inclusion of codes for new goods has been jointly developed by United Nations University (UNU) and Statistics Netherlands (Baldé et al., 2015).

### 2.2.3 European Information Technology Observatory

Sales data from reports by European Information Technology Observatory (EITO, 2015) are used as complementary data sources. These reports cover information and telecommunication markets development. Table 3 provides the EITO evolution over the years (1996-2015).

Table 4. EITO coverage over the years

UNU keys	Year			
	1996	2005	2011	2015
0301 Small IT	√			
0302 Desktops	√		√	√
0303 Laptops			√	√
0304 Printers	√		√	√
0306 Mobile phones				√
0307 Professional IT	√		√	√
0309 LCD monitors			√	
0401 Small consumer electronics		√	√	
0402 Portable audio video equipment		√	√	
0403 Radio, Hi-Fi and Music		√	√	
0404 Video		√	√	
0406 Cameras		√	√	
0407 CRT TVs		√		
0408 LCD TVs		√	√	
0702 Game consoles		√	√	

### 2.2.4 European Union Statistics on Social Income and Living Conditions (EU-SILC)

European Union Statistics on Social Income and Living Conditions (EU-SILC) is an instrument to collect comparable micro data on income, poverty, social exclusion and living conditions. A part of the micro data describes the penetration level per household (percentage of households that possess the item) for the following durable goods: washing machines (0104), computers (0302 and 0303 together), phone connections (0305 and 0306 together) and possession of a colour TV (0407 and 0408 together). This data can be used as an indicative measure of the stocks in households for these particular goods and provides a cross-check for the calculated stocks based on the apparent consumption approach.

### 2.2.5 Additional stock data

More detailed national statistics, consumer surveys and country studies such as in the Netherlands (Huisman et al., 2012), Italy (Magalini et al., 2012), France (Monier et al., 2013), Belgium (Wielenga and Huisman, 2011), and Romania (Magalini et al., 2015b) are used to improve the used parameters for lifespan and average weights in particular. These studies serve as in- depth knowledge of consumer behaviour, their purchasing power, and product lifespan based on consumer disposal attitude. Likewise, they provide comparable data points for stocks in households, businesses, waste generation amounts and collection rates.

For a more complete overview, see Annex 2a.

## 2.3 Data sources for BATT stocks

### 2.3.1 Overview of the data sources

Table 5 lists the data sources providing data either directly on stocks, or on the parameters used to estimate the stocks and the waste generation, i.e. the volumes of batteries put on the market and residence times. The data sources are presented more in detail in sections 2.3.2 to 2.3.4.

**Table 5. Data sources for sales volumes put on the market, residence times and stocks (see Annex 2b)**

Reference	Scope	Description	Data availability
<b>Eurostat (LoW)</b>	Portable batteries	Portable batteries POM and collected	Eurostat: <a href="http://ec.europa.eu/eurostat/web/waste/key-waste-streams/batteries">http://ec.europa.eu/eurostat/web/waste/key-waste-streams/batteries</a>
<b>ProdCom</b>	All battery types	Sold production in, exports from and imports to the member states	Eurostat
<b>SYDEREP - French Battery producer Register</b>	All battery types	Batteries put on the market, collected and treated in France	Public: <a href="http://www.ademe.fr/en/batteries-and-accumulators-in-france-summary">www.ademe.fr/en/batteries-and-accumulators-in-france-summary</a>
<b>Avicenne</b>	All battery types	Battery Market Development for Consumer Electronics, Automotive, and Industrial	Publication of Avicenne at the yearly Nice Batteries Congresses
<b>Eucobat key figures of batteries POM and collected</b>	Portable and some data on industrial batteries on POM in the countries in which collection of industrial batteries by schemes is not forbidden	Data collected by the Eucobat members on portable and industrial batteries POM and collected 2011-2014	Confidential data made available by Eucobat after signature of a NDA
<b>IHS, Eurobat, ACEA, JAMA, KAMA, ILA</b>	Lead automotive batteries	Automotive lead-based batteries POM, collected and recycled	Executive summary publicly available: <a href="http://www.eurobat.org/sites/default/files/ihs_eurobat_report_lead_lores_final.pdf">http://www.eurobat.org/sites/default/files/ihs_eurobat_report_lead_lores_final.pdf</a>
<b>EUROBAT</b>	Lead industrial batteries	Battery market volumes	Available online: <a href="http://www.eurobat.org/sites/default/files/industrial_batteries_data_and_outlook-update_2013.pdf">http://www.eurobat.org/sites/default/files/industrial_batteries_data_and_outlook-update_2013.pdf</a>
<b>Bebat + similar studies in NL +FR</b>	Portable batteries	Batteries in use and hoarded	Confidential data made available after signature of a non-disclosure agreement
<b>Eucobat study</b>	Portable batteries	Age and types of batteries collected in 6 countries.	Confidential Eucobat data available in 2016
<b>EPBA</b>	Portable batteries	Portable batteries POM and collected	Public: <a href="http://www.epbaeurope.net/documents/Perchar ds Sagis- EPBA collection target report - Final.pdf">http://www.epbaeurope.net/documents/Perchar ds Sagis- EPBA collection target report - Final.pdf</a>

<b>Stiftung Gemeinsames Rücknahmesystem Batterien</b>	All battery types	Batteries put on the market and collected	Public: <a href="http://www.grs-batterien.de/grs-batterien/zahlen-und-fakten.html">www.grs-batterien.de/grs-batterien/zahlen-und-fakten.html</a>
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### 2.3.2 Public statistics on batteries placed on the market

At a European level, the statistical office of the European Commission Eurostat provides two sources of data on batteries put on the market:

- The Environmental Data Centre on Waste (Eurostat, 2015c) provides data on generation of Batteries and accumulator wastes (Eurostat 2015d) in kg per inhabitant and tonnes, in which different types of batteries are not distinguished.
- Statistics on the production of manufactured goods (ProdCom) provide data on sold production in, exports from and imports to the EU member states as well as Iceland, Norway and Turkey for four categories of batteries (Primary cells and primary batteries, Lead-acid accumulators for starting piston engines, Lead-acid accumulators, excluding for starting piston engines, Nickel-cadmium, nickel metal hydride, lithium-ion, lithium polymer, nickel-iron and other electric accumulators).

The missing distinction of the different types of batteries as well as doubts on the data quality reduce the usefulness the data. Some countries like France (SYDEREP, 2016) publish national statistics on batteries put on the market and distinguish more types of batteries.

### 2.3.3 Avicenne data on batteries placed on the market

Every year, the consulting company Avicenne publishes market data at the Battery Congress in Nice (France). These data are collected every year by RECHARGE. Also a commercial report is made available by (Avicenne, 2015)

### 2.3.4 Data from industrial associations and companies on batteries placed on the market

The industrial associations Eucobat (Eucobat, 2015), Eurobat (Eurobat, 2013), EPBA (Perchards, 2015), as well as other organisations like collection schemes for waste batteries (e.g. the German GRS Batterien Foundation (GRS Batterien, 2015)) collect data on batteries placed on the market. Some of the data are publicly available, others are confidential but agreements will be found and signed to aggregate and use them in ProSUM.

### 2.3.5 Data on stocks

Data on stocks of batteries is provided by the company Bebat, as well as the French organisation Corepile and the Dutch organisation Stibat. The raw data are, in principle, confidential but are made available for ProSUM after signature of a non-disclosure agreement. Like for the data on batteries placed on the market, agreements will be found and signed to enable the use of aggregated data for ProSUM.

For a more complete overview, see Annex 2b.

## 2.4 Data sources for ELV stocks

### 2.4.1 EuroStat and ACEA

The Eurostat database (Eurostat, 2016a) and ACEA (ACEA 2015) are the two primary data sources for vehicle stock data. They each publish monthly data on new vehicles and annual data on stock size. Additionally, the ANFAC report from ACEA (ACEA, 2015) contains a snapshot of the distribution of the fleet in 2014 against all of the vehicle keys described in 1.2.3. This snapshot can be used to test the stock-lifespan model to ensure that the regular data additions will result in an accurate estimate of fleet distributions.

### 2.4.2 National Vehicle Statistics Agencies

The statistics from ACEA and Eurostat omit data for some member countries, in particular the EFTA (EU Free Trade Area) countries Iceland, Norway, and Switzerland. Norway and Switzerland are both highly relevant for tracking internal second hand markets and ELV processing and should therefore be included. For these countries, data on the fleet size and annual additions can be obtained directly from the national statistics offices. Switzerland has highly detailed data (BFS, 2015), but Norwegian data is limited to a small subset of the vehicle keys (SSB, 2015), and thus requires some data consolidation to fit with the main data set.

### 2.4.3 COMTRADE, import/export and second hand vehicle flows

As mentioned in 2.2.2, Europe uses a detailed coding system named Combined Nomenclature (CN codes) to track import and export vehicles (Eurostat, 2011) in the COMTRADE database. COMTRADE data for imports and exports from the EU is not directly necessary for determining POM vehicles, as national registration counts imported vehicles as well. The chief necessity for import/export data is to add data points for approximating how many vehicles are deregistered and then exported for second hand use or external ELV processing.

Internal trade flows of second hand vehicles should theoretically not affect the overall stock of vehicles in service in Europe, but are highly relevant when attempting to calculate the lifespan of stocks in various countries, as many national data sources count second –hand exports as ‘end of life’, producing unrealistically short apparent lifespans. This effect can be well understood by comparing the results in (Oguchi et al., 2015) and (Melhart et al., 2011). The latter is a report produced for the European Commission, and contains a fairly exhaustive accounting of second hand vehicle flows in the EU, using mainly Eurostat and COMTRADE data. It is therefore a critical secondary reference and contains links to all of the relevant publicly available data tables.

### 2.4.4 Bibliographic information (from 2.1 and Annex 2)

Table 6 lists the main data sources described above providing data on stocks, or on the parameters used to estimate the lifetimes and intra-regional trade for second hand vehicles and ELVs. Additional references can be found in Annex 2.

Table 6. Main Data Sources for ELV Stock Modelling (See Annex 2c)

Reference	Scope	Description	Data availability
<b>Eurostat</b>	EU, Vehicles in Use	POM and fleet data	Public: Available at <a href="http://ec.europa.eu/eurostat/data/database">http://ec.europa.eu/eurostat/data/database</a>
<b>ACEA</b>	EU, Vehicles in Use	POM and fleet data	Public: Available at <a href="http://www.acea.be/statistics/tag/category/registrations-and-press-release-calendar">http://www.acea.be/statistics/tag/category/registrations-and-press-release-calendar</a>
<b>COMTRADE</b>	EU	Import/Export data	Public: Available at <a href="http://COMTRADE.un.org/data/">http://COMTRADE.un.org/data/</a>
<b>ANFAC EU Vehicles in Use Report</b>	EU, Vehicles in Use	Statistics breaking fleet down into sub distributions	Public: Available at <a href="http://www.acea.be/uploads/statistic_documents/2013_ANFAC_Report.pdf">http://www.acea.be/uploads/statistic_documents/2013_ANFAC_Report.pdf</a>
<b>Melhart et al., 2011</b>	EU, Vehicles in Use and ELV	Data and methods to use trade data for correcting vehicle stock for second hand trade in EU	Public: available at <a href="http://ec.europa.eu/clima/policies/transport/vehicles/docs/2010_2nd_hand_car_en.pdf">http://ec.europa.eu/clima/policies/transport/vehicles/docs/2010_2nd_hand_car_en.pdf</a>
<b>Oguchi et al., 2015</b>	Global	Methods for inferring stock lifetimes	Private: doi:10.1021/es505245q

For a more complete overview, see Annex 2c.

## 3 Stock and flow modelling approach

### 3.1 Approach for EEE

Based on the approach in Section 1.3, the sales component EEE placed on the market (POM) is estimated with the “Apparent Consumption” methodology. This method uses available statistical data as the central data source:

- In the EU, the figures for domestic production can be taken from the ProdCom statistics.
- EEE products produced domestically can also be sold abroad, thus need to be corrected for by subtracting exports.
- Imports of EEE, on the other hand, can also be consumed in the country of import, thus need to be added to the total.

The import and export data can be retrieved from CN codes. Within CN codes, the legally reported import and export of second-hand goods are included along with the new products. Each ProdCom code has one or more corresponding trade codes. With these codes, the EEE POM for a certain type of equipment in a territory can be calculated with the following equation:

$$\text{Apparent consumption} = \text{Domestic Production} + \text{Import} - \text{Export}$$

Statistical data are needed for all the relevant ProdCom and CN codes to apply this methodology. The relevant codes for EEE have been identified according to the 2012 classification for CN codes. The CN codes can be linked to ProdCom codes using correspondence tables published by Eurostat to the EU Ramon database. For some ProdCom and CN codes, the data is available in weight; in other cases, pieces are used as the primary unit. Product average weights per UNU key are listed in Table 7. The ProdCom and CN codes are revised annually, and the year-to-year changes are also published in the EU Ramon Database. National Statistical Institutes collect, process and publish statistics on manufactured goods and international trade. These are published periodically in their respective online databases. Data from the National Statistical Institutes are also published on the EUROBASE (the Eurostat dissemination base), which is operated by Eurostat. For the non-EU countries, data can be retrieved from the United Nations Statistical Division, particularly from the COMTRADE database. A detailed methodology is described in Annex 3.

**Table 7. Product average weight per UNU key ( in kg/pc)**

Average product weight	2010	2014	Average product weight	2010	2014	Average product weight	2010	2014
0001	30.9	30.3	0205	0.5	0.4	0501	0.1	0.1
0002	20.0	20.0	0301	0.3	0.4	0502	0.1	0.1
0101	48.9	13.2	0302	8.8	8.0	0503	0.1	0.1
0102	43.3	40.8	0303	3.2	3.2	0504	0.1	0.1
0103	47.7	42.6	0304	10.3	10.2	0505	n/a	0.1
0104	72.4	57.6	0305	0.5	0.5	0506	0.5	0.4
0105	45.9	26.4	0306	0.1	0.1	0507	2.7	2.5
0106	5.5	3.9	0307	11.6	7.8	0601	15.7	11.2
0108	54.8	49.8	0308	22.0	5.9	0602	3.5	5.9
0109	44.1	37.9	0309	5.5	5.5	0701	0.5	0.4
0111	26.7	17.5	0401	0.4	0.4	0702	1.9	2.0
0112	41.1	23.4	0402	0.2	0.2	0703	7.4	6.2
0113	91.5	56.2	0403	3.4	3.7	0801	0.2	0.2

<b>0114</b>	22.9	16.6	<b>0404</b>	2.7	2.2	<b>0802</b>	5.2	1.1
<b>0201</b>	0.8	0.8	<b>0405</b>	2.1	2.1	<b>0901</b>	0.4	0.6
<b>0202</b>	3.0	2.1	<b>0406</b>	0.3	0.3	<b>0902</b>	5.5	4.7
<b>0203</b>	2.8	1.9	<b>0407</b>	33.2	n/a	<b>1001</b>	44.0	12.0
<b>0204</b>	5.9	4.6	<b>0408</b>	14.7	14.7	<b>1002</b>	92.2	29.4

\* See Annex 4 for the list of products represented for above UNU keys

According to the common methodology and the application of model B as explained in section 1.3, the quantity of WEEE generated in a specific year is calculated by a collective sum of discarded products that were placed on the market in all historical years multiplied by the appropriate lifespan distribution. The lifespan distribution reflects the probability of a product batch being discarded over time, thus matching the definition of waste according to article 3 of the Waste Framework Directive.

To apply the methodology selected, for each type of product, the following data are needed for each country:

- Historical EEE POM data for product type by weight;
- and lifespan distribution per product type.

The lifespan for the various UNU keys were taken largely from previous country studies. Table 8 provides an overview of lifespan used for this study based on the methodology described above.

**Table 8. Product lifespan per UNU key for year 2014**

UNU keys	Median lifespan (years)	UNU keys	Median lifespan (years)	UNU keys	Median lifespan (years)
<b>0001</b>	11.8	<b>0205</b>	6.0	<b>0501</b>	6.7
<b>0002</b>	21.6	<b>0301</b>	4.6	<b>0502</b>	6.7
<b>0101</b>	13.3	<b>0302</b>	8.4	<b>0503</b>	4.7
<b>0102</b>	14.0	<b>0303</b>	7.3	<b>0504</b>	5.5
<b>0103</b>	16.1	<b>0304</b>	7.7	<b>0505</b>	8.3
<b>0104</b>	10.9	<b>0305</b>	5.8	<b>0506</b>	14.2
<b>0105</b>	15.7	<b>0306</b>	4.4	<b>0507</b>	10.4
<b>0106</b>	11.2	<b>0307</b>	6.0	<b>0601</b>	12.2
<b>0108</b>	14.1	<b>0308</b>	12.3	<b>0602</b>	13.4
<b>0109</b>	13.9	<b>0309</b>	10.4	<b>0701</b>	3.5
<b>0111</b>	17.2	<b>0401</b>	7.5	<b>0702</b>	3.5
<b>0112</b>	11.4	<b>0402</b>	7.8	<b>0703</b>	9.9
<b>0113</b>	12.2	<b>0403</b>	8.5	<b>0801</b>	11.2
<b>0114</b>	15.1	<b>0404</b>	6.0	<b>0802</b>	11.6
<b>0201</b>	5.9	<b>0405</b>	9.1	<b>0901</b>	4.7
<b>0202</b>	9.2	<b>0406</b>	5.0	<b>0902</b>	9.6
<b>0203</b>	5.6	<b>0407</b>	10.4	<b>1001</b>	8.4
<b>0204</b>	7.8	<b>0408</b>	9.0	<b>1002</b>	12.5

\* See Annex 4 for the list of products represented for above UNU keys

### 3.2 Approach for BATT

Similar to WEEE, a lifetime distribution of batteries is modelled, based on data on the age of collected batteries, using a Weibull function. The lifetime distribution is defined as the probability density function that a battery that entered the use phase at time  $t_0$ , exits use as a waste battery at time  $t_1$ . As with EEE, a sales-lifespan approach is taken to calculate EU totals.

Data on the flows of batteries in tons put on the European markets in the year 2000-2014 were published by (Avicenne, 2015). The data were mixed with other data sources like Eurostat to get figures differentiated according to the countries and to the electrochemical systems (BATT keys). Experimental data on the residence time distribution of portable batteries collected in 2012 were presented by Bebat at the International Congress for Battery Recycling 2014 (Bebat, 2014). These data are currently being refined by Eucobat with a more comprehensive study in six European countries, for which results are expected by June 2016.

The expected arising as waste batteries in the years after being put on the market was calculated based on the modelling of the residence time distribution. The total modelled generation of waste batteries for the year X is the sum of the generation in year X of batteries put on the market in all years before X. The stocks are the sum of the batteries already put on the market but not yet generated as waste. The subsequent modelled stocks can be compared with the data periodically collected through surveys in households by Bebat and cross-checked.

### 3.3 Approach for ELV

There are a large number of data sources that report historically registered vehicle stocks at an aggregated and national level within the EU. Eurostat and ACEA/ANFAC will be the primary data sources used, and have been detailed in section 2.4.1. As mentioned, new registrations are reported with detailed data available for most member states, and with high reliability. The ANFAC report from (ACEA, 2015) also contains a detailed snapshot of the fleet distribution in 2014. The main issue with the available data sources is that annual deregistrations are typically reported as an aggregated number, and it is usually not clear whether a deregistered vehicle represents a vehicle sent to processing, inter-state trade, or to the passive stock. There are significant discrepancies in available vehicle and ELV reporting, both in numbers and in methodology. The primary information need and thus the objective of modelling is thus to disaggregate these end of life flows and to produce a stock-lifespan model (see section 1.3 for a detailed description) incorporating the best data available for the vehicle key distribution (section 1.2.3).

Finding fleet lifespans is therefore a primary issue. Previous literature aimed only at finding the 'in-service' age distribution of the stock has ignored the end-of-life fate issue (Oguchi et. al, 2015) and used 'leaving the national active fleet' as a lifespan definition, which is not sufficient for our purposes. Generalized approaches for a stock-lifespan model estimation that inspired our work can be found in (Petiot et al. 2015) and (Melhart et. al, 2011). Data on age distribution of ELV flows exists for some member nations and will be combined with studies on second hand vehicle trade e.g. (Melhart et al. 2011), in order to estimate the lifespan parameters in our stock-lifespan model. This allows the accurate aggregated new registrations and total stock figures to be mapped to the best possible estimates for how the stock is distributed in terms of both age and with the detailed categorisation used in our vehicle keys.

## 4 Results and Discussion

This chapter provides the results produced using the methodologies described in Chapters 2 and 3. Due to the existing methodology, and expansion thereof, the WEEE part is more advanced. It provides POM, waste generation and stocks data by Member State (MS) and collection category. Initial results for the BATT and ELV approaches are also highlighted.

### 4.1 WEEE

#### 4.1.1 Market entry (incl. reconstruction historic POM)

Data sources for EEE, WEEE and stock include the UNU Article 7 study (Magalini et al., 2016), (EITO, 2015), Eurostat, IMF, individual country studies and the CWIT report (Huisman et al., 2015). In Figure 3, the **newly** estimated market input is presented in kg/inh per EU Member State for the year 2014. Norway ranks top in the chart with 34.7 kg/inh with a breakdown of 7.4 kg/inh in temperature exchange equipment, 3.4 kg/inh in screens, 0.3 kg/inh in lamps, 9.7 kg/inh in large equipment, 11.4 kg/inh in small equipment, and 2.4 kg/inh in small IT.

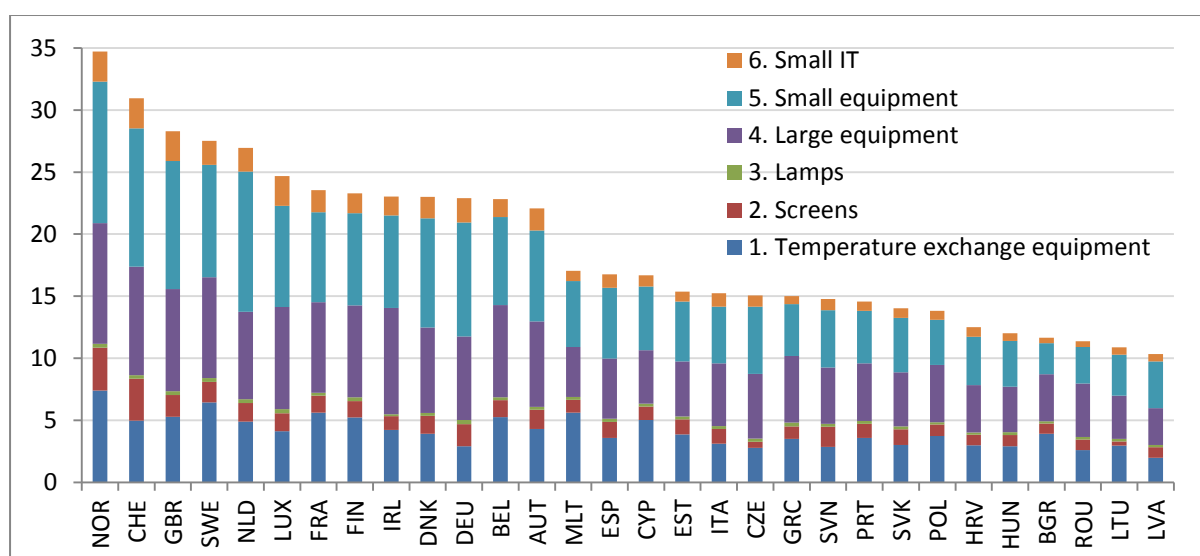


Figure 3. POM per Member State in kg/inh, 2014

The historic consumption of EEE is growing at a very rapid pace from 1995 until 2005, in particular. In 1995 put on market EEE accounts for 7,299 ktons, followed by 11,066 ktons in 2005, 10,698 ktons in 2010, and 10,290 ktons in 2015. With linear extrapolation beyond 2015, EEE will account for 10,490 ktons in 2020 (excluding PV after 2013). The main driver behind this is the rise of a new middle class in the Central and Eastern EU countries, having more income to buy much more electronic products. Behind these numbers in tonnages, there is a high growth rate in the number of products sold, against ongoing miniaturisation and lighter products.

It should also be noted that for 2014 onwards, no PV data is available yet. This UNU key is determined by reviewing the total installed PV capacity per member state which is not available at Eurostat yet. Unlike other products, there is no market prognosis provided for PV due to very unpredictable market developments.

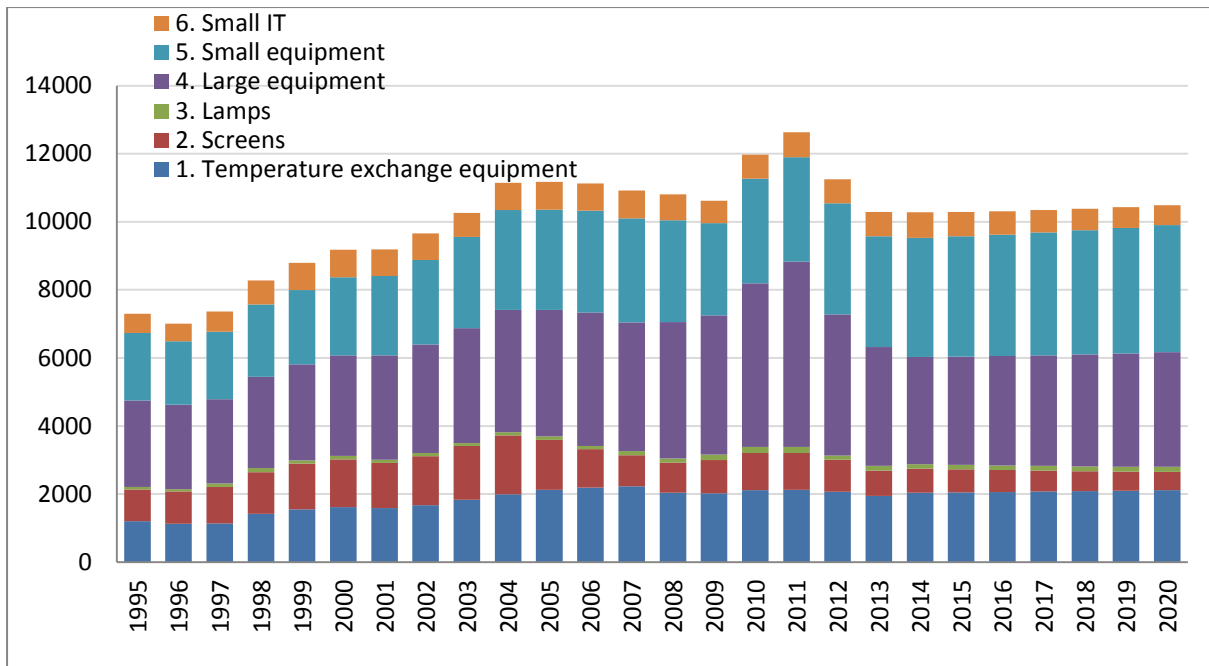


Figure 4. POM 1995-2020 per collection category in kt

#### 4.1.2 Stocks (kg/inh)

Using the methodology described in Chapter 2, the total stocks and WEEE generation is determined per UNU key, per country for 1995-2020. The resulting stock per country is presented in Figure 5 for 2014 in kg per inhabitant. The values range from 333 kg/inh and 310 kg/inh for the richest countries being Norway and Switzerland, to 128 kg/inh and 120 kg/inh for the lower income countries Latvia and Romania, respectively.

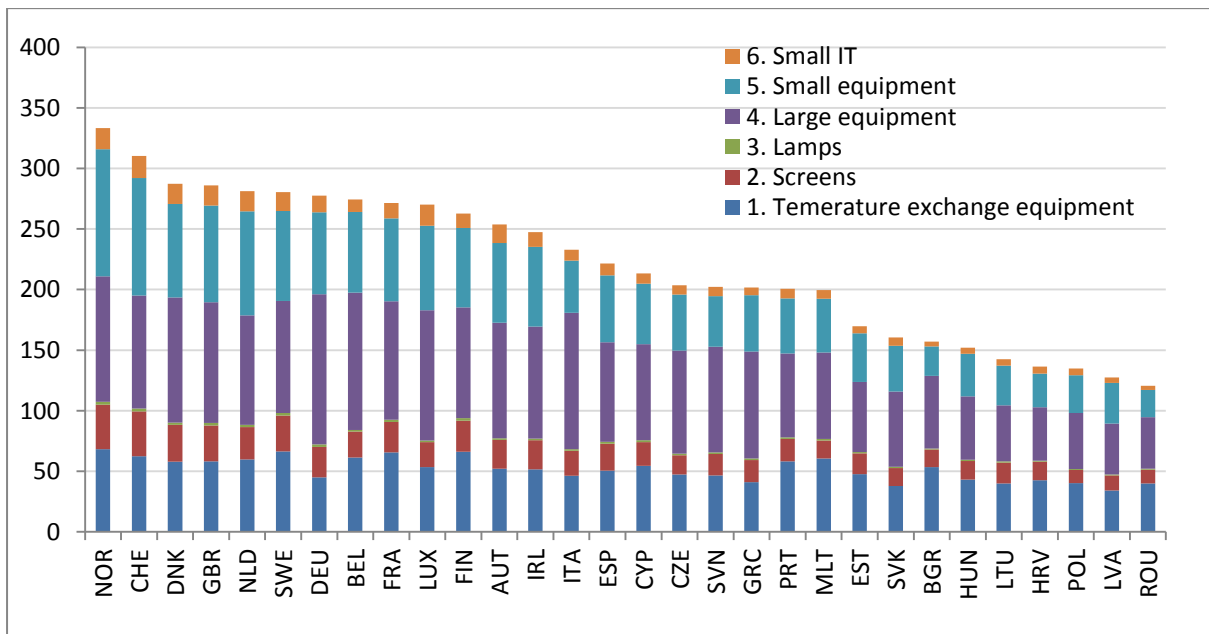


Figure 5. Stock in kg/ inh per Member State for year 2014

The total stock development is displayed in Figure 6. The total stock contributes to around 126 million tonnes by 2020 (excluding POM of PV from after 2014).

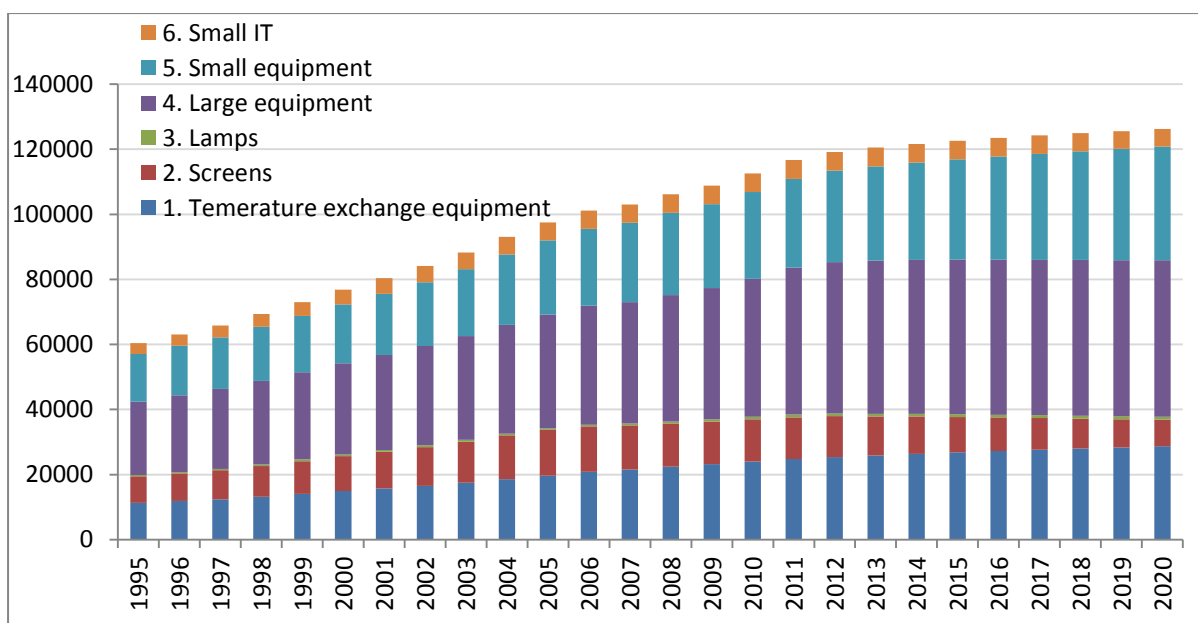


Figure 6. Historic stock per collection category in kt

Data from the Netherlands (Huisman et al., 2012) with very detailed information is used to determine split factors between equipment in stock at households versus those in businesses and public space. Table 9 lists the households and businesses data in kg/inh updated to the year 2014. This information is relevant since for most other countries, only data on the amounts present in households is available, which is not always the majority of the stock. When only household data is used and cross-checked this may lead to underestimates for country totals.

Table 9. Dutch B2B, B2C stock splits

WEEE recast collection categories	Sum of Stock/inh	Sum of B2B kg/inh	Sum of B2C kg/inh
1. Temperature exchange equipment	59.8	9.9	50.0
2. Screens	26.8	4.5	22.3
3. Lamps	1.7	0.5	1.3
4. Large equipment	90.5	9.0	81.5
5. Small equipment	85.9	4.3	81.6
6. Small IT	16.7	3.9	12.8

#### 4.1.3 Waste generated (kg/ inh)

The WEEE generation for the EU market, resulting from the sales lifespan approach as outlined in Chapter 2, is displayed in Figure 7 in kg per inhabitant. WEEE Generation ranges from around 25 kg/inh for Norway and Switzerland to around 10 kg/inh for Bulgaria, Poland and Romania.

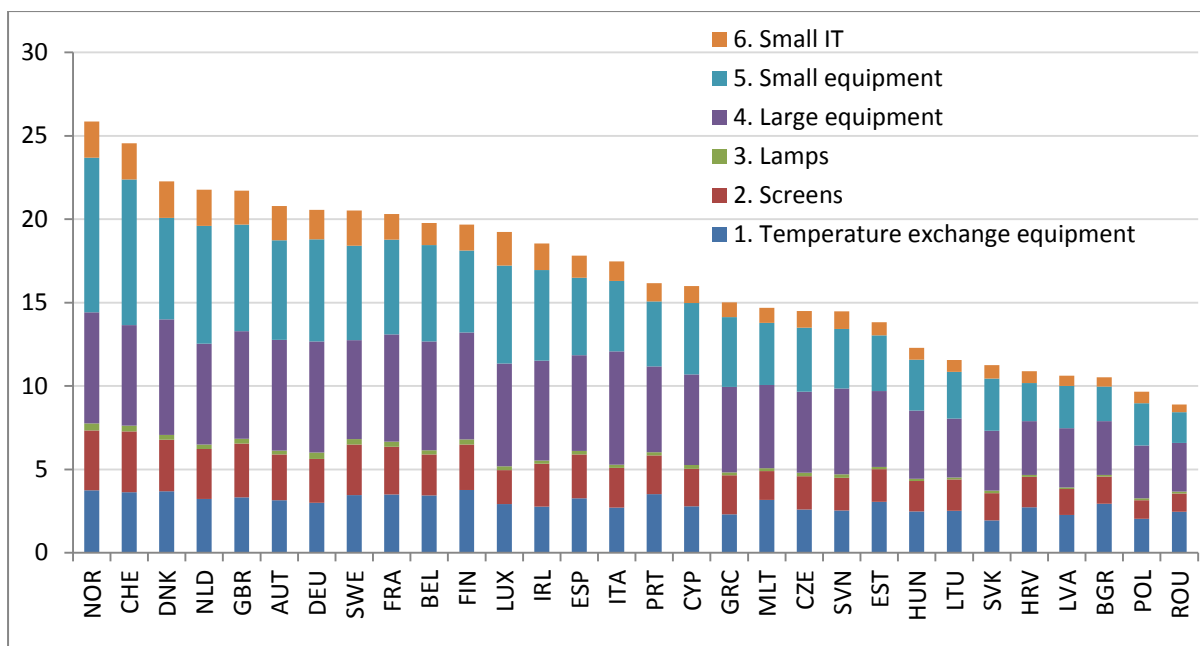


Figure 7. Waste generation per Member State in kg/inh, 2014

In Figure 8 the WEEE Generation over time is visualised per collection category. In 1995, waste generation accounts for 4.2 kt, followed by 7 kt in 2005, 8.5 kt in 2010, and 9.56 kt in 2015. With linear extrapolation beyond 2015, WEEE will account for 10 kt in 2020 (excluding PV after 2013).

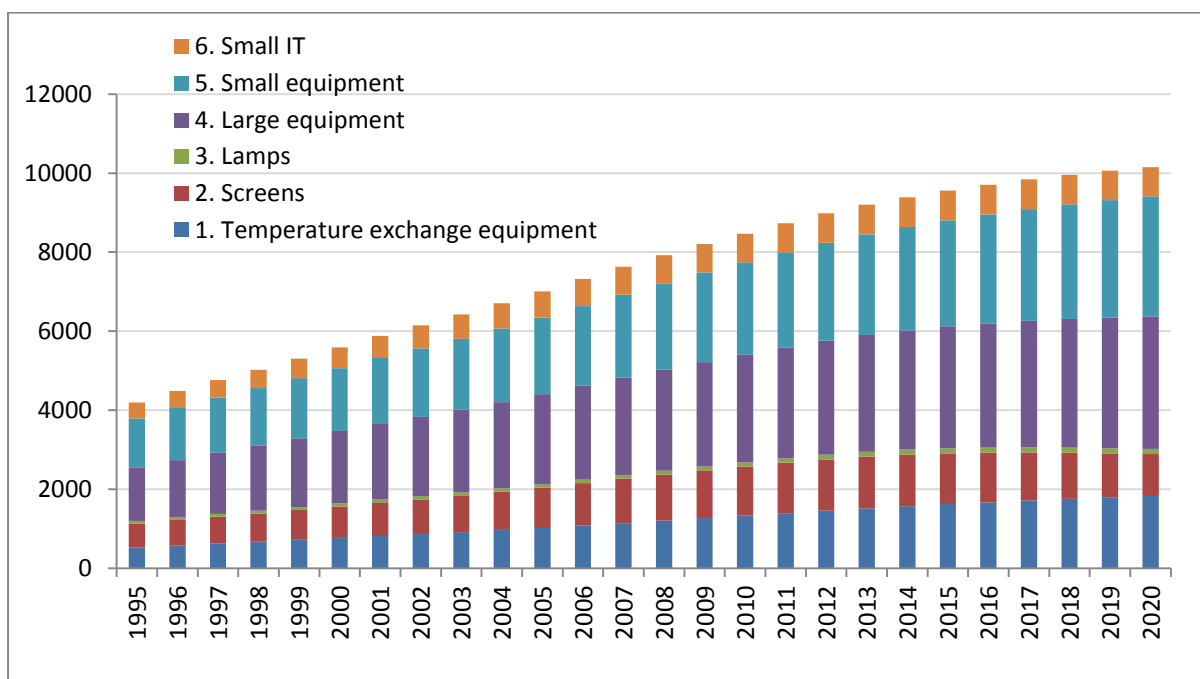


Figure 8. Historic waste generation per collection category in kt

## 4.2 BATT

This section presents initial results of the stocks and flow model for batteries. The consolidation of the identified data and the modelling will be continued in the coming tasks, in order to gather the modelled data on stocks of batteries and generation of waste batteries, which will be compared to the measured data on stocks (through survey) and flows of collected waste batteries (see section 2.3).

#### 4.2.1 Market entry

A preliminary analysis of the (Avicenne, 2015) data by Recharge focused on the batteries put on the market in laptops in the years 2000-2014. Figure 10 shows the amounts of batteries put on the market in tons per year.

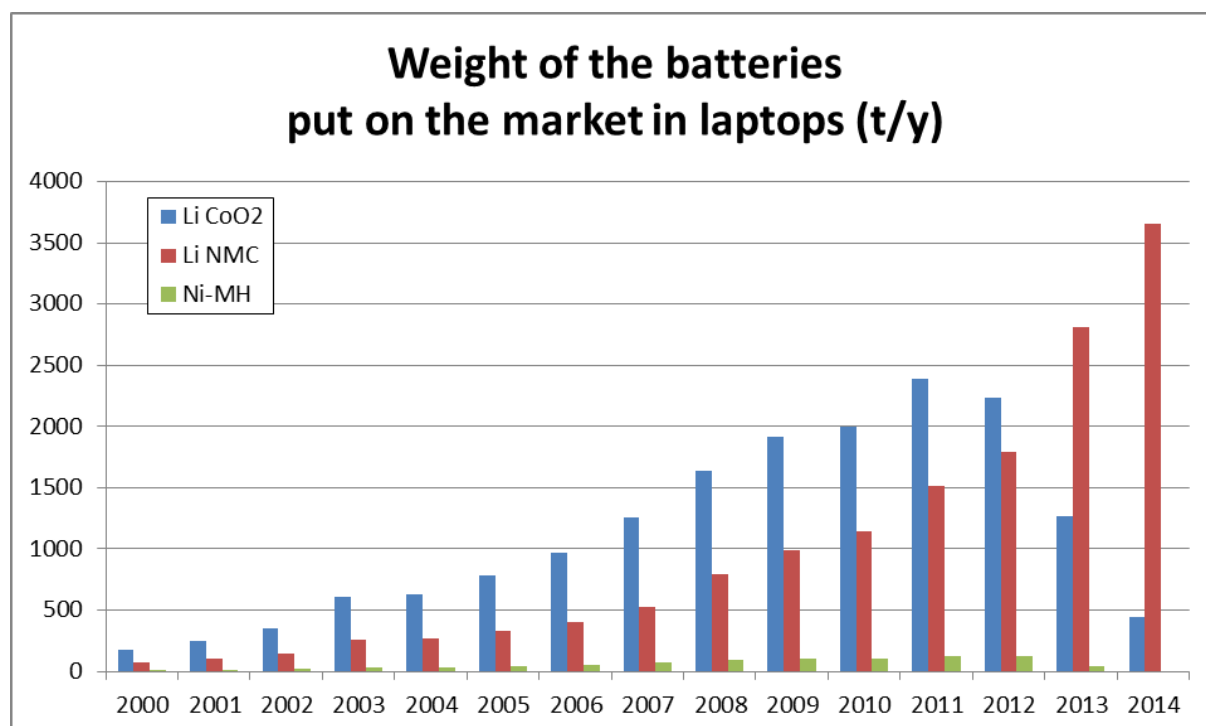


Figure 9. Weight of the batteries put on the market in laptops (t/y) (data source: Avicenne data prepared by Recharge)

To make the volumes in tonnes convertible into units, data on the average weight of batteries in different products are necessary. The available data presented in Table 10.

Table 10. Average weight of batteries classified according to the BATT keys in kg in different products (data source: Avicenne data prepared by Recharge)

	Portable batteries						Auto-motive	Mobility				
BATT key	Portable PC	tablets	cell phones	cameras/ga mes	cordless tools	others portable	SLI	E-bikes	HEV	PHEV	EV	forklift, handling equipment
Li-ion	0.29		0.03	0.17	0.3	0.17		2.2	5.4	56	156	5.2
Ni-MH	0.29	0.05	0.03									
Ni-Cd					0.9							
Others												26.9
Pb auto-motive							18					

#### 4.2.2 Residence time

Preliminary data on the age of collected waste batteries (lifespan from production to collection in Belgium in 2012) were presented by Bebat at the International Congress for Battery Recycling (BEBAT, 2014), showing the age of an extensive sample of 17000 waste batteries with a known production date collected in Belgium in 2012. For lithium rechargeable batteries contained in 4 products types, the probability density function that best fits the experimental data, i.e. the model

of the lifespan distribution of the sampled waste batteries, was determined using both a Weibull and a normal distribution (Figure 10).

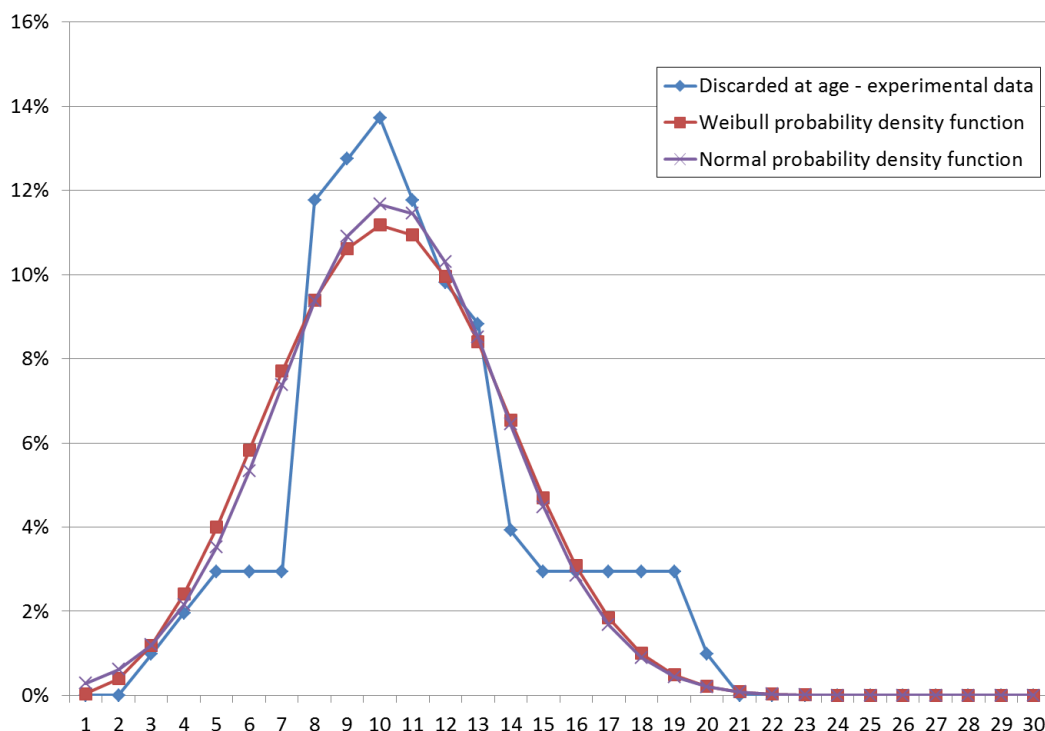


Figure 10: Modelling of the experimental data using a Weibull and a normal probability density function

The parameters of the Weibull function, which better fitted the experimental data than the normal function, were determined, including the median lifespans (Table 11).

Table 11. Median lifespan of batteries contained in 4 product types (data source: Bebat, 2014)

Product	Median lifespan (years)	Sample size (number of batteries analysed)
Laptop battery	9.8	102
Power tools	2.6	33
Cell phone	6.1	162
Camera and others	6.6	118

This experimental data are currently improved by an extensive sampling and age determination of collected waste batteries in 6 countries in a study conducted by Eucobat. The results are planned to be available in June 2016. This will be further processed in deliverables 3.3 and 3.4.

#### 4.2.3 Waste generated and stocks

The modelling approach was tested on a dataset indicating the number of batteries (including lithium-ion and NiMH batteries) put on the market in laptops in the years 1998 to 2014. For the years after 2014, it was assumed that the market stayed stable and the sales volumes for 2014 were used. The lifespan distribution was modelled based on the data mentioned in section 4.2.2, resulting in a Weibull function with a shape of 3.2 and a scale of 11.0.

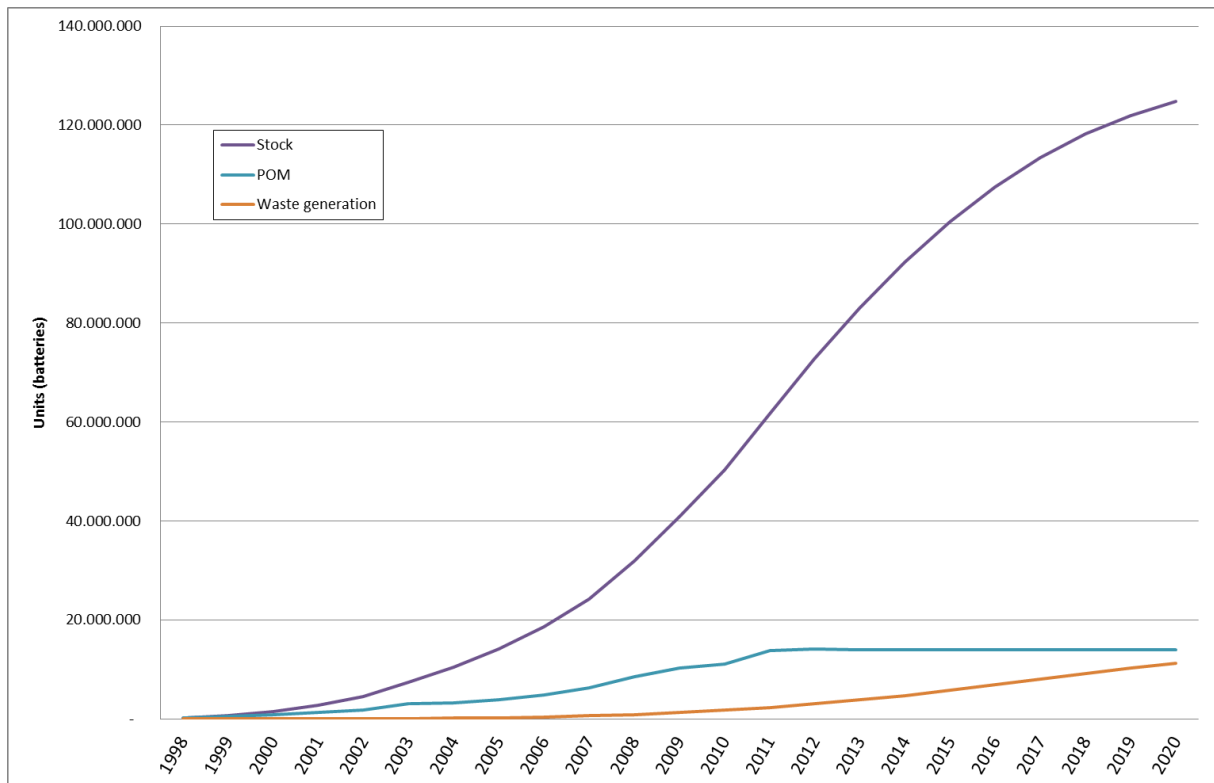


Figure 11: Number of batteries put on the market (POM), in stocks and generated as waste in the EU-28

#### 4.2.4 Next steps of the modelling of stocks and flows

The methodology testing could be considered as successful for the selected case study. As a next step, the modelling needs to be expanded to further dimensions to obtain the targeted granularity in terms of countries, battery keys, sub-keys and products. They also need to be compared to the data gathered for EEE and for vehicles, since the stocks and flows of batteries are linked to the stocks and flows of products in which they are embedded, even though the number of units are not necessarily identical (e.g. a user can own a second battery for his/her laptop).

This exercise of data consolidation, which was not conducted yet, will consider the data from different data sources, identify the discrepancy with the aim of understanding them and determine the most valid data for entering it into the modelling and including into the database. Not only the used data need to be compared, aligned and discussed, but also the results of the modelling, in order to deliver robust data on stocks and flows that enable a better understanding of the location of (critical) secondary raw materials.

## 4.3 ELV

### 4.3.1 Market entry (including reconstruction of historic POM)

The historic record from vehicles POM is shown in Figure 12 taken directly from ACEA data (ACEA, 2015). The figures include both domestically produced vehicles and new vehicles imported into the EU. Overall, new vehicle registrations have declined somewhat since the peak in 2007. The top five nations (Germany, the United Kingdom, France, Italy and Spain) consistently represent slightly over two thirds of all new vehicle registrations.

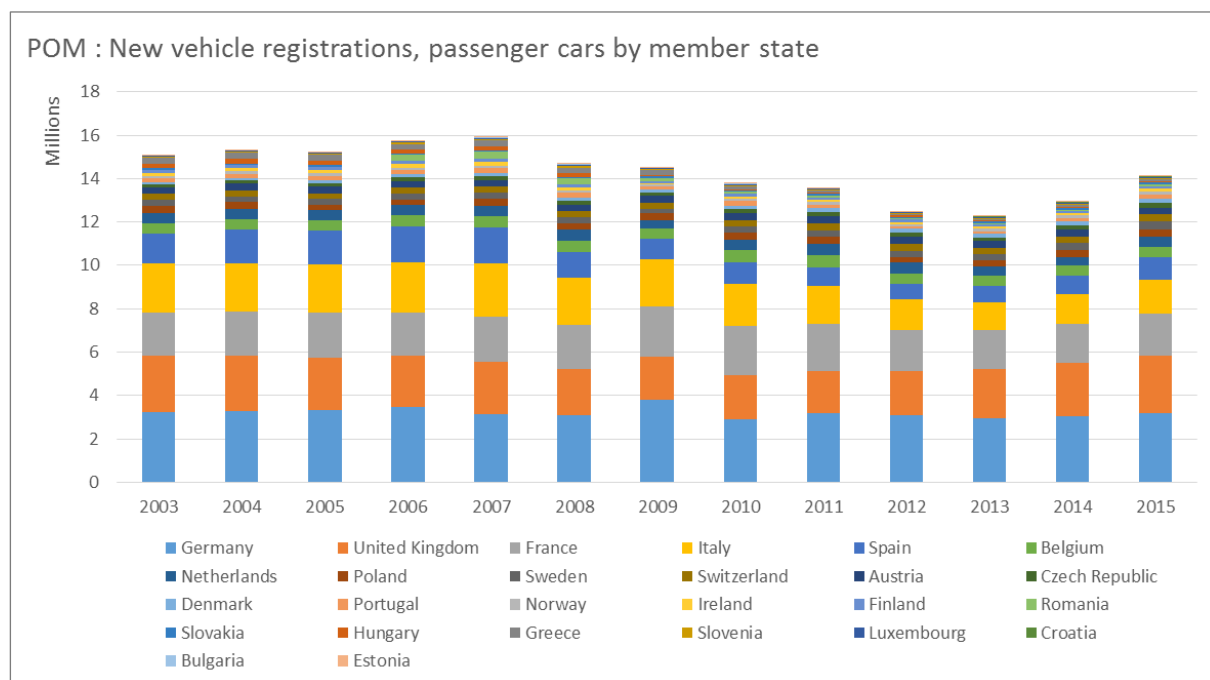


Figure 12. Historic vehicle registrations (2003-15) per Member State

Removals from the registered fleet are approximately twelve million per year, leaving a net increase of some two million vehicles annually. The total EU fleet is thus growing at 0.8% per year at present, as shown below.

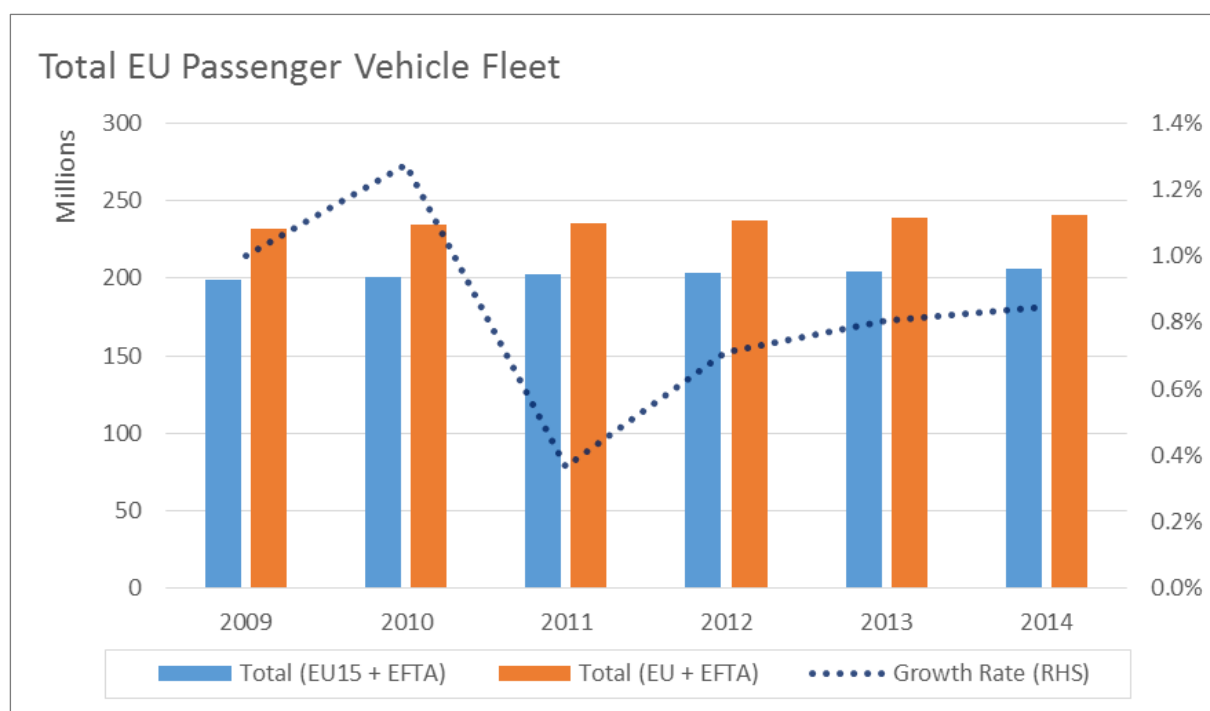


Figure 13: Aggregate EU vehicle fleet size (left axis) and growth rate (right axis)

The breakdown of the aggregate and national fleets into the vehicle keys such as fuel type is available from both ACEA and Eurostat, which will greatly simplify calculation of the age distribution for each vehicle key. ACEA data for cylinder size however only indicates above or below 2000cc, meaning that other primary sources will be required to fully populate the cylinder size data set. Eurostat includes this data, but in terms of POM vehicles and thus some harmonization work is still required.

#### 4.3.2 Lifetime estimates and age distributions of the in-use fleet

Again, the in-use fleet is taken directly from primary consolidated data from (ACEA, 2015). The ACEA data only has detailed breakdowns of the fleet age distribution for each of the last ten years and an aggregate total for vehicles over ten years of age, but also includes an average age for each national fleet. By calculating the average age of the known vehicle cohorts under ten years of age, the average age of vehicles over ten years can be inferred for each of the national fleets, as in Figure 14.

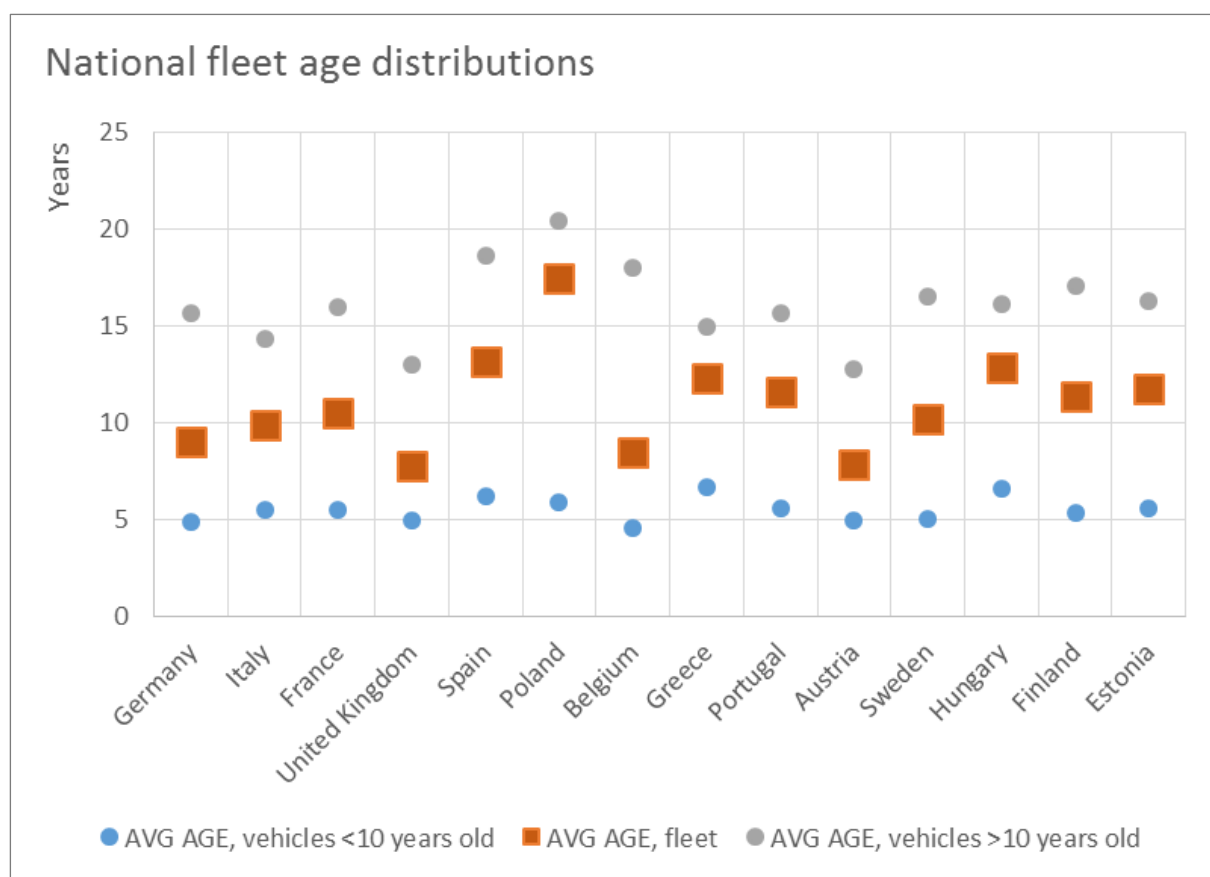


Figure 14: Calculated vehicle age averages for the largest national fleets

The average age of vehicles over ten years in the EU fleet can thus be calculated by a weighted average; the result is that a vehicle older than ten years in the EU is on average 16.5 years old. Given this average as well as the total number of such vehicles, many possible distributions can be fitted to both parameters. The best available estimate for this remaining distribution at present is a Weibull decay curve, which gives a rapid drop off and a long tail. The full age distribution is known for several national fleets, and together with the historical vehicle sales can add finer resolution. Further work to refine this estimate is ongoing.

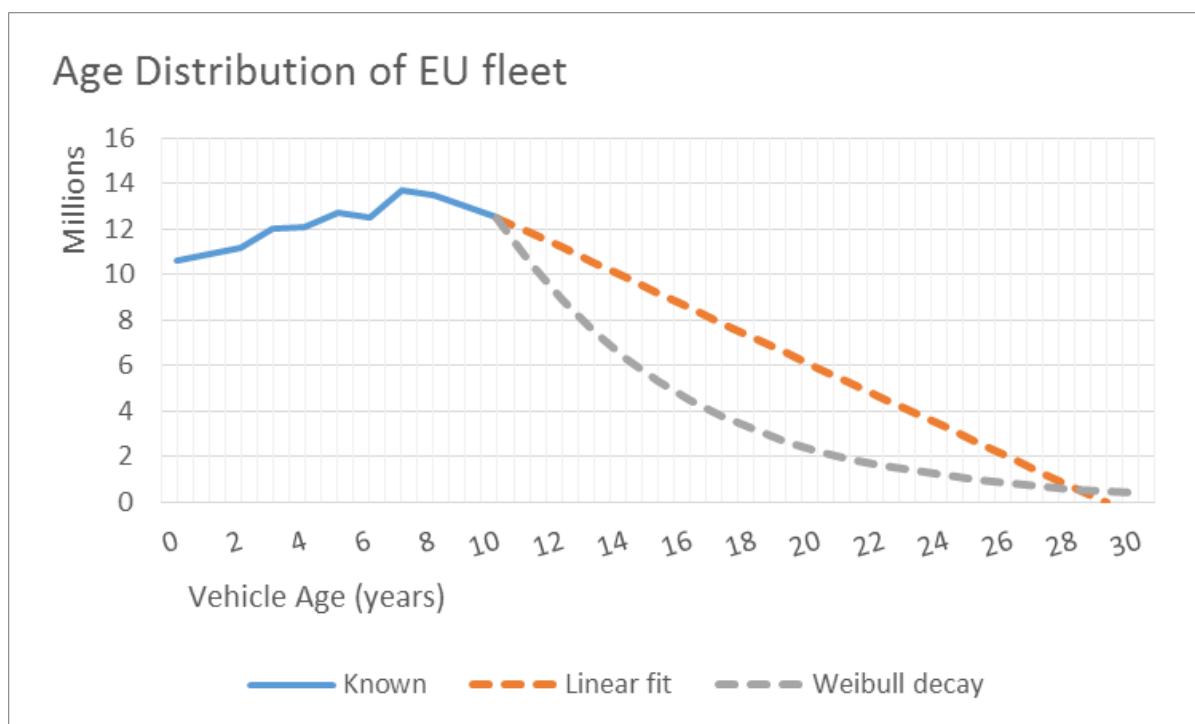


Figure 15. The age distribution of the EU fleet, with two examples of potential distributions for vehicles older than 10 years.

The final required input for a stock-flow model capable of fully populating the vehicle keys with age vintages is to produce an estimate of the 'death' rate, i.e. the rate at which vehicles reach end-of-life waste handling. A first estimate of this death rate can be produced by taking the fleet age distribution, adjusting for second hand exports and comparing the decrease from year to year with the fleet size. The result of this exercise is shown below in Figure 16. Most notable is the very high variance. As the estimates for national fleet age distributions are refined, individual estimates for each member state should produce an improved overall picture.

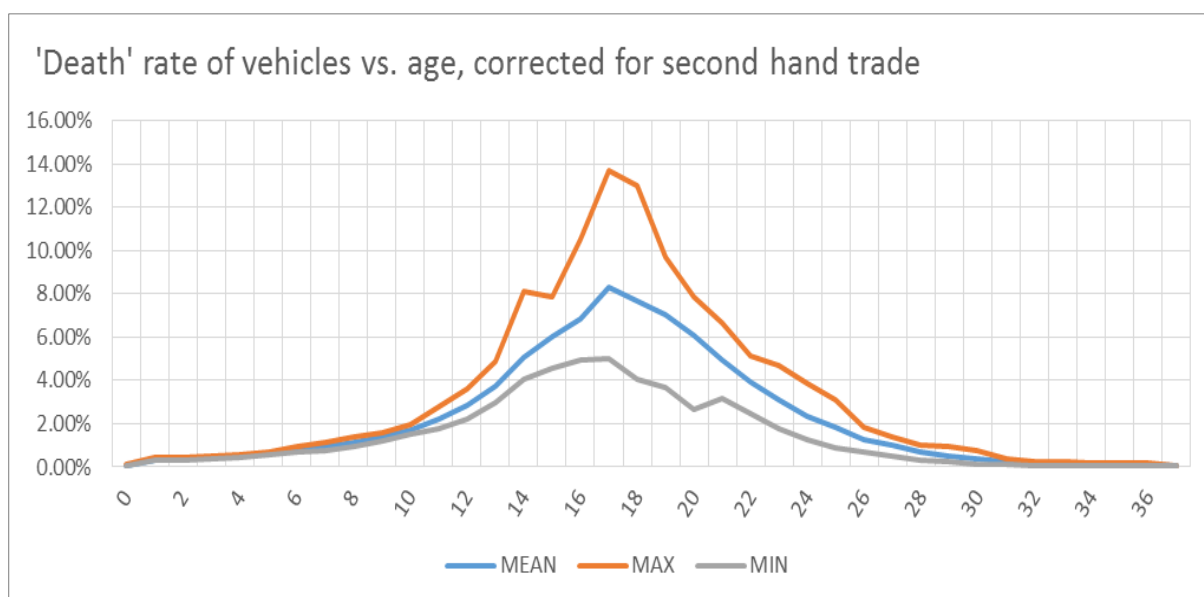


Figure 16. Estimated 'death' rate of vehicles for all countries

## 5 Conclusions and Recommendations

### 5.1 Conclusions

The main result of Deliverable 3.1 is the development of a common approach for taking inventory of stocks and flows information for EEE, BATT and vehicles among all the research groups involved in ProSUM. This includes CRM parameters (D2.2), stocks and flows (D3.1) and waste flows (D4.1). The ProSUM bibliography developed in EndNote allows different researchers in the ProSUM project to store and track data consistently in a harmonised manner. This enables and supports further robust analysis of the data identified in these sources by structured tracking of all meta-data parameters. This first step is important as the basis for the EU-Urban Mine Knowledge Data Platform currently in development

For these three deliverables, the data analysis included currently 336 of the most relevant references available. For the purpose of this deliverable, the total number of references containing some sort of stock and flow information includes 144 references. This includes 3 large European databases at Eurostat plus the ACEA database for vehicles. The majority of other sources comprises studies, reports and academic journal articles. Some specific datasets and confidential sources are also available but not stored in Endnote for confidentiality reasons.

For WEEE, currently 92 sources are from EEE stock and flow studies, from which 34 have an explicit EU coverage and of which another 8 are rather comprehensive covering most EEE equipment types. Of these 8 references, UNU was involved in all except one. In the context of this deliverable, the earlier EEE modelling is expanded, advanced and further updated. In comparison with the previous studies on either a national or EU level, new inclusions of 2013 and 2014 market input data is performed. In addition, the calculation of EEE stocks as part of this Deliverable is improved for 2011 and 2012, using recently updated trade statistics. In the previous two large EU studies no calculation of stocks data was undertaken. Stocks have now been calculated as a result of this project. This also means that some tasks to complete D3.3 and D3.4 have already been completed.

For BATT, there are currently 21 key references on stocks and flows of which around 6 references contain more comprehensive data on all battery types. In general, the data coverage for different battery types compared to all EEE types is better. The expected waste generation from batteries in the years after being put on the market was calculated based on the modelling of the residence time distribution. The battery stock and flows modelling will be further aligned with the WEEE stock and flows modelling as batteries are often a component in WEEE.

For vehicles, there are also currently 19 references identified, with 5 references with more comprehensive data on EU vehicle stocks and flows. The advantage of the vehicle information is that vehicles are generally regarded as one product type. The stock and flow modelling to produce reliable waste generation amounts relies on the availability of stocks information in the form of vehicle fleets. The nature of the available data on vehicle stocks in the EU will allow high confidence in estimating aggregated flows and reasonable confidence in calculating distributions over the chosen vehicle keys. Examples in literature exist for using primary data to produce estimates of inter-state trade.

It should be noted that many of the vehicle keys are not CRM-relevant. All vehicle statistics are designed for traffic and transport economy, fuel demand and air emission purposes and obviously not for their CRM composition, or trends affecting these CRM parameters.

### 5.2 Identified data gaps and recommended next steps

Compared to the BATT and vehicle stock and flow modelling, for a number of UNU keys the data is not always very reliable. In particular, for some of the smaller and less commonly used equipment types, data reliability and availability remains an issue. The same counts for goods codes with particular description or average weight issues. This will require improvement in

future. The refinement of the modelling including clear specification of key stock and flow parameters is reviewed and described in chapter 2. This includes the average weights and lifespan parameters for all UNU keys, where distribution and reliability can be improved using the data identified and stored in EndNote and new information continuously being received.

For BATT, the main data gaps stem more from the granularity of the data rather than from limitations due to the number and the quality of data sources, since several data sources are available, but not all of the data is coherent. To achieve the objective of ProSUM, i.e. providing data on (critical) materials in the urban mine, the data needs to distinguish the different types of batteries, in order to link the data on stocks and flows to material composition of batteries and calculate stocks and flows of materials. A large part of the required granularity is not provided by the available data sources.

To improve the granularity of the data, the data sources will need to be cross-checked and assumptions will have to be developed and documented, in order to extrapolate the information on the types of batteries contained in a flow in one country to other countries. The data reconciliation will therefore be a challenging task in assessing the data validity and understanding the discrepancies of redundant data, and developing strategies to cover data gaps.

For vehicles, data from some member states is missing and difficult to find e.g. the distribution of vehicle keys and ages in the Czech Republic. The total size of these missing stocks is however quite small in comparison to that of the overall EU vehicle fleet, and some data, such as an aggregated average age, does exist for many of these missing spots which will allow estimates of the missing data as well as the magnitude of the potential error. There are some additional gaps in coverage with regard to the intersection sets of some vehicle keys e.g., while data exists for both the cylinder size distributions and the weight class distributions of the various national fleets, there is no mapping of how the cylinder sizes are distributed in the weight classes.

For the purpose of linking the vehicle stock and flow modelling with the CRM parameters, there are some clear concerns. It will require more detailed work to improve understanding of the limitations of the vehicle data which initially focused on finding primary data that would allow better estimates of the missing data, and on estimating possible inaccuracies. An example of this is the assumption as a null hypothesis that cylinder size is evenly distributed over vehicle mass. It is anticipated that the discrepancies potentially introduced from the base case approach will be small in comparison with the uncertainty that exists in mapping vehicle keys to their constituent components and elements.

The work undertaken in this deliverable will result in the final mathematical approach and common methodology for the stocks and flows by M24 for D3.3. In summary, the approaches for EEE have been advanced. For certain UNU keys the data is less reliable than the BATT or Vehicle total stocks and flows identification. For BATT, the approach will be harmonised with the EEE approach.

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## Annexes

### Annex 1a. EU28+2 Population Overview (x1000) (some years not shown to limit the number of columns)

Country/ Year	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Source: IMF World Economic Outlook (WEO) database												Source: Eurostat, TurkStat or Worldbank					
AUT	7,948	8,012	8,225	8,268	8,301	8,337	8,363	8,388	8,421	8,466	8,484	8,520	8,566	8,623	8,680	8,737	8,794	8,837
BEL	10,131	10,239	10,446	10,511	10,585	10,667	10,753	10,840	11,001	11,095	11,176	11,260	11,383	11,493	11,603	11,714	11,824	11,921
BGR	8,297	8,149	7,719	7,679	7,640	7,607	7,564	7,505	7,327	7,254	7,181	7,146	7,181	7,130	7,078	7,027	6,975	6,930
CHE	7,019	7,164	7,415	7,459	7,509	7,593	7,785	7,870	7,954	8,002	8,050	8,098	8,249	8,354	8,459	8,565	8,670	8,750
CYP	652	698	744	758	776	797	819	840	862	872	874	876	874	878	883	887	891	894
CZE	10,333	10,278	10,221	10,251	10,287	10,381	10,468	10,507	10,530	10,553	10,575	10,594	10,559	10,580	10,602	10,623	10,645	10,657
DEU	81,661	82,188	82,465	82,366	82,262	82,120	81,875	81,757	81,779	81,917	81,753	81,589	81,560	81,329	81,098	80,868	80,637	80,557
DNK	5,216	5,330	5,411	5,427	5,447	5,476	5,511	5,535	5,561	5,581	5,591	5,610	5,660	5,688	5,717	5,745	5,774	5,799
ESP	39,388	40,264	43,398	44,068	44,874	45,593	45,929	46,073	46,125	46,163	46,097	45,995	46,417	46,261	46,105	45,950	45,794	45,679
EST	1,448	1,372	1,348	1,345	1,342	1,341	1,340	1,340	1,340	1,340	1,340	1,340	1,308	1,302	1,296	1,290	1,284	1,278
FIN	5,117	5,181	5,256	5,277	5,300	5,326	5,351	5,375	5,401	5,426	5,451	5,476	5,491	5,523	5,555	5,587	5,619	5,643
FRA	57,753	58,858	60,963	61,400	61,795	62,135	62,466	62,765	63,089	63,409	63,704	63,996	66,272	66,619	66,966	67,312	67,659	67,908
GBR	58,025	58,886	60,235	60,584	60,986	61,398	61,792	62,262	62,735	63,244	63,758	64,271	64,828	65,295	65,761	66,227	66,693	67,037
GRC	10,672	10,942	11,064	11,087	11,112	11,292	11,327	11,359	11,390	11,299	11,265	11,242	10,943	10,883	10,823	10,763	10,703	10,648
HRV	4,453	4,381	4,442	4,440	4,436	4,434	4,429	4,418	4,402	4,402	4,402	4,402	4,241	4,231	4,220	4,209	4,199	4,189
HUN	10,337	10,222	10,098	10,077	10,066	10,045	10,031	10,014	9,986	9,962	9,942	9,922	9,872	9,854	9,836	9,818	9,800	9,789
IRL	3,601	3,790	4,134	4,233	4,376	4,485	4,533	4,555	4,575	4,585	4,613	4,641	4,597	4,601	4,604	4,607	4,610	4,605
ITA	56,846	56,924	58,462	58,752	59,131	59,619	60,045	60,340	60,626	60,821	60,997	61,156	60,444	60,823	61,203	61,582	61,961	62,157
LTU	3,629	3,500	3,414	3,394	3,376	3,358	3,339	3,287	3,030	3,008	2,988	2,970	2,872	2,822	2,771	2,721	2,671	2,628
LUX	410	437	466	473	481	489	498	508	519	529	540	550	569	585	601	617	633	646
LVA	2,501	2,382	2,250	2,228	2,209	2,192	2,163	2,121	2,075	2,042	2,036	2,030	1,976	1,952	1,928	1,904	1,880	1,858
MLT	365	380	403	405	408	410	414	414	416	417	417	418	427	430	433	435	438	440
NLD	15,459	15,926	16,320	16,346	16,382	16,446	16,530	16,615	16,693	16,755	16,820	16,861	16,897	16,956	17,015	17,074	17,132	17,171
NOR	4,370	4,501	4,632	4,672	4,722	4,787	4,843	4,908	4,973	5,038	5,094	5,150	5,217	5,299	5,382	5,465	5,548	5,622
POL	38,581	38,654	38,174	38,157	38,125	38,116	38,136	38,167	38,530	38,896	39,265	39,638	38,486	38,462	38,438	38,414	38,391	38,312
PRT	10,018	10,195	10,529	10,570	10,599	10,618	10,627	10,638	10,572	10,542	10,557	10,569	10,372	10,314	10,256	10,198	10,140	10,107
ROU	22,904	22,334	21,609	21,575	21,551	21,517	21,484	21,447	21,384	21,347	21,306	21,266	19,909	19,853	19,798	19,742	19,687	19,625
SVK	5,368	5,377	5,379	5,389	5,391	5,396	5,409	5,422	5,435	5,439	5,443	5,447	5,412	5,413	5,413	5,414	5,415	5,405
SVN	1,990	1,988	1,998	2,003	2,010	2,010	2,032	2,047	2,050	2,055	2,061	2,066	2,068	2,073	2,077	2,082	2,087	2,087
SWE	8,837	8,883	9,048	9,113	9,183	9,256	9,341	9,416	9,483	9,540	9,597	9,655	9,750	9,847	9,944	10,041	10,138	10,216

## Annex 1b. EU28+2, number of Households

GEO/TIME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Austria	3,474.80	3,509.40	3,540.10	3,568.20	3,596.40	3,622.90	3,652.00	3,685.00	3,721.50	3,768.20
Belgium	4,384.20	4,436.40	4,438.50	4,509.30	4,568.00	4,622.40	4,653.10	4,637.90	4,644.60	4,651.80
Bulgaria	2,874.00	2,870.20	2,866.20	2,881.60	2,900.80	2,753.80	2,775.80	2,792.00	2,729.50	2,759.90
Croatia	1,569.60	1,569.90	1,518.50	1,518.80	1,518.70	1,519.00	1,518.90	1,519.00	1,518.80	1,518.90
Cyprus	249.9	251.6	261.1	268.1	270	284.6	297.6	295.4	290.5	288.8
Czech Republic	4,123.00	4,139.40	4,219.40	4,319.00	4,366.30	4,423.20	4,420.80	4,465.80	4,582.80	4,606.90
Denmark	2,353.80	2,365.00	2,366.80	2,423.70	2,391.10	2,313.70	2,323.60	2,329.90	2,339.10	2,360.20
Estonia	575.6	546.9	545.9	546.9	545.7	548.8	554	557.8	555.5	561.1
Finland	2,403.30	2,412.90	2,433.70	2,453.00	2,482.00	2,512.60	2,531.50	2,551.00	2,571.00	2,595.00
France	25,858.00	26,175.60	26,456.50	26,714.20	26,986.40	27,205.10	27,440.50	27,638.30	27,804.20	28,718.20
Germany	38,512.30	39,188.50	39,290.50	39,646.20	39,311.20	39,615.90	38,994.00	39,166.10	39,410.70	39,709.60
Greece	4,219.70	4,236.30	4,280.80	4,293.70	4,348.10	4,352.60	4,343.00	4,334.50	4,336.00	4,344.50
Hungary	3,816.20	3,836.00	3,880.70	3,925.20	3,969.80	4,014.50	4,058.40	4,085.50	4,105.60	4,129.70
Ireland	:	1,484.60	1,547.00	1,598.10	1,659.80	1,689.00	1,687.70	1,703.10	1,707.40	1,707.20
Italy	23,166.10	23,438.80	23,710.70	24,073.20	24,409.10	24,669.80	24,921.70	25,195.90	25,518.00	25,767.60
Latvia	805.7	825.2	834.7	830.2	810.7	809	829	832.4	833.1	830.3
Lithuania	1,182.70	1,187.30	1,226.80	1,374.80	1,363.70	1,348.90	1,325.90	1,326.70	1,309.80	1,308.90
Luxembourg	180.7	184.5	186.6	189.6	202	204.9	211.2	216.6	220.1	224.6
Malta	128.8	129.4	131.1	133.7	138.1	137.2	138.7	144.2	149.1	150
Netherlands	7,008.00	7,155.40	7,201.90	7,206.60	7,269.80	7,335.80	7,367.50	7,453.00	7,548.80	7,594.60
Norway	2036890	2064841	2104531	2142638	2170893	2201787	2147150	2258794	:	:
Poland	12,702.70	12,768.80	12,932.90	13,050.90	13,319.20	13,276.00	13,320.40	13,444.30	13,660.10	13,927.60
Portugal	3,767.30	3,819.10	3,836.20	3,879.10	3,910.80	3,942.10	4,001.20	4,012.50	4,007.10	4,062.60
Romania	7,360.20	7,373.20	7,381.30	7,383.80	7,395.70	7,402.10	7,426.50	7,423.10	7,451.50	7,470.20
Slovakia	1,672.10	1,705.60	1,697.00	1,713.60	1,756.50	1,754.10	1,781.10	1,811.30	1,810.50	1,837.10
Slovenia	747	753.9	745.4	773.8	791.3	807.1	829.8	842.3	854.7	862.2
Spain	15,759.80	16,179.80	16,643.00	17,067.80	17,384.30	17,645.20	17,897.30	18,090.90	18,212.40	18,328.90
Sweden	:	:	:	:	4,248.70	4,460.30	4,541.40	4,594.80	4,632.30	4,590.90
Switzerland	3248237	3286306	3324296	3362073	3399321	3505616	3534508	:	:	:
United Kingdom	26,226.10	26,483.10	26,799.40	26,721.90	26,944.20	27,229.20	28,112.80	28,150.40	27,610.90	28,076.00
: broken series										

## Annex 2a. Overview of (literature) available data sources for W(EEE)

Data sources	Product category	Keys	Years covered	Countries covered	Data Sources		Methodology used		Product average weight	EEE POM	Stock			Waste generation	Product Age		Additional fields	
					Original data (Register data, National statistics, EITO/ Eurostat)	Compiled/ Consolidated data; Secondary reference, Others	Material flow analysis; Estimation method i. disposal method, ii. IOA models	Others			Stocks per (non)household	In-use stock	Hibernating Stock		Residence times	Lifespan parameters, etc...	Description	Data availability
Put on the market (POM)	EEE		2005-2013		x												EEE put on the market, in number (if available), tonnes, percent (%) and kg per inhabitant	Public: Available at <a href="http://appsso.eurostat.ec.europa.eu/nui/show.do">http://appsso.eurostat.ec.europa.eu/nui/show.do</a>
Eurostat, IMF, individual country consenses: population data	EEE		1980-2020	EU28+2	x												Population data is available by various characteristics and can be grouped around the following topics: ageing and structure, population density, population change	Public: Available at <a href="http://ec.europa.eu/eurostat/web/population-demography-migration-projections/population-data">http://ec.europa.eu/eurostat/web/population-demography-migration-projections/population-data</a>
Eurostat, households data	EEE		2005-2014	EU28	x												presents data on household size and household type in the European Union (EU)	Public: Available at <a href="http://ec.europa.eu/eurostat/statistics-explained/index.php/Household_composition_statistics">http://ec.europa.eu/eurostat/statistics-explained/index.php/Household_composition_statistics</a>
Prodcom+International trade statistics	EEE				x												Prodcom provides statistics on the production of manufactured goods.	Public: Available at <a href="http://ec.europa.eu/eurostat/web/prodcom">http://ec.europa.eu/eurostat/web/prodcom</a>
European Union Statistics on Social Income and Living Conditions (EU-SILC)	EEE	0104, 0302, 0303, 0305, 0306, 0407, 0408			x												It collect comparable micro data on income, poverty, social exclusion and living conditions.	Public: Available at <a href="http://ec.europa.eu/eurostat/web/income-and-living-conditions/overview">http://ec.europa.eu/eurostat/web/income-and-living-conditions/overview</a>
European Information Technology Observatory (EITO)	EEE	0303, 0304, 0305, 0306	1993-2016	EU28+2	x												These reports cover information and telecommunication markets development.	Confidential, a hard/soft copy can be bought
Eurostat, waste generation	W(EEE)	EU10 WEEE collection categories	2005-2013											x			All data collected on WEEE generated is presented here.	Public: Available at <a href="http://ec.europa.eu/eurostat/web/waste/key-waste-streams/weee">http://ec.europa.eu/eurostat/web/waste/key-waste-streams/weee</a>
Melo, 1999	Aluminium scrap		1970-2012	DEU	x		B (IOA)				x				x	x	estimating the potential arising of scrap from discarded metal-containing products are developed	Available at PII: S0921-3449(98)00077-9
Binder et al., 2001	Durable goods		1993-2005	Tunja, Colombia	x		C (IOA)				x			x	x		dynamic models for managing durables are applied for the first time to an urban region in developing countries	Available at PII: S0921-8009(01)00155-0
van der Voet et al., 2002	Waste emissions						B, C (IOA)			x	x			x	x		Future flows of emissions and waste from society to the environment can be estimated either as a percentage of the future stock or as a delayed input.	Available at PII: S0921-8009(02)00028-9
HFT Network OY, 2003	W(EEE)	0102, 0103, 0104, 0108, 0109, 0202, 0306, 0403, 0404, 0407	POM 1998-2002	EST	x			x	x	x	x			x	x		Assessment of waste streams of WEEE in Estonia	Public: Available at <a href="http://www.envir.ee/sites/default/files/assessmentofwastestreams_2003.pdf">http://www.envir.ee/sites/default/files/assessmentofwastestreams_2003.pdf</a>
Streicher-Porte et al., 2005	W(EEE)	0301, 0302, 0308	1996-2003	Delhi, India		x	MFA		x	x				x	x		Management and recycling of waste electrical and electronic equipment WEEE was assessed in the city of Delhi, India.	Available at doi:10.1016/j.eiar.2005.04.004

Data sources	Product category	Keys	Years covered	Countries covered	Data Sources		Methodology used		Product average weight	EEE POM	Stock			Waste generation	Product Age		Additional fields	
					Original data (Register data, National statistics, EITO/ Eurostat)	Compiled/ Consolidated data; Secondary reference, Others	Material flow analysis; Estimation method i. disposal method, ii. IOA models	Others			Stocks per (non)household	In-use stock	Hibernating Stock		Residence times	Lifespan parameters, etc...	Description	Data availability
Liu et al., 2006	W(EEE)	0104, 0108, 0111, 0301, 0302, 0308, 0407	1984-2004	Beijing, China		x	B (IOA)		x	x	x						a case study implemented in Beijing, the capital city of China, with the purpose of predicting the amount of obsolete equipment for five main kinds of electronic appliances from urban households and to analyse the flow after the end of their useful phase	Available at DOI: 10.1177/0734242X06067449
Jain and Sareen, 2006	W(EEE)	0302, 0303, 0407	1983-2010	Delhi, India	x		B (IOA)				x			x	x		methodology to quantify electronic waste (e-waste) in India	Available at DOI 10.1007/s10163-005-0145-2
Kang and Schoenung, 2006	W(EEE)	0303, 0308, 0309	1995-2010	California		x	B (IOA)							x	x		Estimation of the future amounts of e-waste	Available at doi:10.1016/j.jhazmat.2006.03.062
Peralta and Fontanos, 2006	W(EEE)	0407, 0111, 0108, 0408, 0104	1985-2003	Philippines	x		B (IOA)							x	x		estimates the current and future quantity of e-waste in the Philippines, with a focus on televisions, refrigerators, air conditioners, washing machines, and radios.	Available at DOI 10.1007/s10163-005-0142-5
Waema and Mureithi, 2008	W(EEE)	0301, 0302, 0303, 0304, 0308, 0309	2004-7	Nairobi, Kenya		x	MFA		x					x	x		It presents the findings of a baseline study into electronic waste (e-waste) in Kenya	Public: Available at <a href="http://www.unep.org/ietc/Portals/136/Events/WEE-E-E%20workshop%20July%202011/06.Kenya.pdf">http://www.unep.org/ietc/Portals/136/Events/WEE-E-E%20workshop%20July%202011/06.Kenya.pdf</a>
Oguchi et al., 2008	W(EEE)	0104, 0108, 0111, 0302, 0303, 0306, 0308, 0309	2003	Japan		doestic shipments	A (IOA)		x	x	x			x	x	x	Study conducted a product flowanalysis (PFA) for 94 consumer durables in Japan to obtain a complete picture of the domestic flow	Available at doi:10.1016/j.resconrec.2007.06.001
Wasswa and Schluep, 2008	W(EEE)	0308, 0309	2007	Uganda		x	MFA			x	x	x		x	x	x	A situational analysis of e-waste management and generation with special emphasis on personal computers	Public: Available at <a href="https://www.unido.org/fileadmin/user_media/Services/PSD/ICT/E_Waste_Study.pdf">https://www.unido.org/fileadmin/user_media/Services/PSD/ICT/E_Waste_Study.pdf</a>
Yang et al., 2008	W(EEE)	0407, 0111, 0108, 0408, 0104	2003-2010	China	x		B (IOA)		x	x				x	x		the sources and generation of WEEE in China are identified, and WEEE volumes are calculated	Available at doi:10.1016/j.wasman.2007.08.019
Müller et al., 2009	W(EEE)	0302, 0303		Global	x		C (I/O)		x	x	x			x	x	x	estimating e-waste quantities in a certain region or country as well as on a global scale.	Available at <a href="http://www.ewasteguide.info">www.ewasteguide.info</a>
Robinson, 2009	W(EEE)	0104, 0108, 0111, 0308, 0309, 0407, 0408, 0302, 0303	2010-2012	Global	x		C (I/O)		x					x	x		E-waste: An assessment of global production and environmental impacts	Available at doi:10.1016/j.scitotenv.2009.09.044

Data sources	Product category	Keys	Years covered	Countries covered	Data Sources		Methodology used		Product average weight	EEE POM	Stock			Waste generation	Product Age		Additional fields	
					Original data (Register data, National statistics, EITO/ Eurostat)	Compiled/ Consolidated data; Secondary reference, Others	Material flow analysis; Estimation method i. disposal method, ii. IOA models	Others			Stocks per (non)household	In-use stock	Hibernating Stock		Residence times	Lifespan parameters, etc...	Description	Data availability
Yoshida et al., 2009	W(EEE)	0302, 0303		Japan		doestic shipments		x		x	x			x	x	x	A method is developed a method of minimizing the errors in estimating the material flow of used PCs.	Available at doi:10.1016/j.wasman.2008.10.021
Walk, 2009	W(EEE)	0308, 0407	POM 1005-2015, WEEE 2000-2015	Baden-Württemberg		x	C (I/O)		x	x	x			x	x	x	It presents a forecast of future household waste CRT quantities based on the past and present equipment of households with television sets and computer monitors	Available at doi:10.1016/j.wasman.2008.07.012
Bolliger, 2010	W(EEE)	0306		Global flows			MFA		x			x			x		conditions foster the development of a cradle-to-cradle flow network for metals in mobile phones	Available at
Steubing et al., 2010	W(EEE)	0302, 0303, 0308, 0309	POM 1984-2020, WEEE 1996-2020	Chile	x	x	B (IOA)		x	x	x			x	x		quantitative data basis on generated e-waste quantities	Available at doi:10.1016/j.wasman.2009.09.007
Yu et al., 2010	W(EEE)	0302, 0303, 0308, 0309	POM 1980-2005, WEEE 1990-2030	Forecasting Global generation		x	A (IOA)	logistic model		x	x			x	x		forecasting the global generation of obsolete personal computers (PCs) using the logistic model and material flow analysis.	Available at doi: 10.1021/es903350q
Chung et al., 2011	W(EEE)	0302, 0303, 0308, 0309, 0407, 0408		Hong Kong	x		C (I/O)		x		x			x	x	x	estimating electrical and electronic waste (e-waste) generation for building appropriate infrastructure for its collection and recycling	Available at doi:10.1016/j.wasman.2010.10.003
wrap, 2011	W(EEE)	Display, cooling, lamps, and photovoltaics in addition to EU 10 WEEE collection categories	POM data: 2007-2009, used EEE: 2010-2030, WEEE: 2009-2020	UK	x	x	C (I/O)		x	x	x	x	x	x	x	x	This report predicts the quantities of waste electrical and electronic equipment (WEEE) arising in the UK now and in future.	Public: Available at <a href="http://www.oakdenehollins.co.uk/media/316/WRAP_01_316_IMT002_CRM5_in_the_UK_Summary_FINAL_0.pdf">http://www.oakdenehollins.co.uk/media/316/WRAP_01_316_IMT002_CRM5_in_the_UK_Summary_FINAL_0.pdf</a>
Wielenga et al., 2011	W(EEE)	55 UNU keys including 0107	POM 2000-2011, WEEE 2000-2015	BEL	x		C (IOA)			x	x			x	x	x	Belgian case study to apply the Input-Output Analysis	Public: Available at <a href="http://www.weee-forum.org/system/files/documents/2011_weee_mass_balance_and_market_structure_in_belgium.pdf">http://www.weee-forum.org/system/files/documents/2011_weee_mass_balance_and_market_structure_in_belgium.pdf</a>
Araújo et al., 2012	W(EEE)	0104, 0108, 0109, 0407, 0408, 0403, 0302, 0303, 0306	POM, WEEE 2000-8	Brazil		x	A, D (IOA)		x	x	x			x	x		the literature regarding estimation of waste electrical and electronic equipment (WEEE), focusing on developing countries, particularly in Latin America	Available at doi:10.1016/j.wasman.2011.09.020
Kahhat and Williams, 2012	W(EEE)		2010-11	US	x		MFA							x			address the data gap by proposing and implementing an approach to quantify the exportation of used and scrap equipment	Available at <a href="http://dx.doi.org/10.1016/j.resconrec.2012.07.008">http://dx.doi.org/10.1016/j.resconrec.2012.07.008</a>
Wang et al., 2013	W(EEE)	all UNU keys excl. 0001 and 0002	1995, 2005, 2010	NLD	x		E (IOA)		x	x				x	x	x	Dutch case study to apply the advanced Input-Output Analysis	Only abstract available online, connected to purchase or library membership
Huisman, 2012	W(EEE)	all UNU keys, excluding LED Lamps	POM/WEEE 1995-2010	NLD	x		C (IOA)			x	x			x	x	x	Dutch Ewaste quantificationase study to apply the advanced Input-Output Analysis	Public: Available at <a href="http://ec.europa.eu/environment/waste/weee/pdf/Report_Dutch_WEEE_Flows%202012%2003%2015.pdf">http://ec.europa.eu/environment/waste/weee/pdf/Report_Dutch_WEEE_Flows%202012%2003%2015.pdf</a>
Magalini et al., 2012	W(EEE)	EU10 WEEE collection categories and UNU keys	POM 1993-2011, WEEE 2005-2013	ITA	x		C (IOA)		x	x	x			x	x	x	Household WEEE generation in Italy	Public: Available at <a href="http://www.weee-forum.org/system/files/2012_ecodom_weee_arising_in_italy_en.pdf">http://www.weee-forum.org/system/files/2012_ecodom_weee_arising_in_italy_en.pdf</a>
Monier et al., 2013	W(EEE)	EU10 WEEE collection categories	POM 1995-2015	FRA	x		C (IOA)		x	x	x			x	x	x	Study on the quantification of waste of electrical and electronic equipment (WEEE) in France	Public: Available at <a href="http://www.ademe.fr/sites/default/files/assets/documents/91257_report-weee-arising-france.pdf">http://www.ademe.fr/sites/default/files/assets/documents/91257_report-weee-arising-france.pdf</a>

Data sources	Product category	Keys	Years covered	Countries covered	Data Sources		Methodology used		Product average weight	EEE POM	Stock			Waste generation	Product Age		Additional fields	
					Original data (Register data, National statistics, EITO/ Eurostat)	Compiled/ Consolidated data; Secondary reference, Others	Material flow analysis; Estimation method i. disposal method, ii. IOA models	Others			Stocks per (non)household	In-use stock	Hibernating Stock		Residence times	Lifespan parameters, etc...	Description	Data availability
Magalini et al., 2015	W(EEE)	EUG WEEE collection categories and UNU keys	POM 2000-2015, WEEE 2010-2018	ROU	x		C (IOA)			x	x			x	x	x	Quantifying WEEE generation in Romania	Public: Available at <a href="http://www.ecotic.ro/wp-content/uploads/2015/11/WEEE-Generated-study-2015.pdf">http://www.ecotic.ro/wp-content/uploads/2015/11/WEEE-Generated-study-2015.pdf</a>
Tran et al., 2016	W(EEE)	0407, 0408	1966-2035	Vietnam	x		E (IOA)		x	x	x			x		x	qualitatively and quantitatively investigate the invisible inflow of TVs in Vietnam	Available at DOI: 10.1021/acs.est.5b01388
Zeng et al., 2016	W(EEE)	0001, 0104, 0106, 0108, 0111, 0303, 0304, 0305, 0308, 0309, 0407, 0408	WEEE 2010-2030 (kt/y)	China	x	x	C (IOA)		x		x			x		x	Identification of the amounts and valuable-resource components of the "new" WEEE generated is critical to solving the ewaste problem	Available at DOI: 10.1021/acs.est.5b05446

	Data available
	Partially available
	No data
	Confidential

## Annex 2b. Overview of (literature) available data sources for BATT

Data sources	Product category	Keys	Years covered	Countries covered	Data Sources		Methodology used		Product average weight	EEE POM	Stock			Disposal information	Product Age		Additional fields	
					Original data (Register data, National statistics, EITO/ Eurostat)	Compiled/ Consolidated data; Secondary reference, Others	Material flow analysis; Estimation method i. disposal method, ii. IOA models	Others			Stocks per (non)household	In-use stock	Hibernating Stock	Waste generation	Residence times	Lifespan parameters, etc...	Description	Data availability
Avicenne	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2000-2014	Worldwide	Commercial market data	x		Compilation of available data	x	2000-2014, units, tons, MWh, US-\$							Volumes of batteries put on the market, data collected in cooperation with producers	Available to Recharge, publication of Avicenne at the yearly Nice Batteries Congresses in October
Perchards (EPBA)	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2000-2014	EU28+2, ISL, SRB, UKR, TUR	Analysis of publications of collection organisations (notably annual reports) and national authorities, supported by questionnaires and interviews with representatives from these organisations	x		Compilation of available data		Tonnes				Collected batteries			Data on POM (sales volumes of portable batteries) and collected portable batteries to calculate collection rates per country	Online: <a href="http://www.epbaeurope.net/documents/Reportontheportablebatterycollectionrates-UpdateDec-15-Exerpt.pdf">http://www.epbaeurope.net/documents/Reportontheportablebatterycollectionrates-UpdateDec-15-Exerpt.pdf</a>
Prodcum	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	1995-2012	EU28, but with a lot of data gaps	Eurostat	x		Compilation of available data		Units							Sold production in, exports from and imports to the member states	Eurostat: Eurostat homepage > Statistics > Industry, trade and services > Manufactured goods (prodcum) > database
Eucobat key figures of batteries POM and collected	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2011-2014	BEL, CZE, DEU, DNK, ESP, FIN, FRA, IRL, ITA, LUX, NLD, PRT, ROU		Data from Eucobat members		Compilation of available data		Tonnes, g/inh				Collected batteries			Key figures collected by the Eucobat members on portable and industrial batteries POM and collected 2011-2014, including data on POM and collected embedded in (W)EEE. Distinction is new in 2014. Professional waste collectors/WEEE dismantlers as a new category	Confidential data made available by Eucobat with NDA
Eurobat, ACEA, JAMA, KAMA, ILA	BATT	battPb (automotive)	2010-2012	FRA, DEU, ITA, ESP, SWE, GBR Rest of EU analysed as a group		x		Compilation of available data						x	x		Collection and recycling of automotive lead-based batteries	Executive summary publicly available: <a href="http://www.eurobat.org/sites/default/files/lhs_eurobat_report_lead_lores_final.pdf">http://www.eurobat.org/sites/default/files/lhs_eurobat_report_lead_lores_final.pdf</a>
EUROBAT (lead)	BATT	battPb (industrial)	2011-2012	EU28+2		Data from Eurobat members		Compilation of available data		Tonnes							Market volumes of industrial batteries	Available online: <a href="http://www.eurobat.org/sites/default/files/Industrial_batteries_data_and_outlook-update_2013.pdf">http://www.eurobat.org/sites/default/files/Industrial_batteries_data_and_outlook-update_2013.pdf</a>
Bebat + NL +FR	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2013	BEL NLD FRA	Survey			Survey			x	x	x		x		Batteries in use and hoarded in 2013: once every 2-3 years, numbers of batteries in households and appliances in which they are. Study of BEBAT, they are comparable studies in France and NL that are less elaborated than the Belgian one. NL study is in Dutch, summary in English. FR study in English, a presentation is available	Confidential data made available with a NDA

Data sources	Product category	Keys	Years covered	Countries covered	Data Sources		Methodology used		Product average weight	EEE POM	Stock			Disposal information	Product Age		Additional fields	
					Original data (Register data, National statistics, EITO/ Eurostat)	Compiled/ Consolidated data; Secondary reference, Others	Material flow analysis; Estimation method i. disposal method, ii. IOA models	Others			Stocks per (non)household	In-use stock	Hibernating Stock	Waste generation	Residence times	Lifespan parameters, etc...	Description	Data availability
Eucobat study	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2015	BEL, FRA, NLD, DEU, ROU, ESP	Experimental data			Trial	x					x	x		Age and types of batteries collected in 6 countries (BE FR NL DE RO SP). Sample and registration of batteries (phase 1 - done), data on the year of POM through serial number and data collection from the producers (phase 2, currently running), lifespan analysis is coming (phase 3, spring). Final results expected in June, presentation in September, available end of may/june to ProSUM	Eucobat data available in 2016
Eurostat: Sales and collection of portable batteries and accumulators	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2013	AUT, BEL, BGR, CZE, DEU, EST, FIN, FRA, HUN, IRL, LIE, LTU, LUX, LVA, MLT, POL, PRT, SVK, SVN, SWE	Eurostat	Data reported from member states		Compilation of available data		Tonnes				Collected batteries			Sales and collection of portable batteries and accumulators	Eurostat: <a href="http://ec.europa.eu/eurostat/web/products-datasets/-/env_waspb">http://ec.europa.eu/eurostat/web/products-datasets/-/env_waspb</a> <a href="http://ec.europa.eu/eurostat/web/waste/key-waste-streams/batteries">http://ec.europa.eu/eurostat/web/waste/key-waste-streams/batteries</a>
GRS	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2011-2014	DEU	x			Compilation of available data	x	Tonnes, units				Collected batteries according to battery type, qualitative and quantitative results of recovery and disposal (output products of the recovery)			GRS yearly "Erfolgskontrolle" (success control) reports	Public: <a href="http://www.grs-batterien.de/grs-batterien/zahlen-und-fakten.html">http://www.grs-batterien.de/grs-batterien/zahlen-und-fakten.html</a>
Eucobat survey	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2015	BEL, CZE, DEU, DNK, ESP, FIN, FRA, IRL, ITA, LUX, NLD, PRT, ROU	National statistics from French Environmental Agency ADEME	x		Compilation of available data	x	Tonnes, units				Quantities collected and treated			The Register for B&A aims to collect the B&A producers and recycling companies' annual reporting data on the quantities of batteries and accumulators they put on the market, collect and treat.	Public: <a href="https://syderep.ademe.fr/fr/commun/pa">https://syderep.ademe.fr/fr/commun/pa</a>
ADEME	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2009-2014	FRA	Survey			Survey						x			Survey on number of sorting and recycling plants, location, technology used and capacity. Data available in April 2016	Confidential data from recyclers. Recharge and EBRA (everything but lead batteries --contact Alain Vassart), rechargeable batteries recyclers: SNAM in FR, Umicore in BE are members of Recharge. Lead recyclers: ILA
EBRA statistics	BATT	battLi, battZn, battNiCd, battNiMH, battPb, battOther	2014	AUT, BEL, BGR, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HUN, HRV, ISL, ITA, LTU, LUX, LVA, NLD, NOR, PRT, ROU, SRB, SVK, SVN, SWE, SWZ, TUR, UKR	Data from EBRA members			Compilation of available data						Treated			Statistics about the quantities of batteries and accumulators recycled by the EBRA members are available to EBRA List of battery recycling facilities operated by EBRA members is available, classification according to the type(s) of batteries they treat: Alk+Zn; Zn-Air; Li-primary; Button cells; NiCd portable, NiCd Ind; NiMH portable, NiMH ind, NiMH E-mobility; Li-second portable, Li-second ind, Li-second E-mobility; Mercury (No data on recycling efficiency)	Confidential, data could be delivered with an NDA. Contact is Alain Vassart – EBRA Secretary General, T: +32 3 328 62 48 info@ebra-recycling.org W: www.ebra-recycling.org

	Data available
	Partially available
	No data
	Confidential

## Annex 2c. Overview of (literature) available data sources for ELV

Data sources	Product category	Keys	Years covered	Countries covered	Data Sources		Methodology used		Product average weight	EEE POM	Stock			Waste generation	Product Age		Additional fields	
					Original data (Register data, National statistics, EITO/ Eurostat)	Compiled/ Consolidated data; Secondary reference, Others	Material flow analysis; Estimation method I. disposal method, II. IOA models	Others			Stocks per (non)household	In-use stock	Hibernating Stock		Residence times	Lifespan parameters, etc...	Description	Data availability
Eurostat Transport Statistics	ELV	All Vehicle Keys	POM 1990-2015	21/EU27	x					x	x	x	x		x		Eurostat Transport Statistic Database	Public: Available at <a href="http://ec.europa.eu/eurostat/data/database">http://ec.europa.eu/eurostat/data/database</a>
Eurostat Waste Statistics	ELV		POM 1990-2015	27/EU27	x				x	x				tonnes total			Eurostat Waste Statistic Database	Public: Available at <a href="http://ec.europa.eu/eurostat/data/database">http://ec.europa.eu/eurostat/data/database</a>
Eurostat ELV Directive Statistics	ELV		1990-2015	21/EU27	x				x	x		x		Vehicle counts, tonnes total				Public: Available at <a href="http://ec.europa.eu/eurostat/web/waste/key-waste-streams/elvs">http://ec.europa.eu/eurostat/web/waste/key-waste-streams/elvs</a>
Comtrade Import/Export Statistics (CN codes)	ELV		1990-2015	EU (aggregate)	x					x								Public: Available at <a href="http://comtrade.un.org/data/">http://comtrade.un.org/data/</a>
ACEA New Registrations Statistics	ELV	All Vehicle Keys	1990-2014	27/EU27	x					x	x	x						Public: Available at <a href="http://www.acea.be/statistics/tag/category/registrations-and-press-release-calendar">http://www.acea.be/statistics/tag/category/registrations-and-press-release-calendar</a>
BiSweden Residence Time Statistics	ELV		2013	SWE	x							x	x		x			Private
ANFAC EU Vehicles in use report	ELV	All Vehicle Keys	2000-2010	27/EU27	x					x	x	x	x		x			Public: Available at <a href="http://www.acea.be/uploads/statistic_documents/2013_ANFAC_Report.pdf">http://www.acea.be/uploads/statistic_documents/2013_ANFAC_Report.pdf</a>
Andersen, F. M. et al., 2008.	ELV		2005-2030 (futures study)	27/EU27		x	x			x		x	x	Vehicle Counts	x	x	Projection of end-of-life vehicles: Development of a projection model and estimates of ELVs for 2005-2030.	Public: Available at <a href="http://orbit.dtu.dk/files/3308670/2008_28.pdf">http://orbit.dtu.dk/files/3308670/2008_28.pdf</a>
Statistiques : véhicules routiers	ELV			FRA	x	x				x	x	x				x	Description of vehicle stats in France	Public: Available at <a href="http://www.statistiques.developpement-durable.gouv.fr/transport/l/vehicules-routiers.html">http://www.statistiques.developpement-durable.gouv.fr/transport/l/vehicules-routiers.html</a>
Giannouli et al., 2007	ELV		1990-2020	EU27		x	x		x	x				tonnes			Waste from road transport: development of a model to predict waste from end-of-life and operation phases of road vehicles in Europe.	Private: doi:10.1016/j.jclepro.2006.05.031
Melhart et al., 2011	ELV	All Vehicle Keys	2000-2010	27/EU27	x	x				Vehicle count		x	x	x	x	x	Study of cross border trade in 2h vehicles in EU	Public: available at <a href="http://ec.europa.eu/clima/policies/transport/vehicles/docs/2010_2nd_hand_car_en.pdf">http://ec.europa.eu/clima/policies/transport/vehicles/docs/2010_2nd_hand_car_en.pdf</a>
Petiot, C. et al., 2015	ELV		2011	EU27		x	x	x			x	x		2011, tonnes			Element by element stock flow model in Europe	Public: available at <a href="http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?id=6859&amp;lang=en&amp;tpa_id=1040&amp;title=Study-on-Data-Inventory-for-a-Raw-Material-System-Analysis%3A-Roadmap-and-Test-of-the-Fully-Operational-MSA-for-Raw-Materials-">http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?id=6859&amp;lang=en&amp;tpa_id=1040&amp;title=Study-on-Data-Inventory-for-a-Raw-Material-System-Analysis%3A-Roadmap-and-Test-of-the-Fully-Operational-MSA-for-Raw-Materials-</a>
Oguchi. et al., 2015	ELV		2000-2010			x						x	x		x	x	Methods for stock lifespan estimation	Private: doi:10.1021/es505245q

Data sources	Product category	Keys	Years covered	Countries covered	Data Sources		Methodology used		Product average weight	EEE POM	Stock			Waste generation	Product Age		Additional fields	
					Original data (Register data, National statistics, EITO/ Eurostat)	Compiled/ Consolidated data; Secondary reference, Others	Material flow analysis; Estimation method i. disposal method, ii. IOA models	Others			Stocks per (non)household	In-use stock	Hibernating Stock		Residence times	Lifespan parameters, etc...	Description	Data availability
Statistik Sentralbyrå	ELV		1990-2015	NOR	x					x		x		Vehicle Counts	x		Norwegian ELV data. Includes scrapping age	Public: Available at <a href="https://www.ssb.no/statistikkbanken/selecttable/hovedtabelHjem.asp?KortNavnWeb=bilreg&amp;CMSSubjectArea=transport-og-reiseliv&amp;PLanguage=1&amp;checked=true">https://www.ssb.no/statistikkbanken/selecttable/hovedtabelHjem.asp?KortNavnWeb=bilreg&amp;CMSSubjectArea=transport-og-reiseliv&amp;PLanguage=1&amp;checked=true</a>
Dirección general de tráfico	ELV			ESP	x					x		x		Vehicle Counts	x		Spanish ELV Data	Public: Available at <a href="http://www.dgt.es/es/seguridad-vial/estadisticas-e-indicadores/publicaciones/anuario-estadistico-general/">http://www.dgt.es/es/seguridad-vial/estadisticas-e-indicadores/publicaciones/anuario-estadistico-general/</a>

	Data available
	Partially available
	No data
	Confidential

## Annex 3a: EEE stocks and flows modelling approach

### Article 7 report as basis

The methodology for the article 7 report was the basis for the ProSUM calculations. Some methodological updates were done in comparison to the section 2.2.1.

1. The year 2012 was recalculated with the outcomes of 2013. In the original dataset the year 2012 was the last available year. Data of that year could only be estimated based on the preceding years. The inclusion of 2013 substantially improved the estimations for missing data in 2012. Therefore the outcome for 2012 has been improved.
2. Furthermore results in the UNU keys concerning lamps (0502, 0503 and, 0504) have been improved for the year 2011. This was needed as the ProdCom and CN data for those groups was not available before that year. The inclusion of new 2011 data changed the results slightly. Therefore some data points in other years for these lamps categories have also changed.
3. Furthermore the parameters of one of the data cleaning rules have been altered a bit too clean up data with a lower weight per inhabitant value. Since this is the case only with small values the total impact of this measure is also small but should lead to better time series for UNU keys with small POM values. This has effect on all years and UNU keys.
4. Due to new recent product introductions, a number of ProdCom code has been added. All these categories have been added for the years 2012 to 2014. These codes are:

#### Drones:

- 95030079 "Toys and models, incorporating a motor (excl. plastic, electric trains, scale model assembly kits, and toys representing animals, human or non-human creatures)". The drones have been assigned to UNU Key 0701.

#### Electronic Bikes:

- 87119010 "Cycles, with an auxiliary electric motor with a continuous rated power  $\leq 250$  W". The E-bikes have been assigned to UNU key 0703.

#### 3D printers:

- 84433990 "Printers and facsimile machines (excl. those capable of connecting to an automatic data processing machine or to a network)". The 3D printers have been assigned to UNU key 0304.

1. For solar panels the conversion factors of kg per panel have been changed. This only affects the number of panels, not the total weight of the installed solar panels.
2. Average weights for UNU key 0303 have been updated for the years 2007-2012. And average weights for UNU key and 0408 have been updated for the years 2011-2012.
3. For Norway and Switzerland there was no new data available. Their 2013 and 2014 values have been estimated by the average increase/decrease per UNU key for other countries in the richest group of countries (stratum 1), multiplied with Norway and Switzerland data in 2012.
4. The UNU keys 0601 and 0602 have now switched, making 0601 the small household tools and 0602 the professional tools.

This way a new dataset of POM for 1980 to 2014 has been made. The following chapters show the calculation routines in detail.

## Detailed methodology

### Part 1: Estimating ProdCom confidential records

The confidential ProdCom records are estimated using the international trade statistics.

First a number of manual corrections are being done. Among those are 150 unreliable values about the number of pieces produced in the whole EU28 in various ProdCom categories. These have to be corrected because the values for the total EU are later used to fit estimates for

confidential data from member states. There are also a number of manual corrections for the number of units produced in certain countries and a few concerning unreliable number of units exported. Also these correction take place to better fit estimated confidential data from other countries or from the same country but another year.

The following automatic estimation of the confidential ProdCom record are carried out in the following way:

**Step 1:**

Calculate ratio between units exported and units produced in case both values are not confidential for every ProdCom code, country and year. Calculate for every ProdCom code and country the median of the calculated ratio's (all the years).

Use this median ratio to estimate confidential ProdCom units: export units / ratio = ProdCom units.

**Step 2:**

Same, but this time countries are grouped in 3 groups based on purchasing power. The basis for the categories is the purchasing power of the countries. The countries grouped for this stratum code are listed in the following table 12.

**Table 12. Country grouping as per their purchasing power (1= high, 3=low)**

Country	Stratum	Country	Stratum
AUT	1	ESP	2
BEL	1	GRC	2
CHE	1	ITA	2
DEU	1	MLT	2
DNK	1	PRT	2
FIN	1	SVK	2
FRA	1	SVN	2
GBR	1	BGR	3
IRL	1	EST	3
LUX	1	HRV	3
NLD	1	HUN	3
NOR	1	LTU	3
SWE	1	LVA	3
CYP	2	POL	3
CZE	2	ROU	3

Values that could not have been estimated with step 1, are now being estimated based on the median ratio of the aggregated values of similar countries.

**Step 3, Finalize:**

Estimated values are checked on reliability using the total value for the EU (this is the EU27/28 aggregate). For the first dataset the EU27 aggregate was used. For 2013 and 2014 the EU28 aggregate was used. In most cases there is no difference between those two.

In case the sum of the estimated values in the previous steps is larger than the difference between the EU27/28 aggregate and the sum of the non-confidential values for the EU27/28 countries, the estimated values are scaled downwards proportionally.

*Part 2: Apparent consumption approach*

The ProdCom and International trade (CN) data give the number of units. By using average weight they are converted into weight (kg). CN codes link to ProdCom codes (n:1). These ProdCom codes link to the UNU keys. This way all data is being aggregated to UNU key level. Correspondence

tables between CN codes and ProdCom codes are available at Eurostat. In the Annex of this deliverable there are correspondence tables to link the CN and ProdCom codes to the UNU keys. Also tables with average weights are listed there.

Average weights are sometimes available on ProdCom level. If not average weights on UNU key level are used to convert the units to kg. This table is also available in the Annex.

Then the first calculations of the POM in total weight and number of pieces per country, year and UNU key can be made by making the calculation:  $POM = Production + Imports - Exports$ .

### *Part 3: Checks and corrections of POM*

Input for this part is a dataset which has the total value in kg and in units for each UNU key.

Additional data on number of inhabitants and a stratum code (3 categories, as mentioned before in

Table 12. ) to group similar countries is added.

With those we can calculate the first version of the kg per inhabitant and the units per inhabitant. These ratios will be the basis for the checks and corrections.

Data of UNU key 0703 (mostly sunbeds) is removed for the years for all years to 2011 because of the bad quality of the data. For 2012 to 2014 data associated with e-bikes has been added to this category. Thus all data on UNU key 0703 now includes e-bikes.

### **Manual corrections**

A number of manual corrections are being carried out. These result from the analysis of the automatic corrections. When there are a few years in a row with unreliable data, the automatic procedures cannot correct them.

Some unreliable data has been corrected using knowledge of the market. For instance CRT TVs have not been sold in recent years, so they are set to 0, whereas the source data still showed little amounts of trade for those appliances.

Most manual corrections are for the years 1995-2012. For the newly added years 2013 and 2014 only one manual correction was needed.

### **Additional data sources**

Data on LCD TV's (UNU key 0408) and data on lamps (UNU key 0505) have been replaced by data of UNU researchers which is of better quality than data from the statistical sources.

Data on the installed capacity of solar panels (UNU key 0002) is taken from the Eurostat website. Different conversion factors for the weight per panel have been used in compared to the original 1980-2012 time series. This results in a higher number of panels. No changes to the weight have been done.

For the years up until 2012 in UNU key 0302 data purchased from EITO has been used. This data was not used in 2013 and 2014.

### **Automatic corrections**

The original dataset was calculated all at once. Each data point could be changed because of data from for instance other years and it could by itself also be partly the cause for other data to be changed. For 2013 and 2014 the method has been changed. Now one new data year will be added at a time. It can only result in correcting data of the one preceding year. Historic data will still be used to check the reliability of the newly added year.

### **Remove unreliable data by comparing with other years from the same Country and product category**

The outlier detection is done using the Median Absolute Deviation (MAD). For this outlier detection method in the original time series, the median of the data (all years of a specific country and product category) is calculated. Then, the difference is calculated between each historical value and this median. These differences are expressed as their absolute values, and a new median is calculated of those absolute values. This is the MAD. If a value is 4 times the MAD away from the median of the data points, that value is classified as an outlier.

Example:

year	2005	2006	2007	2008	2009	2010	2011	median
kg per inhabitant	3.08	3.04	3.50	4.96	2.71	2.60	2.47	3.04
deviation from median	0.04	0.00	0.46	1.92	0.33	0.43	0.56	0.43
factor:	4							
lower threshold	1.30	$(= 3.04 - 4 * 0.43)$						
upper threshold	4.78	$(= 3.04 + 4 * 0.43)$						

The value of 2008 (4.96) will be classified as an outlier because it lies above the upper threshold of 4 times the median absolute deviation

There have to be at least 6 values for calculating the median. With less than 6 values, no outliers are being determined.

For the years 2013 and 2014 not all years have been taken into account anymore. Only the last 15 years preceding the year added are being used.

### Remove unreliable data by comparing data on a specific year and product category with other countries

Also this outlier detection is done using the MAD. The only difference is that the data of a specific year and product group is compared with data from similar countries (given by the stratum).

### Calculate years by using the average of other years.

In case one year is missing (in original data or after removal of outliers) it is calculated with the average of the previous and following year.

For instance when 2007 is missing it will be calculated in the following way:

year	2005	2006	2007	2008
kg per inhabitant	1.20	1.20	1.40	1.60

With 2 consecutive missing years a missing year gets 2/3 of the value of the adjacent year and 1/3 of the value of the year next to the other missing year.

For instance when 2006 and 2007 are missing they will be calculated in the following way:

year	2005	2006	2007	2008
kilo's per inhabitant	1.20	1.33	1.47	1.60

If the missing year is the last available year then it is calculated by adding the difference of the two preceding years to the previous year. This way the trend of the previous 2 years is being continued.

For instance when 2014 (the last year for which we have data) is missing it will be calculated in the following way:

Year	2011	2012	2013	2014
kilo's per inhabitant	1.30	1.40	1.70	2.00

### Calculate missing years by using the average of other similar countries.

When the previous method cannot be calculated the missing data points are estimated based on the data of similar countries. First the average kg per inhabitant and average units per inhabitant are calculated for each stratum. Also the average purchasing power of each stratum is calculated (purchasing power per country multiplied with inhabitants of each country, then divided by total inhabitants in stratum).

The purchasing power of the country with the missing data is also known. When the purchasing power of this country is between the average purchasing power of 2 stratum the missing value is calculated by taking the difference between the kg/units per inhabitant of the higher stratum and the lower stratum. This will then be divided by the difference in purchasing power between

the higher stratum and the lower stratum. After this it will be multiplied with the difference in purchasing power between the country with the missing data and that of the lower stratum. Finally this outcome will be added to the average kg/units per inhabitant of the lower stratum. The following example will demonstrate this procedure.

Country	A	B	C	D	E	F	stratum	lower stratum
purchasing power	19500	21928	22028	23193	18023	21344	21307	17480
kg per inhabitant	0.81	1.20	0.70	1.15	0.85	1.10	1.00	0.6

All countries A to F are from the same stratum. Country A had missing data. The average kg per inhabitant for the stratum is 1.00 based on the known values from countries B to F. The average purchasing power is a weighted average using the number of inhabitants of each country. The last column shows the averages for countries in the next lower stratum. The calculation is as follows:  $0.6 + (1.00 - 0.6) / (21,307 - 17,480) * (19,500 - 17,480) = 0.81$

This way a value will be calculated based on the stratum average, but adjusted for the purchasing power. The country with the lowest purchasing power in this dataset is Romania. This country is used to adjust for the purchasing power for countries that have a purchasing power that lies between Romania and the average of the lowest stratum. The country with the highest purchasing power is Luxemburg. This country is used to adjust for the purchasing power of countries that have a purchasing power that lies between the average of the highest stratum and Luxemburg.

### Eliminate big changes between years

After the last calculations there can be big changes from year to year. These are corrected in two ways that are a little bit different for the original 1980-2012 time series compared to the newly added years. The checks in the original series will be discussed first and later the adjustments for the later years.

### 1980-2012

The first check is to see if a specific outcome considering the kg per inhabitant differs more than 50% from the previous year (t-1) while the previous year and the next year (t+1) don't differ more than 20%.

The second check is to see if a specific outcome is more than 20 per cent below the minimum of the two surrounding years and more than 40 per cent below the maximum value of those years. Also if a specific outcome is more than 20 per cent higher than the maximum of the two surrounding years and more than 40 per cent higher than the minimum of those years. This check is not done if the value of year t+2 is within 20 per cent of the year (t) that might be corrected. The reason for this is that in this case the year t+1 might be the one with an unreliable outcome.

Once a check has had a positive outcome the corresponding value will be deleted.

After this the empty values will be again calculated in the same way as described in the part "Calculate years by using the average of other years" above. So they will be replaced by the average of surrounding years.

### 2013 and 2014

The years 2013 and 2014 have been added separately to the original time series. So they were both the last year at the time they were added and no data for a later year was used in the calculations. Therefore the first check as described in the previous section could only be done to correct the value of the year before based on the two surrounding years.

The second check could also only be done to correct the previous year. Also the condition that the correction only takes place when the year that is 2 years ahead is outside 20% of the value of the year that is being corrected, does not take place since no data on that year is present for the calculations at that time.

### Additional data sources and corrections

The amount of CRT monitors (UNU key 0308) is not reliable with the above method. Therefore they are calculated in a different way. For 1995 to 2012 they are calculated with the formula: CRT Monitors (kg) = ((Desktop sales, pieces \* 116% ) - Flatpanels (pieces) ) \* average weight CRT Monitors. The desktop sales are the outcome of UNU key 0302 and the flatpanels are UNU key 0309. For 2012 to 2014 the sales of CRT monitors are put to zero.

Data on solar panels is used based on the data of Eurostat. This data is only available in megawatts. We calculate the kg and number of units by conversion factors. The following table shows the conversions factors used for each specific year. Compared to the dataset 1980-2012 the kg per panel values have been altered.

**Table 13. Solar panels conversion factors**

Year	Kg per megawatt	Kg per panel	Year	Kg per megawatt	Kg per panel
2014	84,500	18	2002	130,000	25
2013	84,500	18	2001	135,000	25
2012	89,667	19	2000	140,000	25
2011	94,833	19	1999	145,000	25
2010	100,000	20	1998	150,000	25
2009	100,000	21	1997	150,000	25
2008	100,000	22	1996	150,000	25
2007	105,000	23	1995	150,000	25
2006	110,000	24	1994	150,000	25
2005	115,000	25	1993	150,000	25
2004	120,000	25	1992	150,000	25
2003	125,000	25	1991	150,000	25

#### **Calculate past POM based on 1995-2012 data**

CBS calculated the POM for 1980 to 1994 based on the POM for 1995 to 1997. Lowest stratum countries are an exception because of lack of data for 1995 to 1999 we calculate the POM for 1980 to 1999 based on 2000 to 2002.

In general 1994 is calculated as the average of 1995 to 1997 minus a fixed percentage. This fixed percentage is 2 per cent for every UNU key. Every lower year is the same as one year higher minus the fixed percentage.

In case these calculations form a strange graph an extra correction is done. For instance when 1995 is lower than 1996 but also lower than 1994, the year 1995 will be changed to the average of 1994 and 1996.

#### **Conclusions on EEE stock and flow data inventory**

The same approach used to add the years 2013 and 2014 can be used to calculate future years. The ProdCom and International trade data has to be available. Furthermore a check has to be done if relevant codes have been added or removed. The new codes have to be linked to UNU keys. Also the average weights per UNU key have to be checked. The basis can be the one from the previous year but attention has to go to product categories in which changes have taken place in the product properties.

## Annex 3b: Apparent consumption method with aggregated code lists

For the apparent consumption method the International trade codes (CN) are first aggregated to ProdCom codes. For this the links in table 1 are used. The special ProdCom codes starting with CBS are explained afterwards.

Table 14. International trade (CN) to ProdCom

CN code	ProdCom		CN code	ProdCom		CN code	ProdCom
63011000	27511400		85161080	27512560		85393900	27401550
84031010	25211200		85162100	27512630		85394100	27401570
84031090	25211200		85162910	27512650		85414090	26112240
84145100	27511530		85162950	27512650		85437010	CBSNL008
84146000	27511580		85162991	27512650		85437050	27904070
84151010	28251220		85162999	27512690		85437060	CBSNL011
84151090	28251220		85163100	27512310		87119010	30911300
84152000	28251240		85163200	27512330		90066100	299900Z1
84158100	28251250		85163300	27512350		90066900	299900Z1
84158200	28251250		85164000	27512370		90071000	26701500
84158300	28251270		85165000	27512700		90072000	26701600
84181020	27511110		85166010	27512810		90085000	299900Z1
84181080	27511110		85166050	27512830		90101000	299900Z1
84182110	27511133		85166070	27512850		90105000	299900Z1
84182151	27511133		85166080	27512870		90106000	299900Z1
84182159	27511135		85166090	27512890		90151010	26511215
84182191	27511133		85167100	27512430		90152010	26511215
84182199	27511133		85167200	27512450		90153010	28293960
84182900	27511133		85167920	27512490		90154010	26511215
84183020	27511150		85167970	27512490		90158011	26511235
84183080	27511150		85171100	26302100		90158019	26511239
84184020	27511170		85171200	26302200		90173000	26513300
84184080	27511170		85171800	26302330		90181100	26601230
84185011	28251333		85176100	26302310		90181200	26601280
84185019	28251335		85176200	26302320		90181300	26601280
84185090	28251360		85176910	26302330		90181400	26601280
84186100	28251380		85176920	26302370		90181910	26601280
84186900	28251390		85176931	26302340		90181990	26601280
84211200	28942300		85176939	26404400		90184100	32501130
84221100	27511200		85176990	26302370		90214000	26601433
84231010	28293200		85181030	26404100		90241011	26516210
84231090	28293200		85181095	26404100		90241013	26516210
84331110	28304010		85182100	26404235		90241019	26516210
84331910	28304010		85182200	26404237		90248011	26516255
84431200	28232200		85183020	26404270		90248019	26516255
84433120	26201800		85183095	26404270		90251920	26515135
84433180	26201800		85184030	26404355		90258040	26515175

CN code	ProdCom		CN code	ProdCom		CN code	ProdCom
84433210	26201640		85184080	26404359		90258080	26515179
84433230	26201640		85185000	26404370		90261021	26515235
84433291	26201640		85192010	26403100		90261029	26515239
84433293	26201640		85192091	26403100		90262020	26515271
84433299	26201640		85192099	26403100		90268020	26515283
84433910	28232100		85193000	26403100		90271010	26515313
84433931	28232100		85195000	26302370		90278011	26515381
84433939	28232100		85198111	26403100		90278013	26515383
84433990	28991490		85198115	26403100		90278017	26515383
84501111	CBSNL016		85198121	26403100		90302091	26514555
84501119	CBSNL016		85198125	26403100		90303310	26514330
84501190	CBSNL016		85198131	26403100		90304000	26514400
84501200	CBSNL016		85198135	26403100		90308930	26514555
84501900	CBSNL016		85198145	26403100		90314910	26516630
84502000	28942230		85198151	28232300		90318032	26516650
84511000	28942250		85198155	CBSNL020		90318034	26516650
84512100	CBSNL017		85198161	CBSNL020		90318038	26516670
84512900	28942270		85198165	CBSNL020		90321020	26517015
84513000	28942130		85198175	CBSNL020		91011100	26521100
84521011	28944000		85198181	CBSNL020		91011900	26521100
84521019	28944000		85198185	CBSNL020		91012100	26521100
84521090	28944000		85198195	CBSNL019		91012900	26521100
84672110	28241113		85198911	26403100		91019100	26521100
84672191	28241115		85198915	26403100		91019900	26521100
84672199	28241117		85198919	26403100		91021100	26521200
84672210	28241123		85198990	CBSNL020		91021200	26521200
84672230	28241125		85211020	26403300		91021900	26521200
84672290	28241127		85211095	26403300		91022100	26521200
84672920	28241120		85219000	26403300		91022900	26521200
84672951	28241150		85256000	26301100		91029100	26521200
84672953	28241150		85258011	26301300		91029900	26521200
84672959	28241150		85258019	26301300		91031000	26521400
84672970	28241150		85258030	26701300		91039000	26521400
84672980	28241180		85258091	26403300		91051100	26521400
84672985	28241185		85258099	26403300		91051900	26521400
84690010	28231100		85271210	26401100		91052100	26521400
84690091	28231100		85271290	26401100		91052900	26521400
84690099	28231100		85271310	26401100		91059100	26521400
84701000	28231200		85271391	26401100		91059900	26521400
84702100	28231200		85271399	26401100		91070000	26522870
84702900	28231200		85271900	26401100		91081100	26522100
84703000	28231300		85272120	26401270		91081200	26522100
84705000	CBSNL018		85272152	26401270		91081900	26522100

CN code	ProdCom		CN code	ProdCom		CN code	ProdCom
84709000	CBSNL018		85272159	26401270		91082000	26522100
84713000	26201100		85272170	26401270		91089000	26522100
84714100	26201300		85272192	26401270		91091000	26522200
84714900	26201400		85272198	26401270		91099000	26522200
84715000	26201500		85272900	26401290		92071010	32201400
84716060	26201650		85279111	26401100		92071030	32201400
84716070	26201660		85279119	26401100		92071050	32201400
84717020	26202100		85279135	26401100		92071080	32201400
84717030	26202100		85279191	26401100		92079010	32201400
84717050	26202100		85279199	26401100		92079090	32201400
84717070	26202100		85279210	26401100		94051021	27402500
84717080	26202100		85279290	26401100		94051040	27402500
84717098	26202100		85279900	26401100		94051050	27402500
84718000	269900Z0		85284100	CBSNL001		94051091	27402500
84719000	269900Z0		85284910	26403480		94051098	27402500
84721000	28232300		85284980	26403440		94052011	27402200
84723000	28232300		85285100	CBSNL003		94052040	27402200
84729010	28232300		85285920	26403480		94052050	27402200
84729070	28232300		85285931	26403460		94052091	27402200
84762100	28294330		85286100	CBSNL002		94052099	27402200
84762900	28294350		85286910	26403420		94053000	27403200
84768100	28294330		85286991	26403420		94054010	27403300
84768900	28294350		85286999	26403420		94054031	27403930
85081100	27512123		85287210	26402040		94054035	27403930
85081900	27512125		85287220	CBSNL006		94054039	27403930
85086000	27512410		85287300	CBSNL006		94054091	27403930
85094000	27512170		85311030	26305080		94054095	27403930
85098000	27512190		85311095	26305020		94054099	27403930
85101000	27512200		85312020	27902050		95030030	32402000
85102000	27512200		85312040	27902020		95030035	32402000
85103000	27512200		85312095	27902020		95030039	32402000
85121000	29312310		85318020	27902080		95030055	32403920
85131000	27402100		85318095	27902080		95030070	32403920
85151100	27903109		85392130	27401250		95030075	32403920
85151900	27903118		85392192	27401293		95030079	32403920
85152100	27903145		85392198	27401295		95030081	32403920
85152900	27903145		85393110	27401510		95045000	26406050
85153100	27903154		85393190	27401530		95049010	32404250

After this the ProdCom codes are aggregated to UNU keys. However, for 7 ProdCom codes, the ProdCom code links to multiple CN, of which the CN should be assigned to different UNU keys. Since most of sales in European countries comes from imported commodities, it is more important that the trade code is assigned correctly to the UNU key. Therefore, those ProdCom codes get a converted internal code of which the name starts with CBS. These codes that are

changed are listed in Table 15. The links are the same for the year 2013 and 2014. Then the ProdCom codes are aggregated to UNU keys. For this Table 16 is used for both the year 2013 and 2014. The converted ProdCom codes are used in this table.

When a ProdCom code is for instance split into 3 internal codes, each one receives 1/3 of the original value in the ProdCom. This way their total value is still the same as the original ProdCom value.

**Table 15. Converted ProdCom codes**

Converted ProdCom code	Original ProdCom code	Related CN code
CBSNL001	26201700	85284100
CBSNL002	26201700	85286100
CBSNL003	26201700	85285100
CBSNL005	26402090	85287240
CBSNL005	26402090	85287260
CBSNL005	26402090	85287280
CBSNL006	26402090	85287220
CBSNL006	26402090	85287230
CBSNL006	26402090	85287300
CBSNL007	26402090	85287190
CBSNL008	27901150	85437010
CBSNL011	27901150	85437060
CBSNL012	27901150	85437090
CBSNL016	27511300	84501111
CBSNL016	27511300	84501119
CBSNL016	27511300	84501190
CBSNL016	27511300	84501200
CBSNL016	27511300	84501900
CBSNL017	27511300	84512100
CBSNL018	28231300	84705000
CBSNL018	28231300	84709000
CBSNL019	32303290	85198195
CBSNL020	26403200	85198155
CBSNL020	26403200	85198161
CBSNL020	26403200	85198165
CBSNL020	26403200	85198175
CBSNL020	26403200	85198181
CBSNL020	26403200	85198185
CBSNL020	26403200	85198990
CBSNL030	32403920	95030055
CBSNL030	32403920	95030075
CBSNL030	32403920	95030079
CBSNL031	32403920	95030070
CBSNL031	32403920	95030081

Table 16 shows the links needed to aggregate the ProdCom codes to UNU keys. Furthermore there is a column Average Weight. For the conversion of the units in the ProdCom to weight

conversion factors are used. If available, the Average Weight listed in this table are used. When not available the conversion factors on UNU key level are used. These can be found in Section 3. The Average Weight conversion factors can be different for each year. Below are the conversion factors used to calculate the year 2014.

**Table 16. ProdCom to UNU keys**

ProdCom	UNU key		ProdCom	UNU key
25211200	0001		27511135	0108
26112220	0505		27511150	0109
26112240	0002		27511170	0109
26122000	0301		27511200	0102
26201100	0303		27511400	0201
26201300	0302		27511530	0201
26201400	0302		27511580	0106
26201500	0302		27512123	0204
26201640	0304		27512125	0204
26201650	0301		27512170	0202
26201660	0301		27512190	0201
26201800	0304		27512200	0205
26202100	0301		27512310	0205
26203000	0308		27512330	0205
26301100	0404		27512350	0205
26301300	0404		27512370	0201
26302100	0305		27512410	0204
26302200	0306		27512430	0203
26302310	0306		27512450	0202
26302320	0403		27512490	0202
26302330	0305		27512530	0203
26302340	0305		27512560	0203
26302370	0306		27512630	0106
26305020	0901		27512650	0106
26305080	0901		27512690	0106
26401100	0402		27512700	0114
26401250	0403		27512810	0103
26401270	0403		27512830	0202
26401290	0403		27512850	0202
26403100	0403		27512870	0103
26403200	0403		27512890	0202
26403300	0404		27902020	0309
26403420	0404		27902050	0309
26403440	0308		27902080	0901
26403460	0309		27903109	0601
26403480	0308		27903118	0601
26404100	0401		27903145	0601
26404235	0405		27903154	0601

ProdCom	UNU key		ProdCom	UNU key
26404237	0405		28231100	0301
26404270	0401		28231200	0301
26404355	0601		28232100	0307
26404359	0403		28232200	0307
26404370	0403		28232300	0403
26404400	0305		28241113	0601
26406050	0702		28241115	0601
26511215	0902		28241117	0601
26511235	0902		28241120	0601
26511239	0901		28241123	0601
26513300	0901		28241125	0601
26514330	0901		28241127	0601
26514400	0305		28241150	0601
26514555	0901		28241180	0601
26515135	0901		28241185	0601
26515175	0901		28251220	0111
26515179	0901		28251250	0111
26515235	0901		28251270	0113
26515239	0901		28251333	0113
26515271	0901		28251335	0113
26515283	0901		28251360	0113
26515313	0901		28251380	0112
26515381	0901		28293200	0201
26515383	0901		28294330	1002
26516210	0901		28294350	1001
26516255	0901		28304010	0602
26516650	0901		28942130	0101
26516670	0901		28942230	0104
26517015	0901		28942250	0101
26521100	0201		28942270	0105
26521200	0201		28942300	0105
26521400	0201		28944000	0201
26522100	0201		28991490	0304
26522200	0201		29312310	0501
26522870	0201		299900Z1	0404
26601230	0802		30021640	0304
26601280	0802		30911300	0703
26601433	0801		32201400	0403
26701300	0406		32402000	0701
26701500	0404		32404250	0701
26701600	0404		32501130	0802
26701700	0404		36503349	0701
269900Z0	0301		CBSNL001	0308

ProdCom	UNU key		ProdCom	UNU key
27401510	0503		CBSNL002	0404
27401530	0502		CBSNL003	0309
27401550	0504		CBSNL005	0408
27401570	0503		CBSNL006	0407
27402100	0501		CBSNL007	0404
27402200	0506		CBSNL008	0301
27402500	0506		CBSNL011	0901
27403200	0506		CBSNL016	0104
27403300	0507		CBSNL017	0105
27403930	0506		CBSNL018	0307
27511110	0108		CBSNL020	0403
27511133	0108		CBSNL030	0701

## Annex 4 Products covered by the various UNU keys

UNU key	Description	Original WEEE Directive Annex I	Recast WEEE Directive Annex III
<b>0001</b>	Central Heating (household installed)	Large Household appliances	large equipment
<b>0002</b>	Photovoltaic Panels (incl. inverters)	Consumer equipment	large equipment
<b>0101</b>	Professional Heating & Ventilation (excl. cooling equipment)	Large Household appliances	large equipment
<b>0102</b>	Dishwashers	Large Household appliances	large equipment
<b>0103</b>	Kitchen (e.g., large furnaces, ovens, cooking equipment)	Large Household appliances	large equipment
<b>0104</b>	Washing Machines (incl. combined dryers)	Large Household appliances	large equipment
<b>0105</b>	Dryers (wash dryers, centrifuges)	Large Household appliances	large equipment
<b>0106</b>	Household Heating & Ventilation (e.g., hoods, ventilators, space heaters)	Large Household appliances	large equipment
<b>0108</b>	Fridges (incl. combi-fridges)	Large Household appliances	temperature exchange equipment
<b>0109</b>	Freezers	Large Household appliances	temperature exchange equipment
<b>0111</b>	Air Conditioners (household installed and portable)	Large Household appliances	temperature exchange equipment
<b>0112</b>	Other Cooling (e.g., dehumidifiers, heat pump dryers)	Large Household appliances	temperature exchange equipment
<b>0113</b>	Professional Cooling (e.g., large air conditioners, cooling displays)	Large Household appliances	temperature exchange equipment
<b>0114</b>	Microwaves (incl. combined, excl. grills)	Large Household appliances	small equipment
<b>0201</b>	Other Small Household (e.g., small ventilators, irons, clocks, adapters)	Small Household appliances	small equipment
<b>0202</b>	Food (e.g., toaster, grills, food processing, frying pans)	Small Household appliances	small equipment
<b>0203</b>	Hot Water (e.g. coffee, tea, water cookers)	Small Household appliances	small equipment
<b>0204</b>	Vacuum Cleaners (excl. professional)	Small Household appliances	small equipment
<b>0205</b>	Personal Care (e.g. tooth brushes, hair dryers, razors)	Small Household appliances	small equipment
<b>0301</b>	Small IT (e.g., routers, mice, keyboards, external drives & accessories)	IT and telecommunications equipment	small equipment
<b>0302</b>	Desktop PCs (excl. monitors, accessoires)	IT and telecommunications equipment	small equipment
<b>0303</b>	Laptops (incl. tablets)	IT and telecommunications equipment	screens and monitors (referred to as screens)
<b>0304</b>	Printers (e.g., scanners, multi-functionals, faxes)	IT and telecommunications equipment	small IT and telecommunication equipment
<b>0305</b>	Telecom (e.g., (cordless) phones, answering machines)	IT and telecommunications equipment	small IT and telecommunication equipment
<b>0306</b>	Mobile Phones (incl. smartphones, pagers)	IT and telecommunications equipment	small IT and telecommunication equipment

<b>0307</b> Professional IT (e.g., servers, routers, data storage, copiers)	IT and telecommunications equipment	large equipment
<b>0308</b> Cathode Ray Tube Monitors	IT and telecommunications equipment	screens and monitors (referred to as screens)
<b>0309</b> Flat Display Panel Monitors (LCD, LED)	IT and telecommunications equipment	screens and monitors (referred to as screens)
<b>0401</b> Small Consumer Electronics (e.g. headphones, remote controls)	Consumer equipment	small equipment
<b>0402</b> Portable Audio & Video (e.g., MP3, e-readers, car navigation)	Consumer equipment	small equipment
<b>0403</b> Music Instruments, Radio, Hi-Fi (incl. audio sets)	Consumer equipment	small equipment
<b>0404</b> Video (e.g., Video recorders, DVD, Blue Ray, set-top boxes)	Consumer equipment	small equipment
<b>0405</b> Speakers	Consumer equipment	small equipment
<b>0406</b> Cameras (e.g., camcorders, photo & digital still cameras)	Consumer equipment	small equipment
<b>0407</b> Cathode Ray Tube TVs	Consumer equipment	screens and monitors (referred to as screens)
<b>0408</b> Flat Display Panel TVs (LCD, LED, Plasma)	Consumer equipment	screens and monitors (referred to as screens)
<b>0501</b> Small lighting equipment (excl. LED & incandescent)	Lighting equipment	small equipment
<b>0502</b> Compact Fluorescent Lamps (incl. retrofit & non-retrofit)	Lighting equipment	lamps
<b>0503</b> Straight Tube Fluorescent Lamps	Lighting equipment	lamps
<b>0504</b> Special Lamps (e.g., professional mercury, high & low pressure sodium)	Lighting equipment	lamps
<b>0505</b> LED Lamps (incl. retrofit LED lamps)	Lighting equipment	lamps
<b>0506</b> Household Luminaires (incl. household incandescent fittings & household LED luminaires)	Lighting equipment	small equipment
<b>0507</b> Professional Luminaires (offices, public space, industry)	Lighting equipment	small equipment
<b>0601</b> Household Tools (e.g., drills, saws, high-pressure cleaners, lawn mowers)	Electrical and electronic tools	small equipment
<b>0602</b> Professional Tools (e.g. for welding, soldering, milling)	Electrical and electronic tools	large equipment
<b>0701</b> Toys (e.g., car racing sets, electric trains, music toys, biking computers)	Toys, leisure and sports equipment	small equipment
<b>0702</b> Game Consoles	Toys, leisure and sports equipment	small IT and telecommunication equipment
<b>0703</b> Leisure (e.g., large exercise, sports equipment)	Toys, leisure and sports equipment	large equipment
<b>0801</b> Household Medical (e.g. thermometers, blood pressure meters)	Medical devices	small equipment
<b>0802</b> Professional Medical (e.g., hospital, dentist, diagnostics)	Medical devices	large equipment
<b>0901</b> Household Monitoring & Control (alarm, heat, smoke, excl. screens)	Monitoring and control instruments	small equipment
<b>0902</b> Professional Monitoring & Control (e.g., laboratory, control panels)	Monitoring and control instruments	large equipment
<b>1001</b> Non Cooled Dispensers (e.g., for vending, hot drinks, tickets, money)	Automatic dispensers	large equipment
<b>1002</b> Cooled Dispensers (e.g., for vending, cold drinks)	Automatic dispensers	temperature exchange equipment

## Annex 5 Glossary of terms and definitions (see also project Deliverable 5.3)

### Abbreviations

<b>ACEA</b>	<b>European Automobile Association</b>
<b>ANFAC</b>	Asociación Española de Fabricantes de Automóviles et Camiones
<b>BATT</b>	Batteries
<b>CN</b>	Combined Nomenclature
<b>COMTRADE</b>	UN Comtrade (Commerce and Trade) database
<b>CRMs</b>	Critical Raw Materials
<b>EEE</b>	Electric and Electronic Equipment
<b>ELV</b>	End-of-Life Vehicle
<b>EoL</b>	End-of-Life
<b>ETFA</b>	EU Free Trade Area
<b>Eurostat</b>	European Statistics Association database
<b>EU28+2</b>	Austria (AUT), Belgium (BEL), Bulgaria (BGR), Cyprus (CYP), Czech Republic (CZE), Germany (DEU), Denmark (DNK), Spain (ESP), Estonia (EST), Finland (FIN), France (FRA), Great Britain (GBR), Greece (GRC), Croatia (HRV), Hungary (HUN), Ireland (IRL), Italy (ITA), Lithuania (LTU), Latvia (LVA), Malta (MLT), the Netherlands (NLD), Poland (POL), Portugal (PRT), Romania (ROU), Slovakia (SVK), Slovenia (SVN), Sweden (SWE), plus Switzerland (CHE) and Norway (NOR)
<b>HH</b>	Households
<b>inh</b>	inhabitant
<b>IOA</b>	Input-Output Analysis
<b>kg</b>	kilogram
<b>kg/HH</b>	Kilogram/household
<b>kg/inh</b>	Kilogram/ inhabitant
<b>kt</b>	kilotons
<b>MAD</b>	Median Absolute Deviation
<b>MWh</b>	Megawatt hours
<b>pcs</b>	pieces
<b>pcs/HH</b>	Pieces/household
<b>pcs/inh</b>	Pieces/inhabitant
<b>POM</b>	Put on Market
<b>ProdCom</b>	PRODUCTION COMMUNAUTAIRE
<b>PV</b>	Photo voltaic

## 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.

### **Batteries (BATT)**

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).

### **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).

### **EOL**

End-of-Life.

### **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.

### **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.

### **Exported**

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

### **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).

### **(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 the total amount of products (EEE, BATT and vehicles) in households, businesses and public sector. This is destined to become waste in the future and is also often referred to as the "urban mine". The stocks can be differentiated between in-use stocks and hibernated stocks (functioning and non-functioning products).

### **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**

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 Batteries (BATT)**

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).

**Waste flows**

Waste flows are the amounts of waste from the point of being waste generated heading via collection to various recycling, recovery, disposal and export (for reuse) destinations.

**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, BATT, ELV collected (and treated)**

The WEEE that is collected, reported and regulated by national transposition of the WEEE, Battery or ELV Directive. This includes WEEE, BATT, ELV that is collected, exported and treated and recorded in national and European statistics.

**WEEE, BATT, ELV Generated**

The amount WEEE, BATT, ELV 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, Battery, ELV Directive. Generally WEEE and BATT generated is calculated using a sales-lifespan approach, according to internationally agreed statistical guidelines (Baldé, 2015) using the UNU keys for WEEE (Magalini et al, 2016) and the BATT keys for batteries (following D5.3). For ELV Generated, a stock- lifespan approach is developed (see section 4.3)