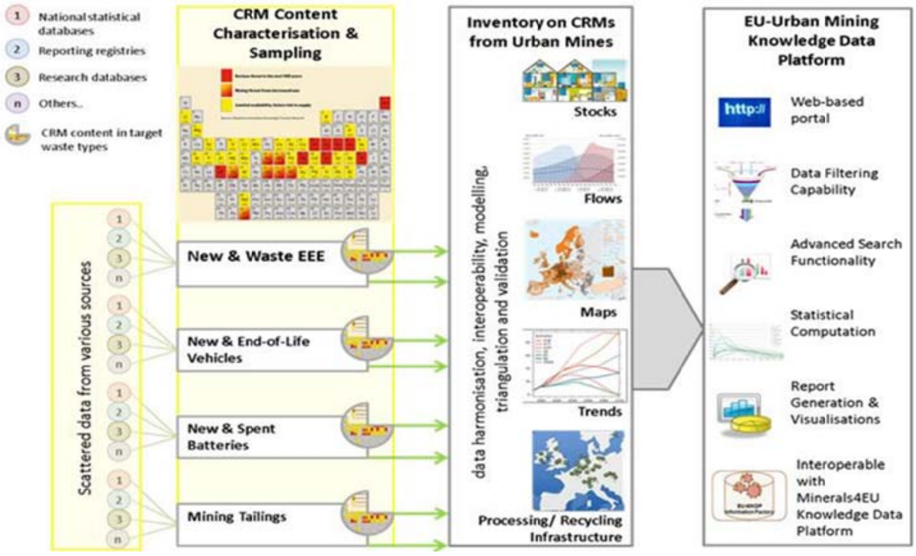
Assessment of Complementary Waste Flows

Deliverable 3.2



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PURPOSE

The primary objective of ProSUM Work Package 3 (WP3) is to review and consolidate geographic, demographic, economic and time-series data on stocks and flows of in-use and end-of-life EEE, vehicles and BATT across the European Union (EU). The intended result includes the mapping of various flows of products containing secondary raw materials, in particular Critical Raw Materials (CRM). The purpose of Deliverable 3.2, managed by WRAP, is to assess the disposal trends of WEEE, BATT and ELV with an aim to better understand and quantify complementary and unreported flows of WEEE, BATT and ELV, both within and outside official collection systems.

Deliverable 3.2 takes inventory of the data sources available on specific (complementary) flows, structured according to the classification and harmonisation system produced in Deliverable 5.3. The proposed formats are tested and expanded by processing both structured and unstructured data for this deliverable. Subsequent harmonisation efforts are being made in the ProSUM consortium to ensure compatibility of approaches throughout the project. The data gathering performed in Deliverable 3.1 on product market input and stocks, as well data from Deliverable 2.2 on Product Trends, and Deliverable 4.1 on the Waste Flow studies has been used as a basis for this deliverable and where needed, the harmonisation protocols under development are being adapted.

The output of this work will be used in Deliverable 3.3 for the completion of the stock and flow modelling. All available published academic literature, Eurostat information, technical reports, national producer registries and consumer surveys containing information on complementary flows have been analysed, structured and described in such a way that they match the ProSUM unified data model in development under WP5 to allow for data harvesting.

The results from the complementary flows analysis provide a much more comprehensive view on where data sources are available and where there are unavoidable significant gaps in data. For WEEE the results include a full description of the data quality and uncertainty levels, which are shown to be substantial due to the inherently scarce, scattered and unstructured nature of most information sources.

For a glossary of terms and definitions used, see Annex 1.

EXECUTIVE SUMMARY

The purpose of Deliverable 3.2 is to assess disposal trends of WEEE, BATT and ELV with an aim to better understand and quantify complementary flows of WEEE, BATT and ELV taking place outside of the officially reported collection systems.

The term **complementary flows** mainly refers to all waste flows that are not reported at a national level by the official compliance systems, and others, according to the ELV, BATT and WEEE Directives. A certain portion of these flows are exported, incinerated or landfilled.

The term also **includes non-compliant treatment** e.g. recycling with other waste streams such as mixed metal scrap. This type of recycling does not always meet the same efficiency and treatment standards as the officially reported amounts, and is financed via other (mainly market) mechanisms.

Another example is **B2B waste collected and recycled** that is not reported to producer compliance schemes and/or national authorities. The amount of WEEE and BATT treated this way is very difficult to quantify. Where data is available, it is mainly estimated from a limited number of observations. The term non-compliant does not necessarily imply substandard treatment, but rather refers to quantities not being declared to national/ EU levels. Other terms commonly used are complementary treatment or unreported treatment. The term unreported is not utilised as often, as this wasteis declared to regional authorities but under different reporting regimes.

For ELV, which ordinarily doesn't reach landfill or incineration destinations, the **complementary flows** are referred to as **unknown whereabouts of ELV**. These are vehicles which are not reported. They are neither registered as part of the European vehicle stock (also called "vehicle fleet" or "vehicle parc"), nor as vehicles exported from the EU (termed extra EU-Export in COMEXT), nor as ELVs (Eurostat). Unknown whereabouts of ELV cover both legal and illegal activity and may be partly caused by suboptimal end-of-life vehicle registration systems (registering, deregistering, re-registering and issuing certificates of destruction.)

The purpose of this report is to ensure that the ProSUM stock and flow model which will be developed as part of Deliverable 3.3 has accurate data based on both reported and unreported information. Moreover this work is aligned with the simultaneous development of the ProSUM unified data model. This includes the specific templates used throughout the consortium to ensure harmonisation of all the analytical work, ease of future updating and a clear description of both data quality and uncertainty levels related to the data.

Officially reported WEEE and BATT figures are those related to activities which are registered in national and EU waste statistics such as: collected and treated amounts; recycling and reuse percentages declared to the producer compliance schemes by authorised treatment facilities; and producers and authorities responsible for WEEE compliance in EU member states. For BATT, three main application areas are mentioned in the BATT Directive: Portable, Industrial and Automotive Batteries. In each of these, specific complementary flows and varying economic drivers exist.

For ELV the reported data includes:

- European Automobile Manufacturers' Association (ACEA) for data on new registrations within EU;
- Eurostat for data on ELVs. This data is annually reported by Member States;
- POLK (Part of IHS Automotive market analysis report) for data on vehicle fleet composition;
- Eurostat Foreign Trade Statistics (FTS) on Extra-EU trade of used cars in COMEXT, i.e. data on import and export of used vehicles to and from the European Union.

From waste generated data minus the reported collection data and the sum of all additional sources on complementary flows, it is possible to estimate the approximate size of the remaining data gap. It is more challenging however to estimate the size of each individual type of complementary flow that forms part of the gap in the mass balance.

Due to the use of a large number of coherent estimates, the quality and uncertainty related to the various flows identified needs to be substantiated. A tiered approach has been taken to gathering and reviewing data. As complementary flows data is by definition not officially reported, it was necessary to engage with individuals and organisations that have access to data not in the public domain, and to thoroughly analyse all technical reports and academic literature gathered for Deliverable 3.1.

In the first instance, active liaison with partners in the ProSUM project and the wider ProSUM Information Network was undertaken to identify what data was available for analysis. Subsequently, an extensive online search coupled with interviews with key, relevant stakeholders in the sector was carried out. This was followed by analysis and comparison of all identified available data on the topic which led to the development of conclusions and observations regarding the complementary flows of WEEE, BATT and ELV.

The above data identification and collection task resulted in considerably more data points on complementary flows of WEEE and only a limited number of data points on BATT and ELV. Therefore, a more detailed analysis of complementary flows for WEEE was possible.

For WEEE it was possible to provide a detailed breakdown of the various complementary flows on a country level. For batteries it was only possible to quantify two out of four relevant complementary flows for a limited number of countries. Nevertheless the literature and data analysed allowed for a number of observations on the trends related to future BATT in the waste stream.

When it comes to ELV the estimation of the gaps in ELV flows was provided as well as the qualitative assessment of the potential fates of vehicles of unknown whereabouts. Due to limited data it was not possible to quantify individual complementary flows of ELV in Europe. Further research would be needed on the topic in order to quantify the individual complementary flows of ELV.

WEEE Results

The size of complementary flows for WEEE in the EU is displayed in Figure 1 for the year 2012, for which most data points are available. Figure 1 illustrates totals for all collection categories, including the use of coherent estimates and their uncertainty levels.

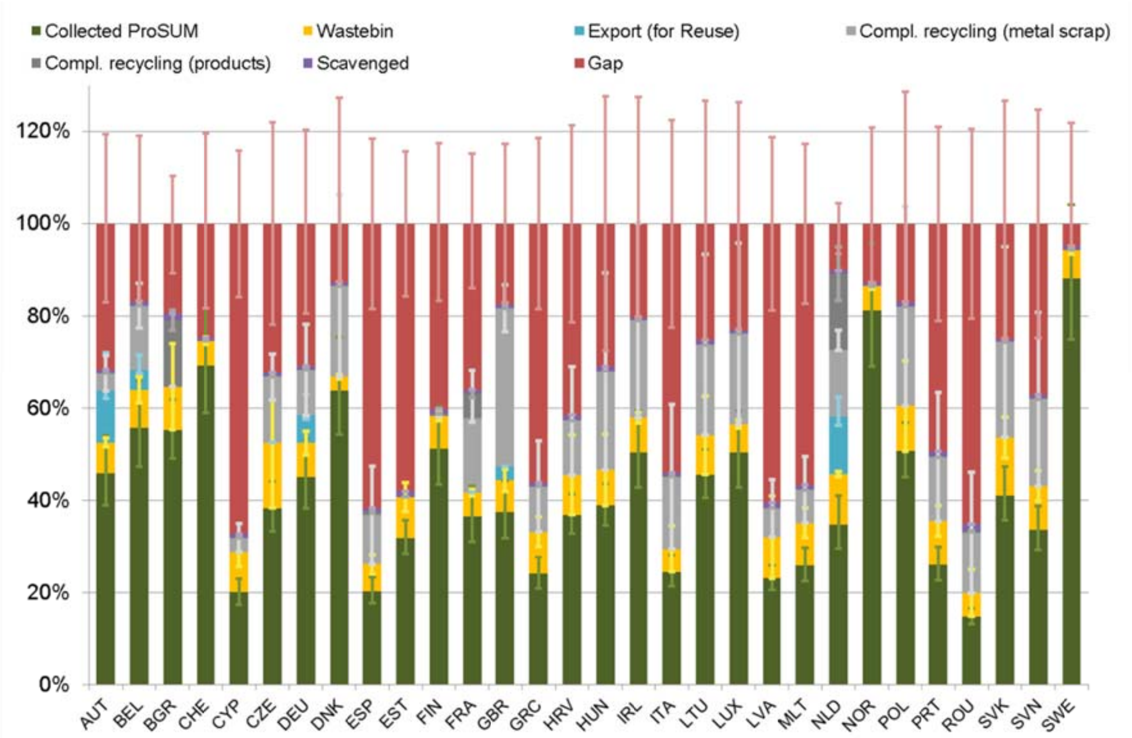

Figure 1. Complementary WEEE Flows 2012 against WEEE Generated (100%), EU28+2, incl.coherent estimates.

A more detailed breakdown of this tonnage is shown in Table 1. The data is available for the years 2010-2014. In the table, 2012 is chosen as the reference year since it has the highest number of data points available.

Table 1. Tonnage of WEEE Flows in 2012, EU28+2

Year: 2012, values in kt	Placed on Market	WEEE Generated	Reported collection	Waste Bin	WEEE in metal scrap	Compl. Recycling products	Scavenged components	Export (for reuse)	GAP
Temp. Exchange Eq.	2,122	1,436	580	-	101	28	76	26	626
Screens	970	1,347	663	26	32	14	-	87	526
Lamps	126	118	14	5	-	3	-	-	96
Large Equipment	2,949	2,876	1,040	21	655	59	-	16	1,084
Small Equipment	3,368	2,573	777	435	452	30	-	20	859
Small IT	728	757	374	117	87	7	-	52	120
Total	10,263	9,107	3,448	604	1,326	141	76	201	3,312

The main complementary flows of WEEE that could be quantified consist of:

1. Small appliances in the waste bin, average 1.2 kg/inh, ranging between 0.5 kg/inh and 1.9 kg/inh.
2. WEEE in mixed (ferrous) metal scrap, average of 1.4 kg/inh, ranging between 0 and 4.5 kg/inh, except for the UK.
3. For the other known streams, both original data and coherent estimates are scarce. For additional unreported recycling of products (e.g professional and B2B appliances), there is limited information available from large recycling market surveys for the Netherlands,

supplemented by a few data points for other countries from the CWIT project. For exported flows (regardless of whether these are legal or illegal transports), coherent data is only available for 5 countries.

The values in the Table 1 are lower than those published in the CWIT report. The main reason is that a more conservative approach is taken here. The values above should therefore be regarded as minimum amounts for the various flows. Especially for WEEE in metal scrap, there is considerable upwards potential.

BATT Results

The complementary flows of BATT consist of:

1. Spent portable BATT disposed of in municipal solid waste destined for incineration and landfill both including BATT in WEEE;
2. Portable BATT embedded in and recycled with WEEE;
3. Industrial BATT mixed with portable BATT due to challenges in distinguishing between industrial and portable battery at a collection stage; and
4. BATT legally and illegally exported for use, reuse or recycling on its own or within a product like EEE or vehicles.

In summary BATT data analysis results suggest that:

- BATT could account for 2,000 to 230,000 tonnes of the 213.4 Mt of municipal waste generated in the EU-28 in 2012;
- Separately collected WEEE contains 91,000-206,000 tonnes of BATT;
- Exports of UEEE and WEEE contain 45,000-102,000 tonnes of BATT.

The limited availability of data allowed for only partial quantification of the four complementary flows above. However flows of BATT are to some extent correlated with complementary flows of WEEE. Therefore these two waste streams shouldn't be analysed in separation.

Table 2 lists percentage of batteries in household waste for England, Flanders, Belgium and Spain.

Table 2. Percentage of BATT in the Household Residual Waste Stream

Country / Geography	BATT as a % of household residual	Source
England	0.11%	Defra (2012)
Flanders	0.05%	VVSG (2013)
Flanders	0.02%	OVAM (2015)
Belgium	0.024%	Bebat and Mobius (2012)
Spain	0.01%	Chemical Engineering Department, University of Salamanca (2011)

Table 3 summarises the analysis of the data obtained for portable BATT embedded in and recycled with WEEE. It takes national estimates of the proportion of WEEE which comprises BATT, and applies these percentages to the WEEE arising across the EU 28 in 2012. It is clear that the different national estimates lead to markedly different estimates for the weight of BATT in WEEE. Subsequent analysis suggests there has not been a change in the proportion of batteries in WEEE over time, nor is there correlation between the composition of WEEE in each country and the proportion of WEEE estimated as containing batteries. Possible explanations could include differing collection and segregation of battery containing items in each country, meaning differing amounts arrive in the WEEE stream. Further research would be required to test this hypothesis.

Table 3. Percentage of BATT in WEEE

Country	BATT as a % of WEEE	Source	Separately collected WEEE (tonnes EU 28 2012) (Eurostat)	Inferred EU-28 battery content using national estimates (tonnes)
Sweden	2.1%	Avfall Sverige (pers comm)	3,019,731	63,414
Germany	1.3% *	GRS Batterien (pers comm)		39,257
Romania	0.6%	ECOTIC (Pers comm)		18,118
Estonia	0.5% *	EEE Ringlus (pers comm)		15,099
Ireland	0.41%	WEEE Ireland (pers comm)		12,381
England and Wales	0.06%	Environment Agency (2016)		1,812
Average	0.8%			25,013
Prosum D4.1	3%-7%			91,358-205,740

*WEEE categories 2 and 3 only

Based on the data analysed a number of observations were made regarding the future of the BATT waste stream and specifically regarding the complementary BATT flows. The conclusions were drawn based on the changing nature of EEE products and batteries placed on the market as well as changing consumer behaviour and the observed pace of technological development.

Furthermore the research identified of a number of challenges in BATT data reporting which resulted in difficulties comparing data between countries. These challenges are listed in the conclusion to this report..

Identifying and specifically quantifying complementary waste flows for BATT was a more challenging task. By their nature there is little or no data recording on the movement of unreported battery flows.

The data did not allow for specific conclusions on the quantities of BATT separately and illegally exported. No publicly available reports or publications exist that identify any complementary, unreported flows of industrial and automotive BATT in Europe. The exact sizes of battery complementary flows of for EU are nearly impossible to estimate due to a lack of sufficient data.

The difficulty in distinguishing a lead industrial battery from a lead portable battery leads to overstated amounts of lead portable batteries in waste battery collection volumes. Compliance organisations and member states need to carefully filter industrial batteries out of portable battery collection reports. Whilst in most countries, the reported return rate for portable lead batteries is 100%, some implausible lead return rates have been reported. For example in the UK the return rate for lead portable batteries was 478%, whereas all other chemistries reported a 5% return rate during 2013.

Inconsistent definitions of the Waste Framework and Battery Directives complicate data collection and enforcement. New batteries placed on the market are defined as ‘portable’, ‘industrial’ and ‘automotive’ batteries. The waste battery categories in the Waste Framework Directive’s European Waste Catalogue distinguish only battery chemistries. Therefore, the licensing requirements for waste batteries management activities (e.g. collection, transport, treatment) do not allow for the identification of waste batteries that should count towards the portable batteries collection rate. This complicates the identification of collection volumes.

ELV Results

Complementary flows of ELV vary between countries and predominantly consist of:

- ELVs recycled in unauthorised treatment facilities;
- ELV exported as 2nd hand vehicles;
- Unrecorded exports of used cars, e.g. exports outside of Europe by transit through European Union-Member State (EU-MS);
- Not depolluted or partially depolluted ELVs exported in breach of the ELV and TFS Regulations; and
- Illegal export of scrap cars.

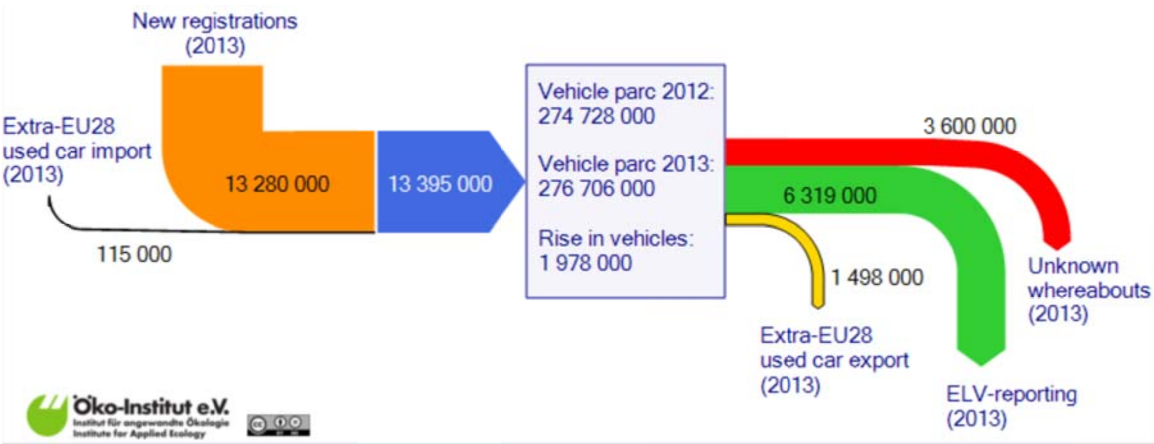

Figure 2. Vehicle Parc Development in Europe – 2013. Source: (Oeko-Institut e.V. Germany, 2016)

According to Figure 2 prepared by the Oeko-Institut e.V Institute the number of vehicles of unknown whereabouts in 2013 amounted to 3,600,000 units and this represent 31% of the total vehicle exits. This calculation has been done on the basis of the following equation (Oeko-Institut e.V, et al., 2016):

$$UNKNOWN_n = N_{n-1} - N_n + IMPORTS_n + NEW\,Reg_n - EXPORTS_n - ELV_n$$

Where:

UNKNOWN	Number of vehicles with unknown whereabouts (positive value = stock exit, negative value = stock entry);
N	Number of vehicles in the vehicle stock;
IMPORTS	Extra-EU 28 imports;
NewReg	Registration of new vehicles within EU 28;
EXPORTS	Extra-EU 28 exports;
ELV	End-of life vehicles (reported);

Only a proportion of vehicles which are **deregistered, receive a Certificate of Destruction (CoD).** There is a clear lack of detailed information about the further use of a large part of deregistered cars, and there is a clear need for improvements on data quality and availability of the national vehicle markets. (Oeko-Institut e.V, et al., 2016)

Next Steps for Improving the Analysis of (WEEE) Complementary Flows Include the Following:

1. Scavenging information could only be determined for compressors from cooling appliances in collection category I. For other parts with a high relevance for valuable materials and CRMs, additional structured surveying is recommended in consultation with the recycling industry and WEEE Forum members.
2. The data gathered for this report and the final mass balance, are not yet reconciled by the use of additional modelling tools. UNU and WRAP will continue to compare the available data in this report with further iterations of national WEEE flow models applied for instance in the UK and the Netherlands in order to further simulate data. Additional sensitivity analysis and/or Monte Carlo analysis will assist in finding the most probable levels for unreported flows from WEEE, BATT and ELV disposal.
3. It is recommended to align this analytical next step with the more detailed determination of stock levels derived in the upcoming Deliverable 3.3 (the stocks and flows model for end of life products). In particular to elaborate on the level of scavenging of components for which more information from Deliverable 4.2 is needed.

Next Steps for Improving the Analysis of (BATT) Complementary Flows Include the Following:

1. The BATT structured data produced in this deliverable, and specifically the final mass balances, will be reconciled by the use of additional modelling tools. The results from this report will continue to be compared with further upcoming iterations of flow models and with additional information from other work packages. The flow models will deliver further information on statistical gaps.
2. Sampling and analysis campaigns are necessary to improve data validity, to get a more comprehensive picture on different types of batteries and where they are present in EEE/WEEE. The sampling needs to be representative and periodically repeated.
3. Mandatory reporting undertaken by the batteries recycling industry already contains information about the total amount per chemistry of batteries treated, and the recycling efficiency per process. Consolidation of these data, used with the proper modelling tool, will clarify the amounts of industrial and automotive BATT recycled in Europe, and consequently allow a better understanding of the BATT complementary flows.
4. Given the nature of BATT in residual waste it is likely that compositional studies will underestimate their presence. Future work in this area could be improved through development of modelling approaches and a better understanding of the time between a battery being placed on the market and its disposal.
5. The implication of the gap analysis is that more single portable BATT are entering the residual waste stream than recycling. This is in line with the reported values as part of the BATT directive. Further efforts to divert BATT further up the waste hierarchy could increase the proportion that is captured within separate data without the need for further compositional analysis.
6. Improvements to collection infrastructure and advice to businesses and household would help to reduce the complementary flows of BATT in the residual waste.
7. Application of a consistent definition for portable batteries across EU member states would help to ensure that industrial batteries are not captured in the reporting of portable batteries.

Next Steps for Improving the Analysis of (ELV) Unknown Whereabouts Include the Following:

1. There is a need to improve the data on ELV at a national level. This indicates a need to improve the ELV reporting system as it is likely that gaps in data occur due to issues with ELV reporting rather than illegal activities.

2. Alignment of the analytical next steps with a detailed determination of stock levels derived from Deliverable 3.3, and the incorporation of information from Deliverable 4.2 on the level of scavenged components are planned.

3. There are currently other projects underway investigating the likely fates of unreported ELVs in Europe. The results of these projects will bring further intelligence to the analysis of unreported flows of ELV. The reports below will be reviewed and relevant data used to improve the estimates for ELVs for the EU.
   a. The German Federal Environment Agency is currently carrying out a study to trace the deregistered vehicles. The objective of this on-going project is to analyse and then improve the data base on the fate of the deregistered vehicles.
   b. The Oko-Institute e.V is currently carrying out a study focused on the unknown whereabouts of ELV in Europe. The outcome of the public consultation Oko-Institute e.V is carrying out as part of the project will help to update intelligence on complementary ELV flows.

A ‘harvesting database’ for WEEE, BATT and ELV has been structured to incorporate all relevant core data and designed in such a way that new information can be handled in the most efficient way. See Figure 3 below for this overview. Due to the inherently scattered nature of data on unreported flows, the approach was to clearly distinguish between three types of information: i) sources containing actual measured data; ii) sources based on coherent estimates and extrapolations; and iii) sources with expert assumptions and extrapolations that are insufficiently substantiated. Due to the lack of data on unreported flows, a clear distinction has been made between the first (original data) and the second approach (coherent estimates), whereas data of the third ‘insufficiently substantiated type’ was excluded from the analysis. For all project databases, this differentiation was included for: each data point, as well as any comments related to the data quality assessment; the description of data consolidation steps where applicable; and the type of estimation used to produce a coherent estimate e.g. extrapolation, interpolation, etc.

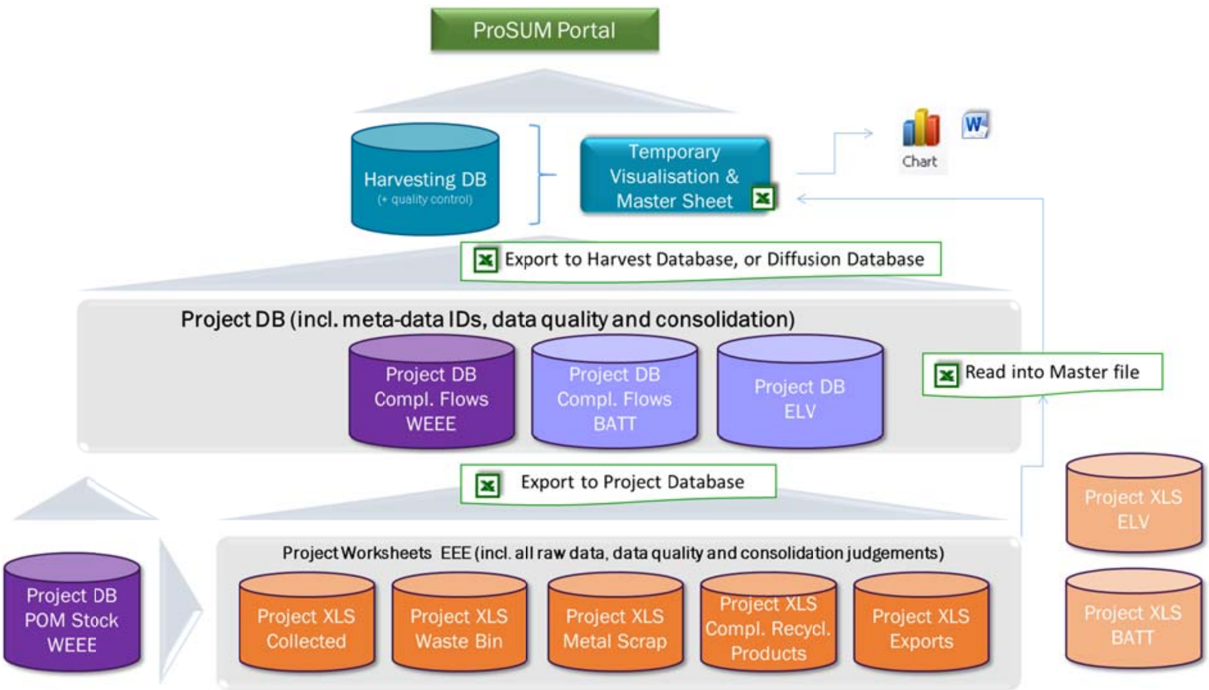

Figure 3. Project Databases Developed and Structure for Harvesting to Feed the UMKDP

1 Introduction

1.1 Aim and Scope of the Deliverable

The aim of this deliverable was to identify and describe what constitutes unreported and so called complementary flows of BATT, WEEE and ELV. This was performed by observing trends in the disposal of CRM containing products in order to quantify the level of complementary flows. Due to the inherently scarce information on flows that are not reported upon at national levels, the deliverable aimed to provide recommendations on how gaps related to unreported flows can be reduced in the future. The comprehensive analysis identified the main data gaps and how, through better data surveying or other measures, the intelligence on these relevant flows can be improved.

This task included review, collection, structuring and analysis of available data on unreported flows from WEEE, BATT and ELV disposal not captured in the nationally reported collection data. It built on the data gathering performed in Deliverable 2.2, 3.1 and 4.1 as highlighted in Figure 4. The complementary flows include for example products being disposed of into landfill and incineration with Municipal Solid Waste and/or exported out of the EU for reuse, recycling (legally and illegally). Primary and secondary data sources on this with varying data qualities and categorisation were examined according to the harmonisation efforts developed in Deliverable 5.3 and subsequent consortium efforts to describe data quality and uncertainty in a common way. This in turn will also feed into the UMKDP (D5.7) and towards proper definition and alignment of the relevant code lists and the appropriate storage and referencing of metadata (D5.6).

The key sources of information included:

1. A thorough review of all collection information from Eurostat, also in comparison with the WEEE Forum Key Figures (WEEE Forum 2010, 2011, 2012, 2013, 2014) and various national registers.
2. Legal and illegal flows from the CWIT project (Huisman et al., 2015), various country quantification studies for WEEE performed by UNU (Huisman et al., 2012, Magalini et al., 2012, Wielenga et al., 2013, Monier et al., 2013), the WEEE studies from WRAP in the UK (WRAP 2011, 2015).
3. Various household waste sorting analyses to assess the presence of WEEE and BATT in residual waste destined for incineration and landfill. Specific flows of waste industrial BATT (not included in the flow of portables BATT going through battery producer compliance scheme) has been assessed with the members of the European Batteries Recyclers Association (EBRA).
4. The export flows for BATT present within WEEE. The analysis was completed, especially for ELVs, with data from surveys on hibernated products, reuse, reported export (for reuse) flows and data from the recycling industry and relevant academic literature sources.

Results have been compared with data from Deliverable 4.1 on reported collection and treatment volumes to map the various flows resulting from the stocks and to validate/provide boundaries for the stock-flow modelling in Deliverables 3.3–3.5. Based on the data formats agreed in Deliverable 5.3, trends regarding observed complementary flows and reported collection volumes over time were analysed to allow for forecasting. The output of Deliverable 3.2 determines the potential supply of WEEE, BATT and ELV for secondary processing examined in Deliverable 4.1 and Deliverable 4.2 and highlights the expected outflows from stocks assessed in D3.1 for the overall assessment of inflows and outflows for Deliverable 3.3.

The identification of gaps in officially reported data, attempts to quantify unreported flows and identify points at which data could be captured will help to set priorities for improvements in the stock and flow models. WP3 will be able to use data on complementary flows to sense check whether the stock and flow model data and assumptions are correct. Finally, the findings from this deliverable will also contribute to discussions with various stakeholders in the ProSUM Information Network to improve the understanding of the type and magnitude of complementary flows and enhance cooperation in reducing data gaps (recommendations in D6.4). WRAP will observe trends on disposal in order to support stock and flow modelling and provide recommendations on how the data surveying can be improved.

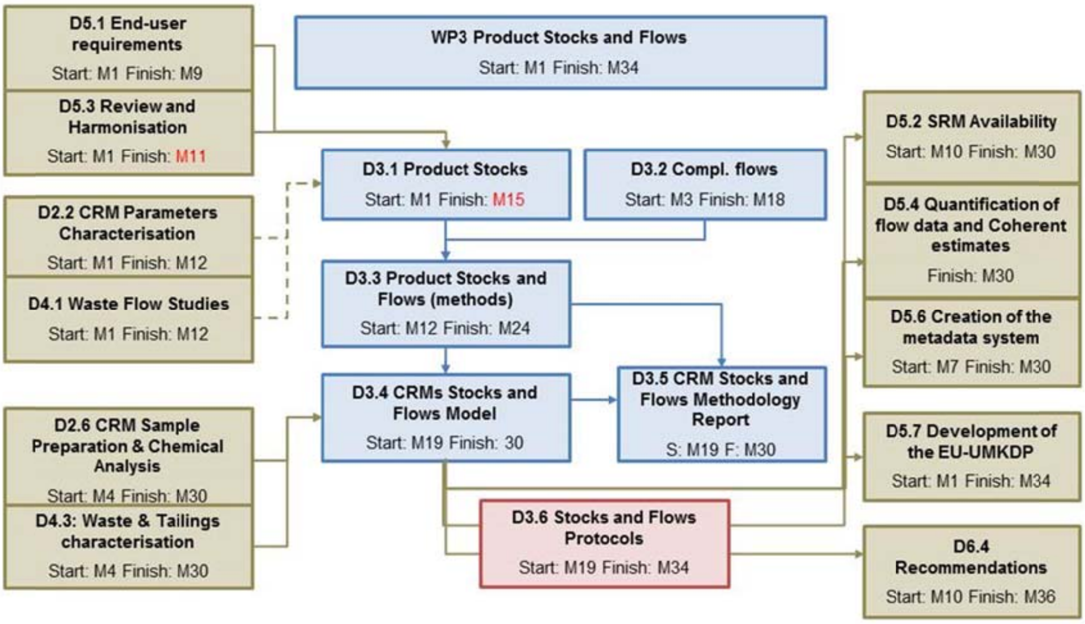

Figure 4. Pert Chart Positioning D3.1 in WP3 and Other Work Packages

The following steps have been taken to fulfil the objectives of this task:

Project Stages	What	How
IDENTIFY Chapter 2	Define the approach and data needs. Identify stakeholders who may have access to data, identify data.	Industry associations, ProSUM partners, WRAP Electrical Sustainability Action Plan (ESAP) members, on-going projects.
COLLECT Chapter 3	Agree on how the data would be obtained, agree the terms of NDA, and obtain data.	Partly through ProSUM partners and partly directly with identified external data owners. Confirm how data will be used.
REVIEW and ANALYSE Chapter 4	Review available data, identify gaps and agree on what analysis will be performed.	The scope of analysis will be limited by the quantity, robustness and comparability of data obtained. Extraction of best quality estimates and extrapolations considering that this involves obtaining and analysing data that often doesn't exist.
CONCLUDE and RECOMMEND Chapter 5	Draw conclusions and come up with recommendations.	Suggest better ways of data capture and actions leading to reduced data gaps.

1.2 Definitions and Glossary of Terms

A glossary of terms has been developed by the ProSUM project (D5.3). In this report it has been adapted and expanded to cover the key terms utilised in Deliverable 3.2.

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. See Annex 1 for all detailed terms and abbreviations.

1.3 Data Quality and Uncertainty Levels

It has been important to establish a uniform method to evaluate the quality and reliability of data across all the three product groups, in particular where uncertainty levels have been used in lieu of information on standard deviations or confidence intervals.

Sources of data with the associated statistical information are preferred. However, for the description of complementary flows that usually are not harmonised and unreported, this is extremely rare. More frequently, the sources available, when having a clear specification of their scope, provide a lower bound or conservative estimate. This is due to defining and documenting only of a portion of the flow. In these cases, the minimum uncertainty level has been set to zero (or close to zero) and the maximum estimated amount, when described, set as the uncertainty level. This has led to asymmetric intervals.

As shown in Table 4 and in accordance with ongoing work in Work Package 5, the following data quality assessment is applied for the majority of cases where no statistical information and no minimum documented amount is observed. The last columns are used when multiple sources are available for the same data point(s). The assessment is done for these qualitative sources based on the following criteria (for example):

- Is there a clear and consistent definition of product scope, of the demographic conditions?
- Is the sample size, assumption and limitations to the data well described?
- Are there alternative sources (partly) confirming the data?
- Does the data fit into the time series, when available?

For the data quality and uncertainty levels applied for the WEEE Generated amount, a specific set of criteria is used, which will be elaborated later in the upcoming Deliverables 3.3 – 3.5.

Where multiple sources were available for the same data point or coherent estimate: then weighting has been applied as indicated below to find the "best estimate" for which the higher confident sources contribute the most.

Table 4. Data Quality Assessment Schema

Data Quality Types	Ranges for qualitative judgement (flows)	Mean	Data Quality Weight	Weight
Highly confident	0-10%	5%	Highly confident	4
Confident	10-20%	15%	Confident	3
Less confident	20-50%	35%	Less confident	2
Dubious	>50%	100%	Dubious	1

For all references (by each main complementary flow in the case of WEEE) the results of the data quality assessment is presented in Chapter 6, Bibliography.

Due to the inherently scattered nature of unreported complementary data flows, the approach taken was to clearly distinguish between three types of information: i) sources containing actual measured data; ii) sources based on coherent estimates and extrapolations; and iii) sources with expert assumptions and extrapolations e.g. insufficiently substantiated. Due to the lack of data on unreported flows, a clear distinction iswas kept between the first (original data) and the second approach (coherent estimates), whereas data of the third 'insufficiently substantiated type' was excluded from the analysis. For all project databases, this differentiation is included for each data point, including: any comments related to the data quality assessment; the description of data consolidation steps where applicable; and the type of estimation in cases where a coherent estimate was included e.g. from extrapolation, interpolation, etc.

2 Approach

Based on available reported data it was possible to estimate data gaps. These gaps constitute the difference between the waste generated and the sum of the complementary unreported flows which are investigated and analysed in this task.

The modelling of the flow for WEEE, BATT and ELV was based on reported data and allowed for estimation of the approximate size of the unreported flows. The modelling is briefly discussed in Chapter 3.1. Although reported data analysis was not the primary task of this report, it is still included where needed to limit the gap as far as possible.

Based upon the research questions, it was necessary to take a tiered approach to gathering and reviewing data. Firstly, as the data is, by definition, unreported, it was necessary to engage with individuals and organisations that may have access to data not in the public domain. Secondly, it was also essential that a review of published literature was undertaken and any inferences which could be drawn from publications identified. For ELV, WEEE and BATT a three tiered approach was pursued, illustrated in Figure 5.

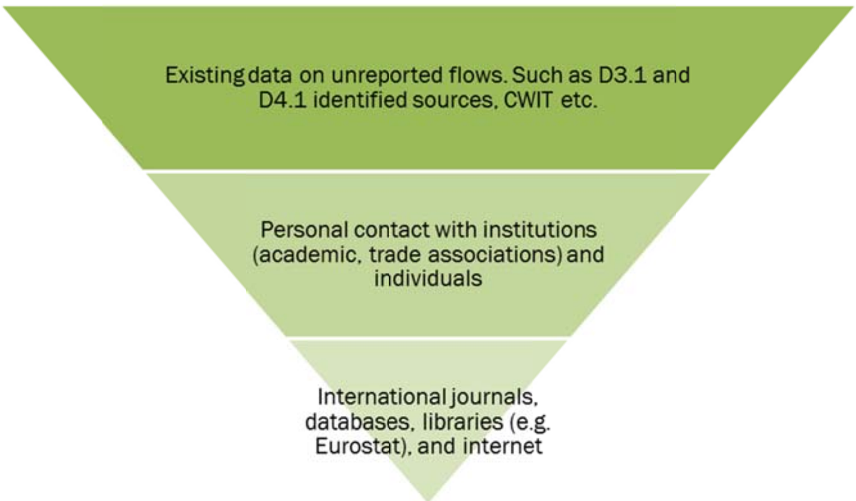

Figure 5. General Approach to Data Collection

2.1 Approach to Data Collection and Analysis for WEEE

The approach to data collection and analysis for WEEE was to examine all available data and literature on the topic. UNU regularly carries out research focused on tackling the e-waste issue (Baldé et al., 2015) and executes specific country studies in particular for quantifying amounts of WEEE in different EU member states (Huisman et al., 2013, Magalini et al., 2013, Wielenga et al., 2013, Monier et al., 2013, Magalini et al., 2015). In addition, previous research on the complementary flows as part of the market assessment of the CWIT project (Countering WEEE Illegal Trade) covers some of the main flows for 2010 and 2012 (Huisman et al., 2015).

WRAP, as part of the DEFRA funded Electrical Sustainability Action Plan, has also carried out a number of research projects looking at flows of WEEE in the UK which are analysed in this report. Other literature and data have been identified through the ProSUM consortium partners, the

ProSUM Information Network, and online libraries and internet searches, which is all captured in the Bibliography from Deliverables 2.2, 3.1 and 4.1.

The primary focus of the WEEE data analysis was to convert all available sources into agreed harmonisation formats in consultation with the other work packages, WP5 in particular. The approach and handling of data is highlighted in Figure 6. Important to note is that the data is not just analysed, but also structured according to project protocols which enable harvesting of the data to feed the web services of the portal. This is done according to the data quality schema in Section 1.3. However, since the portal and the final visualisation of the UMKDP are not yet running, temporary portrayals have been made in an XLS master sheet to support the data consolidation processes which are a significant part of the work behind this deliverable.

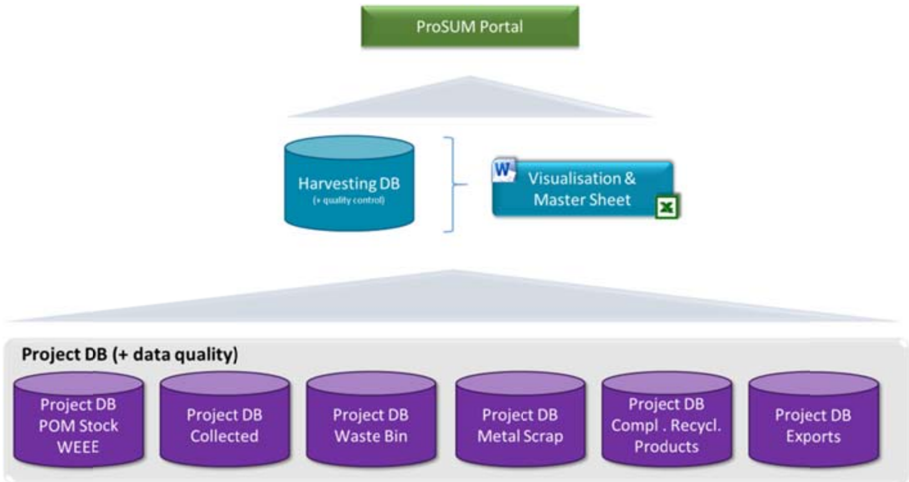

Figure 6. Project Databases Developed Related to WEEE Complementary Flows Information

The CWIT Report (Huisman et al., 2015) covers 2010 and 2012 information and forms a starting point for the analysis. In particular, for WEEE in mixed metal scrap and the waste bin, the data is completed with literature sources and the temporal scope extended to include 2011, 2013 and 2014.

However, as a first starting point, the data for WEEE generated and data for amounts collected and reported from Eurostat were taken to determine the size of the unreported amounts. For officially collected WEEE, data from Eurostat (Eurostat, 2016) was also analysed and compared with data from producer compliance schemes and other sources e.g. national registers. The Eurostat information should include all WEEE from public waste management authorities, third parties, retailers or Producer Compliance Schemes (PCSs), where the mass collected per WEEE category is officially reported to the institutes and organisations on a national level. However, no reporting takes place if WEEE is collected via informal routes or in other waste flows, like residual waste. Therefore no direct statistical sources are available to quantify these.

For WEEE in mixed metal scrap, again following the CWIT report, various country studies were compared and the amount for WEEE in metal scrap and exports was analysed based on available literature. Here, the approach was harmonised by judging each individual source according to the data quality as specified in Section 1.3. Based on the detailed survey data of recyclers, additional complementary recycling of WEEEE products, (so called mono-flows), was analysed. An attempt to quantify the influence of scavenging of components prior to further treatment was also made.

The unclear boundaries between various stages and actors within waste management systems make it difficult to identify waste streams. For example, waste equipment collected by a refurbisher does not automatically indicate that the equipment is repaired and reused. The same is true for recycled equipment, in both the formal and informal recycling sectors, where some valueless or unrecoverable waste fractions end up in a landfill.

Using data from research covering a limited demographic or geographic area may be problematic when used to represent a greater population. As national electronic waste flow data is not usually available, results from smaller datasets have been used as a representation of the larger population when necessary, despite the potential for demographic differences. As a consequence, it was decided to classify information at the level of each available data point in terms of whether it contained original data representing the actual (complementary) amounts well versus coherent estimates (where extrapolations of observations were made with sufficient coverage to describe the total magnitude of the flows). Estimates regarded as too uncertain or based on too few data points hindering a coherent extrapolation were not included. For all sources where statistical analysis of uncertainty and data quality cannot be computed, a qualitative assessment was made and included for each data point. Based on this, the results can also be displayed with uncertainty levels.

2.2 Approach to Data Collection and Analysis for BATT

In reviewing literature for the complementary flows of BATT, several potentially relevant references were identified. Preference was given to studies following standardised methodologies (e.g. Eurostat reporting guidelines) and which had been peer reviewed, either through a journal or through independent assessment.

As per Figure 5, the first stage of data gathering was to approach organisations which may hold relevant data not in the public domain. Following the workshop in April 2015, WEEE Forum members, PCS, ProSUM consortium partners and members of the ProSUM Information Network (ProSUM IN), Municipal Waste Europe and ACR+ were consulted on what data may become available for analysis. WEEE Forum members were able to provide data on collection of BATT. A number of PCS offered to share data on the BATT contained in WEEE with ProSUM. ProSUM consortium partners and members of the ProSUM IN have also provided some data on BATT in WEEE and in municipal waste, as have Municipal Waste Europe. No data was obtained from ACR+.

Data on collection of BATT have also been obtained from EUCOBAT, UNU, EPBA and EBRA. Interviews with a number of industry experts have been carried out. This includes but is not limited to the Environment Agency in the UK, EBRA, ILA, Digital Europe, EBRA, EPBA.

The next stage was to review published literature and databases to seek data which could be used either directly or indirectly to infer complementary flows. Primary and secondary data sources with varying data qualities and categorisations were examined along with available literature on the topic. WRAP also engaged and consulted with current projects and initiatives where relevant data is being gathered in order to leverage synergies. The literature review is presented in section 3.3 by complementary flow.

As per the data hierarchy, the following data sources were used in order of preference. The order of preference was determined by the ability of the source to provide data that could consistently reflect the complementary flows of BATT for the EU28.

ProSUM Deliverables 3.1 and 4.1

ProSUM Deliverables 3.1 and 4.1 provide insights into the lifetime of BATT and the proportion of BATT in WEEE. For consistency across the project, the same data sources and assumptions have been made wherever possible. These were reviewed against other literature included in this list.

Eurostat

Eurostat is the statistical office of the European Union. Its task is to provide the European Union with statistics at European level that enable comparisons between countries and regions. Eurostat is actually the only provider of statistics at European level and the data Eurostat issue are harmonised as far as possible (Eurostat, Eurostat - what we do, 2016). Eurostat contains reported data on flows on sold production, imports and exports of BATT and battery-containing items as well as information on separately collected BATT and battery containing items for the EU-28. All data is collected following standard definitions and criteria. This can be used to identify complementary flows.

CWIT Project

The Countering WEEE Illegal Trade (CWIT) Project (Huisman et al 2015) received funding from the European Community's Seventh Framework Programme (FP7/2007-2013, Grant Agreement No. 312605). Two of the outcomes of the project were the libraWEEE and the database of e-waste stakeholders which are maintained and updated by the WEEE Forum, a project partner. The libraWEEE holds a compilation of studies and reports dealing with WEEE, specifically literature regarding WEEE flows and criminal activities associated to WEEE. In conjunction with deliverable 4.1, CWIT data can be used to estimate the complimentary flows of BATT in illegally traded items.

ProSUM Partners and External Expert Advisory Board (EEAB)

The ProSUM Consortium comprises 17 organisations with expertise in WEEE, BATT, ELVs and mining activities, as well as management of data, statistics and IT development. Organisations such as TU Berlin, UNU, WRAP or the WEEE Forum have performed studies that will provide input to the project databases.

In addition to this, the project is supported by an external advisory board made up of experts in their sectors who help us steer the project direction. They may be able to support data provision for the project. For EEAB members see http://www.prosumproject.eu/our-eeab.

ProSUM Information Network (IN)

Individuals and organisations from target stakeholder groups are invited to join the Information Network, including Trade Associations. Members of the IN work together: to identify opportunities to enhance data sharing and gathering which meets their needs; uses harmonised methodologies; and is presented in consistent interoperable formats (http://www.prosumproject.eu/information-network).

Associations

There are a number of Associations with national members which exist at European level such as Eucobat, an association of 16 BATT compliance schemes from 14 different countries. Usually these kinds of organisations provide benchmarking for their members, where they may perform studies, collect data and participate in dialogue regarding the regulation of their activities.

Environmental Protection Agency (EPA)

Environmental Protection Agency interchangeable with Ministry of Environment or Government Department. Each Member State has their own arrangements in place concerning which organisations collect and report data concerning Directives on waste. Such organisations gather data from Producer Compliance Schemes as well as licensed and permitted waste management facilities. A list of all Member states EPA, considered for further data inventory, can be found in Annex 1A.

National Governments

Any legal body of a Member state that sets and administers public policy and exercises executive, political and sovereign power through customs, institutions, and laws within a state, such as ministries or national authorities. A list of Member State governmental bodies is in Annex 1A.

Universities and research institutes

Universities and research institutes gather or produce data in a variety of quality, granularity, and formats dependent upon the research need. Research studies and projects are often oriented on common (sector-specific) standards and classifications but are often scattered and/or not publicly available.

2.3 Approach to Data Collection and Analysis for ELV

The data and literature for this section of the report was collected through ProSUM consortium partners in the first instance, the wider ProSUM Information Network, internet searches, as well as networking with stakeholders specialising in the ELV topic. As part of the research the following people were contacted to name a few:

- Artemis Hatzi-Hull, leading on ELV Directive at the Commission;
- Oeko-Institut e.V , the author of the research on trade of used vehicles in Europe;
- Regina Kohlmeyer at Umweltbundesamt, Germany; and
- A number of major ELV recyclers.

The general lack of data on the unknown whereabouts of ELV made the analysis especially challenging.

Data analysis was undertaken as follows:

- Firstly, the available literature on ELVs management was reviewed to see whether there was an indication that complementary flows of ELV exist. The initial literature review focused on two research papers: (Schneider et.,al 2010) and (Mehlhart et al., 2011) At the later stage the research also incorporated early findings from the on-going (Oeko-Institut e.V et al., 2016) project on unknown whereabouts of ELV in Europe.
- Secondly, by looking at the reported data and literature relevant to the topic the size of the unreported/complementary flows of ELVs/unknown whereabouts of ELVs was quantified. For ELV the reported data includes:
  - POLK for data on vehicle fleet composition;
  - European Automobile Manufacturers' Association (ACEA) for data on new registrations within EU;
  - Eurostat for data on ELVs. This data is annually reported by Member States; and
  - Eurostat Foreign Trade Statistics (FTS) on Extra-EU trade of used cars, i.e. data on import and export of used vehicles to and from the European Union.
- Initially the research focused on identifying, listing and analysing data sources that allow for calculating the quantity of vehicles that leave the ELV system without trace.
  The possible causes for the "gap" in unaccounted for ELVs/the unknown whereabouts of the end of life vehicles (ELV) were identified.
  Most importantly, the research aimed to identify likely destinations of unaccounted for ELV by looking at specific country studies.

This section of the report provides information to improve knowledge surrounding the unknown whereabouts of ELV's.

2.4 Risks and Assumptions, Data Availability WEEE

2.4.1 Harmonising Data for WEEE

A range of data sources and reports have been reviewed in order to analyse the complementary flows of WEEE. It is however recognised that there are a range of limitations to the data. Primarily these flows are mainly unreported streams therefore actual data is focused on a selection of reports and locations. This data therefore requires extrapolation across Europe.

All EEE and WEEE data needs to comply with certain harmonised formats to ensure that data processing is efficient. It is important that the data describes the same geographic coverage and is reported according to a standard classification. For the sake of easy data processing, the data gathering is only conducted using four different classifications. Those are the UNU-keys Baldé et al., 2015) the 10 categories of the old WEEE Directive (Huisman et al., 2008), 6 collection categories that represent the waste collection in practice (European Commission, 2002), the 16 categories that are used by the WEEE Forum (Pannuzzo, B., 2014), and in the UNU WEEE Review study of 2007(Bridgwater, E., 2010/11). These four classifications are widely used and can be relatively easily converted to each other by means of the UNU-keys. In addition, the data quality assessment schema from Section 1.3 is followed throughout the analysis.

2.4.2 POM and WEEE Generated

The common methodology developed by Magalini, et al., (2016) for the Article 7 study has been used to determine EEE Put on the Market (POM) and waste generated (WG). A detailed description of common methodology is described in ProSUM Deliverable 3.1 Historic and Product Stocks. Further, the data obtained has been compared with the WEEE Forum Key Figures Platform (WF-KFP) in order to determine the data quality and data uncertainty of individual data points.

The WF-KFP, managed by the WEEE Forum (WF), allows member organisations to benchmark their performance and to provide solid, comparable data to stakeholders. Every year, members are asked to provide their statistics and country data to a web-based software platform on the quantities of electrical and electronic equipment that their client producers have put on the market, the quantities of WEEE that they have collected, and the costs related to WEEE management.

WEEE Forum members provide data from their own systems and data at country level. When no country official data are available, estimates are provided. Figures from public and official sources are sometimes included in the platform such as data from UK, Germany, Italy and France. Often, data from official sources do not match the structure of the categories provided in the WF-KFP. Therefore, members apply estimated split factors in order to make data compatible with the data structure of the platform.

The classification used by the WF comprises 16 categories for the products put on the market. The categories provide a more detailed list based on the 10 WEEE categories defined in the original WEEE Directive. Table 5 displays the list of WF-KFP categories and their correlation with those in the WEEE Directive.

Table 5. List of Key Figures Categories for POM

10 WEEE cat. (Directive)	KF category	Description of KF category
	1a	Large household appliances (ex C&F's)
	1b	Temperature exchange equipment (incl. air con.)
1	1	Total LHHA + C&F
2	2	Total Small Household Appliances
	3a	IT&T equipment (excluding monitors)
	3b	All monitors - IT&T
3	3	Total IT&T equipment + monitors
	4a	Consumer equipment (excluding TV's)
	4b	All TV's – CE
	4c	PV panels

4	4	Total CE + Screens + PV
	5a	Luminaires
	5b	Lamps
5	5	Total Lamps & Luminaires
6	6	Electrical and electronic tools
7	7	Toys, leisure and sports equipment
8	8	Medical devices
9	9	Monitoring and control instruments
10	10	Automatic dispensers
	Other	"Other" WEEE

When data is not available in the WF-KFP categories, WF members apply estimates to split categories. Split factors may be based on the System's experience and knowledge of their national market, trends identified in WEEE Forum members' data, or an EU average value (composition of EEE Put on the Market, see Figure 7).

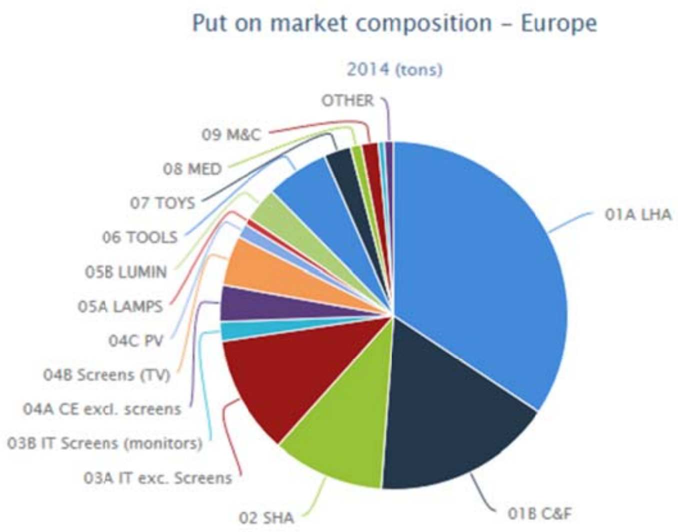

Figure 7. European Put on the Market EEE Composition (WEEE Forum Key Figures, 2014)

2.4.3 Collected and Reported WEEE

WEEE reported as collected is presented in the Eurostat database. Usually this data is reported regularly to national registers by Producer Responsibility Organisations (PROs) and EEE producers. This data often differs with the estimated WEEE generated. Differences in both values are due to a number of reasons (Wielenga et al., 2013; Magalini et al., 2013; Huisman et al., 2013) such as WEEE stocks in houses and WEEE disposed of in flows that are not reported as WEEE. Eurostat provides WEEE collected information in 10 categories as described in the first WEEE Directive. The available Eurostat data covers EU from 2005-2013 except Switzerland. A number of data points are missing from Eurostat data; i.e. 2010 data for Croatia, and 2013 data for Ireland, Greece, Italy, Cyprus and Romania. In addition, 2014 Eurostat WEEE collected data is not available yet (Eurostat, 2015). Due to the lack of Eurostat data for all those countries (incl. Switzerland) in respective years, WEEE Forum collected and reported data has been used to analyse the complementary flows.

In addition to Eurostat, the WEEE Forum also reports the WEEE collected data in the following categories appearing in Table 6.

Table 6. List of Key Figures Categories for WEEE Collected

10 WEEE cat (Directive)	KF category	Description of KF category

1	A	Large household appliances (ex C&F's)
1	B	Temperature exchange equipment (incl. air con.)
3	C	IT&T equipment (excluding monitors)
2, 3, 4, 5, 6, 7, 8, 9, 10	D	SHA (mix of small equipment and other categories not included in other groups)
3, 4	E	Screens
5	F	Lamps
4	G	PV panels

The KF categories used for collection are aligned with the 6 categories of the recast directive 2012/19/EU on waste electrical and electronic equipment (WEEE). In addition to this, the grouping aims to represent the treatment streams, which are usually reported in practice by WEEE treatment operators. Usually a split factor is required to separate IT equipment and SHA, as they are often collected in the same stream and sent to the same treatment facility. With respect to Screens, it should be noted that this category includes Cathode Ray Tube appliances (CRT) and Flat Panel displays (FPD). Currently most of the weight in this stream is due to CRTs, although a logical increase in the amount of FPD is taking place.

When split factors are needed to adapt data to the KF collection categories, usually WF Systems calculate WEEE shares based on their own market knowledge. No trends in the composition of WEEE collected at EU level have been identified.

2.4.4 Waste Bin

WEEE is placed in the residual waste for a number or reasons including an absence of collection or deposit option for the consumer or business, apathy towards WEEE recycling, poor information and signposting at WEEE recycling centres. Due to the misplacement of WEEE in the waste bin there are losses of recoverable material and contamination of other waste streams. The majority of WEEE found in the waste bin is small household appliances, IT and telecommunications. Most of unreported flow is often treated through other disposal routes.

It is estimated the around 750,000 tonnes of mainly small appliances end up in the waste bin, with varying amounts per country of between 1 and 2 kg per inhabitant per year (Huisman et al., 2015). The impact of this is loss of recoverable materials and their value and contamination of other waste streams (Panuzzo, 2014). The majority of these products, as mentioned before are small household appliances, IT and telecommunications, larger items are more often treated through other routes, including through the light iron as discussed later on. Table 7 illustrates the variation of the information for various data sets across a number of countries. This illustrates the challenge associated with truly understanding the availability of material recoverable from this route.

Table 7. Percentage of WEEE in Residual Waste Stream per Country

Country	% residual waste stream classed as WEEE	Date
Finland	0.8%	(Pulkkinen et al., 2008)
Germany	1.273%	(Dimitrakakis et al., 2009)
Netherlands	0.44-0.88%	(Huisman et al., 2012)
Denmark	0.34%	(Bigum et al., 2013)
UK	0-3%	WRAP, 2011
Italy	10% of WEEE disposed via this route	Ecodom 2012
France	1-2Kg per head	WEEE in France, BIO Intelligence 2013

However, these studies also show quite coherent results. In fact they found that mainly small WEEE is misplaced. In addition, it is estimated that the amount of misplaced WEEE and BATT found in the residual waste was, respectively, 16% and 39% of these items is collected properly through the WEEE collection systems. This value is quite large compared to other ones. Another concern is the allocation to collection categories: as an example, (Dimitrakakis et al., 2009) included an extra category (Category 11: detached components and single parts that could be categorised elsewhere) which constituted 49.13% of the total value (1.27%).

Variations between the amounts of residual waste seen in the residual waste stream can also be seen between urban and rural areas, the percentage being slightly higher in rural areas, thought to be as a result of a lack of collection facilities.

For allocation of the total amounts, the municipal waste analysis from (Huisman et al., 2015) was taken as a starting point since it has the most detailed frequency count of appliances identified so far and it covers multiple years and a large set of underlying sorting analysis undertaken covering the various regions of the Netherlands. The data was updated with a few more studies and expanded to the years that where not covered in the CWIT analysis (2011, 2013 and 2014). Here the previous work identified around 14 reports containing relevant information on small appliances in residual solid waste.

The main goal was to capture all WEEE that is disposed of by households and public in the residual waste bin. In order to assess the Waste bin complementary waste flows a comprehensive review and analysis of literature of current data and past trends disposal of WEEE in the waste bin in the EU-28, plus Norway and Switzerland was undertaken. Primary and secondary data sources were analysed using the ProSUM bibliography which consisted of publications, journals and country studies quantifying the country's WEEE and analysis on household waste sorting in order to assess the presence of WEEE in current municipal solid waste flows destined for incineration and landfill.

It should be noted that the wealthier countries and/or those with large economies have more data and literature available indicating their WEEE in waste bin by kg per inhabitant per year, or as a percentage of WEEE present in waste bin generated per year. The results of the literature review are shown in Table 8. If the reported unit is in tonnes it has been converted to kg/inh using the number of inhabitants. Where the data is available as a percentage of residual household waste, it is multiplied with the total amount of residual household waste from households and services. All data is related to the total WG and by combining the best compositional estimates, allocated to the individual collection categories.

Table 8. Raw Data from the Literature Review for WEEE in Waste Bins

Country	Year	Amount	Reported unit	Source
BEL	2010	1.54	kg/inhabitant	(Wielenga, et al., 2013)
BGR	2009	0.0	% in residual waste	(Dvoršak, (2011)
CHE	2012	10	kt	(Stiftung Ear, n.d.)
CZE	2010	24.4	kt	(Wang et al. 2012), (Steiger, 2014)
DEU	2012	0.6 1.4	% in residual household waste in Bayern kg/inh in Hamburg	(LfU Bayern, n.d, 2013)
DNK	2010	0.029	kg per household per week	Eurostat (2005-2013) (Bigum, M. 2013).
ESP	2010	0.12 0.34	% in residual household waste % in Refuse derived fuel	Institute, S. E. (2013)
FRA	2007	1.0	kg / inhabitant	Eurostat (2005-2013)

GBR	2010	194	kt	(Wang,F. et al. 2013) (Pannuzzo, B. 2014)
ITA	2010	per product	% in households disposing WEEE in waste bin	(Magalini, F. et al., 2012)
NLD	2010	2.3	kg/inhabitant	(Huisman, J. 2012)
PRT	2007	16	kt	(Afvall Sverige, 2015)
ROU	2009	0.1	% in residual waste	(Dvoršak, S. 2011).
SWE	2010	0.46%	% in residual waste	(Huisman, J. 2012)

2.4.5 Complementary recycling – WEEE in Metal Scrap

To assess the complementary recycling flows of WEEE in metal scrap a data extraction from Eurostat was undertaken compared and harmonised with publications, journals and country studies. This was done due that the literature information was very scarce and not harmonized.

From five studies, it is estimated that the average concentration of WEEE in metal scrap in those countries is at least 1.4% compared to the total amounts of ferrous, non-ferrous and mixed ferrous and non-ferrous scrap as reported in Eurostat for all countries (every two years). Since Eurostat only provides WEEE in metal scrap data for every two years, the data provided from 2010 and 2012 was extrapolated for the years of 2011, 2013 and 2014. In the case where country studies or journals provided data for a specific year, this data was not extrapolated for that year. At the time of data extraction of WEEE in metal scrap, Eurostat hadn't release its data for the year 2014, therefore as stated before, this year was also extrapolated and marked as coherent estimates.

2.4.6 Complementary Recycling – WEEE Products

For some countries from individual studies (Huisman et al, 2013, Monier et al, 2013) as well as surveys with the electronics recycling industry, specific information is derived for the unreported complementary recycling of products as batches of WEEE. Often this includes quantities of mere professional appliances and amounts sourced from business return channels. The data from individual recyclers is anonymised. These volumes are particularly stated by these recyclers not being reported to either Environment Agencies or any of the compliance schemes.

2.4.7 Scavenged Components

Similarly, based on the CWIT report, further analysis of amounts removed from WEEE prior to collection has been undertaken, in particular for compressors for which the most information was available. The analysis was done by multiplying the percentage of compressors indicated by recyclers and compliance schemes to be missing in the collection volume with the share of compressors in WEEE collection category I.

2.4.8 WEEE Exports

Quantifying unreported WEEE export flows is a very complicated task. Among the many challenges are that no categorisation exists to distinguish between new and used goods being exported, and illegal shipments of UEEE or WEEE may be documented as legal shipments. Customs' statistics from European exporting countries do not always match the data of destination ports, goods are declared using a variety of category codes, trade data are often reported in monetary value rather than by volume, and finally customs declarations are submitted to the authorities as late as possible to avoid possible inspections. There are three types of WEEE export. WEEE may be exported in pre-shredder materials, WEEE may be mixed with other metals to be reprocessed for the end market and finally (U)EEE may be exported as whole items, whether they are working or not.

The quantification of UEEE/WEEE exports flows from Europe to Asia, West Africa or any other destination is very challenging. Information on trans-boundary movements of WEEE are not reported in trade data since no code exists for WEEE in the Basel Convention. This means that the regular reporting on waste movements does not reveal any information about the amounts of WEEE exported and imported between EU countries and to or from countries outside the EU.

The available data and expert opinion only allows for qualitative assessments. There are a limited number of country studies estimating the proportion of WEEE mixed with pre-shredder residue, and those that do tend to focus on North West Europe where due to an apparent over capacity of shredder capacity, there is strong competition for the material. It is not clear whether the same proportion is apparent in other countries, particularly in Eastern Europe. As such we have had to make some assumptions based on the limited estimates available.

Moreover, in order to disguise illegal shipments, general custom declarations are used and there is still a grey zone to distinguish UEEE and WEEE. Moreover, in many parts of Europe the recorded export destination may not be the final destination, for example much of the WEEE is likely to be transhipped via the Netherlands. Misuse of codes in custom declarations makes the problem of disentangling exactly what is UEEE/WEEE even more difficult.

WEEE may also be exported as UEEE. Currently, the definition of UEEE is rather ambiguous. There is a lack of national or international, unequivocal, universally accepted and binding to define the difference between UEEE and WEEE. This especially impedes the work of law enforcement officials during field inspections or during the examination of documents which accompanies the UEEE exports. Finding evidence which shows that the UEEE are second-hand goods and not electronic waste is a very complex process and it requires collaboration between the different participating parties such as customs, exporters, and importers.

2.5 Risks and Assumptions, Data availability BATT

2.5.1 Data Availability BATT

This chapter of the report focuses on risks, assumptions, data availability and accessibility. It is an important section of the report as the availability of data on complementary flows is very limited. Based on the literature available and the discussion with the ProSUM consortium it was identified that the complementary flows of portable BATT consist of:

1. Spent BATT disposed into municipal solid waste destined for incineration and landfill both on its own and in WEEE;
2. BATT embedded in and recycled with WEEE; and
3. BATT legally and illegally exported with EEE and WEEE.

For industrial BATT complementary flows could cover:

- Reporting of BATT mixed with portable BATT due to challenges in distinguishing between industrial and portable battery at a collection stage;
- BATT legally and illegally exported outside Europe for use or reuse (possibly with industrial equipment i.e Uninterruptible Power Supplies (UPS); and
- BATT legally and illegally exported for recycling.

For automotive BATT complementary flows could potentially cover:

- BATT legally and illegally exported outside Europe for use or reuse within a vehicle; and
- BATT legally and illegally exported for recycling.

For industrial BATT and for automotive BATT there is insufficient supporting evidence to assess whether the above potential flows are significant. Therefore for the purpose of this report we have primarily focused on portable BATT flows analysis.

Identifying and quantifying complementary battery waste flows across the EU is a challenging task. By their nature there is little or no data recording the movement of unreported battery flows. Some activities leading to occurrence of complementary flows may be illegal or at the very least outside of the spirit of certain regulations. Indeed, care needs to be taken in interpreting the little data that there is as there is no way of saying how representative it is of the whole EU.

Although the main economies of Europe (Germany, France, UK, Spain, Benelux etc.) represent the majority of BATT POM and often have the best collection systems, they may not be representative of the size and indeed composition of the flows seen elsewhere in Europe.

In their 2013 position paper “Collection Target for Waste BATT”, EUCOBAT identify that there are multiple elements influencing the collection rate and hence also the potential size of a complementary flow. These include:

- Lifespan of BATT;
- WEEE collection rate;
- Removal of BATT from WEEE;
- Impact of competition;
- Interpretation of definitions;
- General consumer awareness towards waste;
- Density of the collection network; and
- Intensive consumer awareness campaigns.

The maturity of the BATT collection schemes in Europe is dependent on the time over which they have been operating. Some countries where the collection schemes have recently been implemented may have much larger unidentified flows than countries where the collection schemes have greater experience and better efficiency.

In Chapter 4.2, the underlying causes leading to different performance of collection schemes in various European countries were examined. The complementary flows of portable BATT were not examined by splitting them further into their chemistry types. This is because data for complementary flows at that level of detail is not available.

Also hoarding times for different portable battery types differ making it difficult to estimate complementary flow size for different chemistries. For example for Ni-Cd the amount collected is increasing over time while that POM is decreasing (RECHARGE, The Advanced Rechargeable & Lithium Batteries Association, 2015). The long service life and the long hoarding time for these battery technologies may be one of the reasons for that.

As described in detail in Deliverables 3.1 and 4.1, the following organisations hold data on BATT:

- Eurostat;
- Environmental protection agency (EPA). The data used by the EPA are provided by the producer compliance schemes;
- Compliance schemes have a contractual relation with the operators of sorting and recycling facilities, who are on this basis obliged to report;
- Operators of sorting and recycling facilities that collect raw data, i.e. the mass of the input and output fractions to and from their facility, quantitative and qualitative results of analyses of the composition, and quality of these fractions etc. These data are usually confidential;
- Industry associations;
- Eucobat European association of national collection schemes for BATT (www.eucobat.eu);
- RECHARGE European association for Advanced Rechargeable BATT (www.rechargeBATT.org);

- Eurobat Association of European Automotive and Industrial Battery Manufacturers (www.eurobat.org);
- EPBA European Portable Battery Association (www.epbaeurope.net);
- EBRA European Battery Recycling Association (www.ebra-recycling.org);
- ILA International Lead Association (www.ila-lead.org);
- ACEA, JAMA, KAMA Automobile Manufacturers Associations (see chapter 2.6.2), including Electrically Chargeable Vehicles (www.acea.be, www.jama-english.jp, http://kama.or.kr/eng/K_eng_main.jsp); and
- Industry Associations usually collect, compile and partly publish data from their members.

2.5.2 BATT Sector Overview

RECHARGE (2015) suggest that "As the use of advanced rechargeable battery (both portable and industrial) is increasing in multiple applications such as cordless power tools (for household or professional use), e-mobility transportation (e-bikes, motorcycles, electric-type automobiles), e-communications devices (i-pods, i-pads, PC, mobile phones), the importance of collection, treatment and recycling increases."

RECHARGE (2015) anticipate an increase in demand for rechargeable BATT in robotics, cordless power tools and communications, as well as in the hybrid and full electric mobility industry, and in renewable energy storage applications. As part of this, RECHARGE have considered the implication for three battery chemistries; Ni-MH, Ni-Cd and lithium-ion (Li-ion). They identify that Nickel- Cadmium (Ni-Cd) BATT are becoming obsolete; as their use has been banned for portable applications in Europe. The numbers placed on the market are continuously decreasing as per Figure 8 due to the substitution of Ni-Cd by Li-ion for the power tools application. However as per Figure 9 and Figure 10 the volume and the weight of Ni-Cd batteries collected compared to Ni-MH and Li-ion batteries is still most significant.

Contrasting with this trend, the Li-ion battery technology market is growing fast. Ni-MH is also growing, mainly due to the development of the HEV market. This is visible in the below Figure 8, which demonstrates how many Li-ion batteries were placed on a market between 2006 and 2013. UNEP (2013) identify that recycling of Li-ion and NiMH rechargeable battery types still have a great potential for improvement, despite their widespread use.

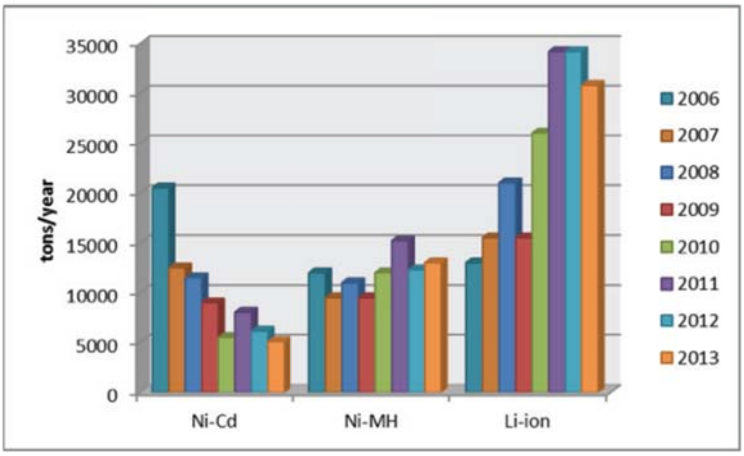

Figure 8. Weight of Portable Ni-Cd, Ni-MH and Li-ion Placed on Market (POM) in Europe (RECHARGE 2015)

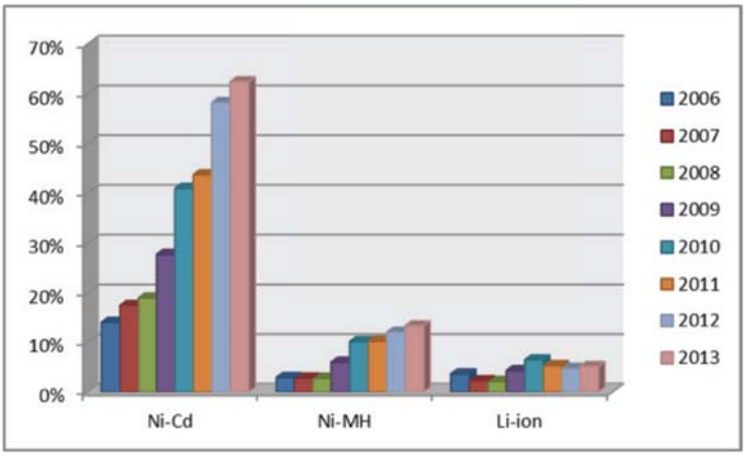

Figure 9. Calculation of the Collection Rate According BATT Directive 2006/66 EC (RECHARGE 2015)

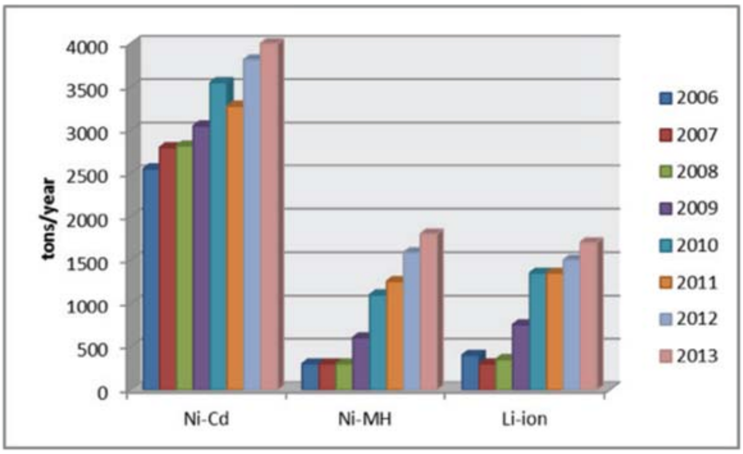

Figure 10. Weight of Portable Ni-Cd, Ni-MH and Li-ion Collected in Europe (RECHARGE (2015)

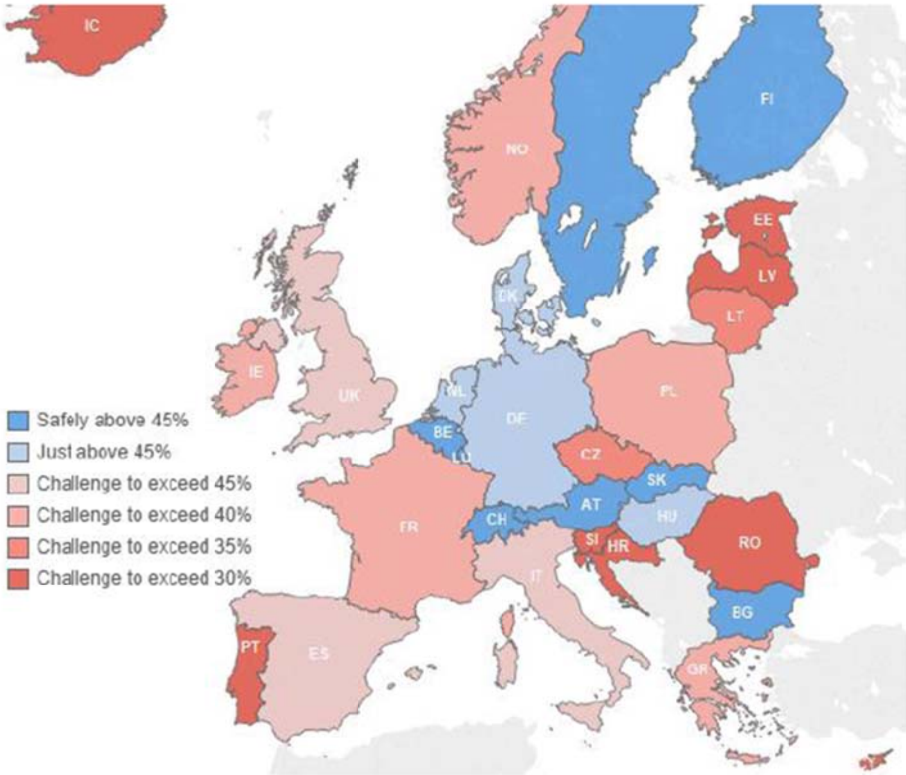

Figure 11. BATT Collection Rates, Source: (Perchards, 2015)

The low collection rate of rechargeable batteries prompts the need for further research. There may be diverse reasons for low collection rates of these batteries including low recovery of rechargeable battery from their application prior to recycling, discrepancies in reporting, as well as the export of refurbished battery bearing devises for reuse. UNEP (2013) also identify that collection in developed countries is further hampered by both legal and illegal exports and domestic hoarding. Figure 11 demonstrates differences in collection rates of portable batteries across Europe. Complementary flows of batteries are discussed in more detail in Section 3.2.

Although the proportion of Ni-Cd BATT in the marketplace is increasing, the amount collected is continuously decreasing due to the substitution of Ni-Cd by Li-ion for the power tools application. Fewer of these BATT will be observed in the waste stream moving forward.

Furthermore the continuous evolution of battery chemistry, the use of manufacturer-specific formulations, and extremely high quality requirements, makes the recycling of rechargeable BATT more difficult, unless one-to-one business-to-business (B2B) relationships between a manufacturer and a recycler are developed.

Recycling operations for future products and material combinations will need the development of even more smelting competence in different Carrier Metals and making the right inter-linkages between processes. This type of response to new products already exists for some of the waste streams that recently have become valuable. For example, Umicore have developed a process for recycling rechargeable BATT, recovering nickel and cobalt. A rare earth oxides fraction can now be created and processed at Rhodia (Rhodia; Umicore, 2011)

2.5.3 Collection and Recycling of Industrial and Automotive BATT

From the nature of the products and their application, industrial and automotive BATT are not an item of concern for inappropriate waste management. The collection and recycling of industrial and automotive BATT is regulated by established industry practices and supplier-customer regimes.

Though the collection regimes vary from country to country within the EU, the efficiency rate is currently high. Industrial BATT are efficiently collected and recycled at the end of their life because they are also often sold with take back clauses in their contracts. (AGEFE, 2007, Lisbon)

Industrial BATT are used in the business to business environment driven by the value of the material and legislation, mainly the Battery Directive. Spent BATT are returned to the producer or the respective dealership. The industrial battery is picked up direct from where it was used. There is also a growing use in business to consumer products, such as electric bicycles.

As for the automotive BATT, the ELV Directive requires that BATT are removed from end-of-life vehicles after they are collected. A battery at its end-of-life is transferred from a car dismantler to a battery recycler and is made available for recycling (RECHARGE 2015).

The ELV Directive requires car producers to have a recycling scheme for new cars within six months after a vehicle is put on the market, and increasing amounts of production scrap will have to be dealt with. (IHS *2014a)* Some complementary guidance has been provided by various Members States when implementing the BATT directive, such as in UK. However there is no collection target for industrial or automotive BATT. Producers, or third parties acting on their behalf (for industrial BATT)/third parties (for automotive BATT) are obliged to take waste BATT back from end-users (Articles 8(3) and 8(4)).

This obligation, combined with the ban on landfilling and incineration (Article 14), should be enough to ensure that BATT are collected. The use of financial incentives (Article 9) and the application of penalties for infringements (Article 25) aim to ensure that BATT are collected properly.

Unlike waste portable BATT, waste industrial and automotive BATT are large, their users are professionals, and they are mainly collected by professionals, due to their economic value. As a result, nearly 100% of industrial and automotive BATT are already being collected.

The lead-acid BATT are collected because of the value of recycled lead and nickel-cadmium, Nickel metal hydride and Lithium-ion BATT are collected because there is a well-developed collection system in place.

Some complementary guidance has been provided by various Members States when implementing the BATT directive, such as in UK for producers. Producers are obliged to take back waste industrial BATT free of charge from an end user, on request, when that end user is not able to return waste industrial BATT to his supplier (for example, when not purchasing new BATT). However, this obligation is not part of the normal customer/supplier relationship and only applies to waste industrial BATT that are of the same chemistry as the new industrial BATT that the producer places on the market in the calendar year in question, or has placed on the market in any of the preceding 3 calendar years. The end-users, in these circumstances are expected to approach the original supplier of the BATT, which have now become waste, if he is registered as a producer.

In the UK, when an end-user is unable to dispose of waste industrial BATT by either of the options above e.g. when an end user has not purchased new BATT, and that chemistry has not been placed on the market for a number of years so that an appropriate producer cannot be located; then the end user's entitlement is to be able to contact any producer to request take back (Environment Agency 2016a). No evidence was identified that this is widespread across the EU.

Spent BATT containing heavy metals such as lead, cadmium and mercury are hazardous waste so there is a need to go through the notification procedure when transporting spent lead acid BATT from one member state to another member state. Authorities of member states who are in charge of the notification procedure will have the data on how many BATT have been exported. However industrial BATT are heavy, valuable, and recycling infrastructure is widely available in Europe so there is little incentive to ship spent lead based battery outside Europe for recycling.

Research by ISH (2014c) confirms that 99% of automotive lead-based BATT are collected for recycling. However as noted by battery industry expert the 99% collection and recycling rate in the report is calculated based on BATT "available for collection in Europe" only. This report has not taken into consideration all existing automotive lead-based BATT flows such as exports and imports of industrial BATT embedded in products.

In addition, all the new and second hand vehicles exported from and into Europe contain lead acid BATT. Used vehicles statistics could be analysed further in order to get a better understanding of these flows, which are not fully balanced.

It is also worth noting that varied lifetimes of industrial BATT depend on their usage pattern making it difficult to assess quantities that may become available for collection. For stationary applications a battery lifetime can be 20 years, but in a traction application such as a forklift truck in a warehouse which runs 24 hours a day, the battery may not last more than one year. If the same forklift from the same supplier and forklift is running once a day the battery will run for 10 or 15 years.

Also, at present, there are few treatment operations recycling large format Li-ion BATT used in hybrid vehicles. These BATT should last the entire vehicle life and end up at car dismantlers or at auto dealers.

Overall, lead–acid recycling seems to work well because it is profitable, it is illegal to dispose of the BATT without recycling, the battery disassembly is simple because of the standard design used, the battery chemistry does not require segregation, and the recycling process is standardised.

A key reason for the success of lead–acid battery recycling is that essentially all of the manufacturers use the same raw materials: lead, lead oxide, and sulphuric acid in a polypropylene case. As the battery design is similar for the manufacturers, automated technology can be used for battery disassembly. The recycling operation is profitable because recycled lead (taken back to its elemental form and purified) is known to be of high quality, so there is little incentive to export to places with less-stringent regulations.

On the other hand the growing demand for these rechargeable hybrid and electric cars BATT mainly based on lithium-ion technologies will spark a need for increased recycling.

Increasing demand for rare earths coupled with China's policies to restrict exports so that they can satisfy their own demands, has provided a significant economic incentive to recover these metals during recycling of large-format Ni–MH BATT used in hybrid vehicles.

Several companies have already announced programmes to recover the rare earths from Ni–MH BATT. Umicore, in Belgium, recovers nickel and has an agreement with Solvay to process slag and recover the rare earths. Retriev Technologies has a plant under construction in Ohio and plans to recover rare earths when its first processing line is completed. Honda has an agreement with Japan Metals and Chemicals to recycle its Ni–MH BATT. In Australia, Toyota offers a $100 rebate when a Prius battery pack is returned, and a discount on a replacement. In summary, Ni–MH BATT seem to be on track for successful recycling.

2.5.4 Lithium – ion Rechargeable BATT for Automotive Applications

Plug-in hybrid and electric passenger cars are propelled by lithium-ion battery systems.

Lithium-ion rechargeable battery systems entered the mass market of small-sized consumer applications in the early 1990s.

Their up-front cost was significantly higher than corresponding battery technologies based on other chemistries. Therefore, larger-sized lithium-ion BATT are currently found in segments such as military and space applications, where their high energy and power density as well as their superior cycling ability create value.

The high capacity of the active materials and a single cell voltage of up to 4.2V give lithium-ion the highest energy density of all rechargeable systems operating at room temperature. In automotive applications, they are the product of choice for plug-in HEVs and full EVs, in which both these criteria are important.

The total volume of industrial BATT and the share of lithium BATT are likely to increase significantly over the next decade. Nevertheless Perchards (2015) and IHS (2014b) suggest that in the short term end of life volumes will remain low due to the current penetration of hybrid and electrical vehicles in the automotive market and the long lifetime of these BATT (> 10 years).

BATT for hybrid and electric vehicles differ from automotive starter BATT in terms of their chemical composition and consequent need to follow different collection and recycling process. According to (Gaines, L., (2014), there is a safety risk related to those BATT getting mixed with the automotive starter BATT in the collection and recycling process. This creates safety issues related to the recycling of mixed BATT.

2.6 Risks and Assumptions, Data Availability ELV

2.6.1 Data Availability ELV

There are various limitations regarding data availability and comparability making it challenging to investigate fates of End of Life Vehicles (ELV) in Europe:

Differentiation Between ELV and Used Car

One crucial factor regarding the accounting of ELVs is the differentiation between the end of life vehicle (ELV) and a used car. To analyse the gap in ELVs arising and to find out if all ELVs are accounted for, it is crucial to differentiate between ELVs and used cars. The question of when a used car ceases to be product and becomes waste according to the Waste Framework Directive (2008/98/EC) is answered in different ways across EU Member States.

There are differences in the interpretation of ELVs and used cars between various EU states and that it is very difficult to distinguish between a used car and ELV. As a consequence there are problems regarding the comparability of the reported data. (Schneider et al., 2010)

The Quality of Data at the National Level

In order to analyse gaps between reported figures on de-registered cars and the arising of ELVs it is necessary to look at data on the national vehicle markets. However, this information is not available consistently for European Member States and therefore is not analysed as part of this report.

In annual reports on ELVs provided by Member States the dubious quality of the data is demonstrated. The gathering template for these annual reports requests data on the export of used vehicles and ELVs. More than half of the Member States submit documents with no or very little information about the export of used vehicles or ELVs. In some cases Member States admit to no availability of the requested data. Additionally, submitted data contains inconsistencies, like for example discrepancies between the reported number of ELVs and the certificate of destruction (CoD) issued (Oeko-Institut e.V. (2016).

In general, data quality and data availability on the national vehicle markets (including data on de-registration of cars, import/export of used cars) could be improved significantly. (Schneider et al., 2010)

The Quality of Data and Different System Boundaries

The quality of the data on intra-EU trade (trade between Member States) is hampered by the data collection method and, in consequence, it is unsuitable to assess the cross-border trade of used vehicles within the EU appropriately.

It is also worth noting that some of the discrepancies in calculations of ELV may be caused by differences in statistics such as different system boundaries:

- Data provided by ACEA cover passenger cars only;
- Data provided by Eurostat cover vehicle classes M1, N1 and three wheeled motor vehicles; and
- Data provided by COMEXT cover motor cars and other motor vehicles principally designed for the transport of persons, including station wagons and racing cars) may cause differences.

All the above contribute to the complexity and difficulty in analysing final fates of ELV in Europe (Mehlhart et al., (2011).

2.6.2 Overview of the Sector for ELV

Charts representing the ELV management system are covered later in the report (Figure 20 and Figure 21). The legislative framework for the ELV system includes:

1. ELV Directive (Directive 2000/53/EC on end-of life vehicles) stipulates targets for reuse, recycling and recovery of ELVs and their components;
2. Article 5(3) of the ELV Directive states that Member States (MS) shall set up a system for the collection, treatment and recovery of ELV's, according to which the presentation of a Certificate of Destruction (CoD) is a condition for de-registration. This CoD shall be issued to the ELV's owner once the vehicle has been transferred to an Authorised Treatment Facility (ATF) for storage and treatment (e.g. dismantling and depollution); and
3. Article 6 and Annex I to the ELV Directive provide the administrative and environmental requirements for ATF operation and ELV treatment (Oeko-Institut e.V. et al., (2016).

ELV Arisings

ELVs may enter the waste stream from a variety of sources, including private individuals, garages, local authorities (in the case of abandoned vehicles) and insurance companies (in the case of accident damaged vehicles). In the UK, it is estimated that 10-15% of ELVs are accident damaged vehicles and that the remaining 85-90% have reached the end of their life naturally.

The average age of ELVs has been variously estimated at 15.3 years (Netherlands, 2004), 12.1 years (UK) and more than 11 years (Hungary). In the UK, TRL (2003) estimated the average age of ELVs as a whole at 12.1 years, with the average age of natural end of life vehicles at 12.8 years and that of premature end of life vehicles at 6.7 years (the average age of the vehicle park). Our current assessment based on Eurostat/ACEA gives the following estimates of the average age of the vehicle parks in various national fleets, together comprising more than 90% of the EU ELV fleet.

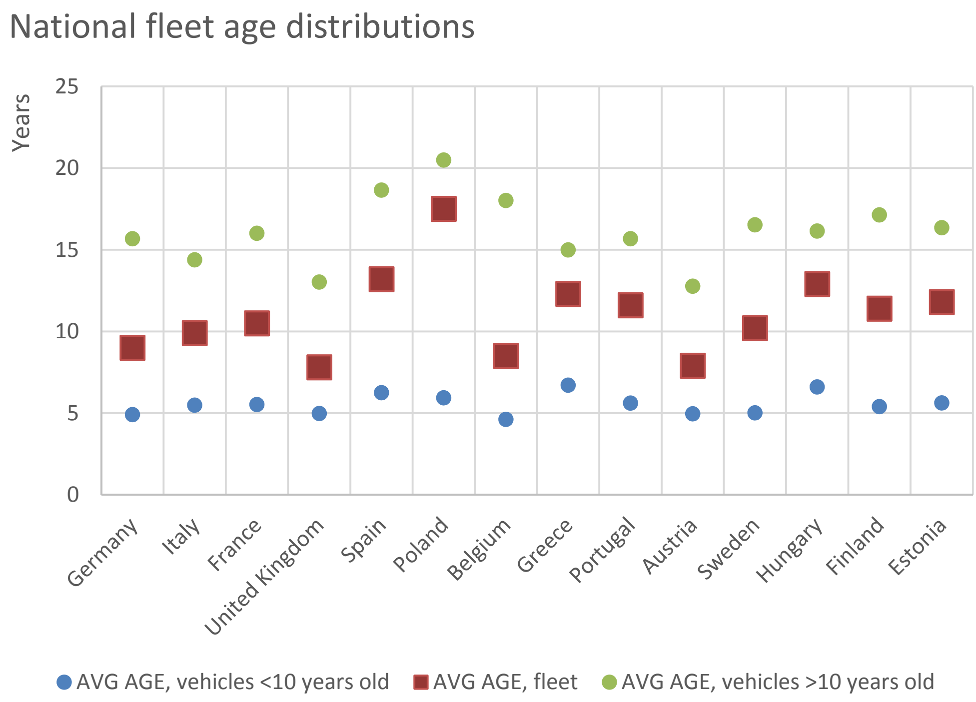

Figure 12. Vehicle Age Averages for the Largest National Fleets

3 Data Analysis of Complementary Flows

3.1 Data Analysis WEEE

3.1.1 Collected and Reported WEEE

WEEE reported is mostly composed of category IV (Large equipment), V (Small equipment), II (Screens) and I (Temperature exchange equipment). Most of the information collected comes from Eurostat which provides the information in the 10 WEEE categories. Estimates have been applied in order to turn WEEE reported figures into the 6 categories per respective stratum shown in Table 9**Error! Reference source not found.**. The strata are based on high, medium and low income levels depending on the Purchasing Power Parity (PPP) as follows: High PPP countries include: Austria, Belgium, Switzerland, Germany, Denmark, Finland, France, United Kingdom, Ireland, Luxemburg, the Netherlands, Norway and Sweden; Medium PPP countries: Cyprus, Czech Republic, Spain, Greece, Italy, Malta, Portugal, Slovakia, and Slovenia; Low PPP countries: Bulgaria, Estonia, Hungary, Lithuania, Latvia, Poland and Romania.

Table 9. UNU Split Factors for WEEE Collected

WEEE Collection Categories	Stratum 1	Stratum 2	Stratum 3
I	15.4%	16.7%	23.3%
II	15.5%	15.1%	14.7%
III	1.2%	1.3%	0.9%
IV	27.9%	30.7%	29.8%
V	29.9%	28.3%	24.5%
VI	10.1%	7.9%	6.8%

Similarly, WF applies the split factors as mentioned in Figure 13 in order to covert 10 WEEE categories into 6 categories. However, the split factors are applied to all countries regardless of PPP. It should be noted that the actual equipment composition of these collection flows differs from one country to another, because the allocation of some common equipment is not homogenous at European level.

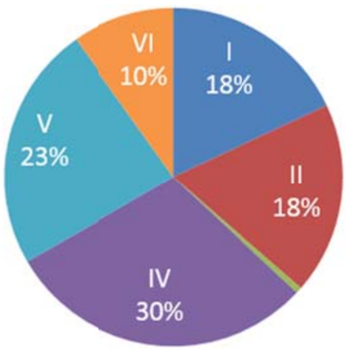

Figure 13. Composition of WEEE Collected. Share Based on Total Data WEEE Collected 2010 to 2014 (WEEE Forum Key Figures, 2014)

For instance, microwave ovens and ventilators may be collected and reported in different categories: LHA or SHA. The total amounts of WEEE Collected at European level remained quite stable during the years 2010-2014, with differences below 5% in consecutive years. This shows that despite the economic crisis that affected sales figures, efforts to increase collection have been effective in general. However the amount of unreported WEEE is still significant in Europe, as stated in the CWIT report. The allocation of collected and reported WEEE is presented in the

Table 10. For each collection category and country, the uncertainty related to allocating amounts from 10 WEEE categories to 6 collection categories is calculated and included in the error bars in the result graphs.

Table 10. Amounts of WEEE Collected, 2012

Year: 2012, values in kt	Temp. Exchange Eq.	Screens	Lamps	Large Equipment	Small Equipment	Small IT	Total
Collected WEEE	580	663	14	1,040	777	374	**3,448**

3.1.2 Waste Bin

For the countries without data found in literature, the data sources identified in Section 2.4.4 are extrapolated using two methods. In the first method, the original values in different units are converted in kg of WEEE per inhabitant in residual waste per inhabitant per country. Countries are furthermore divided into three strata (high, middle and low income) depending on their economic purchasing power.

Then, the average kg of WEEE per inhabitant is calculated per stratum of countries. Those are used to determine the countries which we don't have data. The outcomes are double checked with another extrapolation method, namely via the percentage of WEEE in waste per total WEEE generated. The averages per stratum are calculated and used to determine the other countries as shown in Table 11.

Table 11. WEEE in the Household Waste Bin Analysis

Income level	Country	Population (1000)	Year	Literature	Literature	Estimate (in tonnes
				(kg/inh)	(tonnes)	based on kg/inh.)
High	AT	8,466	2012			15,718
	BE	10,840	2010	1.53	16,632	
	CH	8,002	2012	1.25	10,000	
	DE	81,917	2012	1.4	114,684	
	DK	5,535	2010	0.63	3,488	
	FI	5,426	2012	0.71	3,856	
	FR	61,795	2007	1.5	92,693	
	UK	62,262	2010	3.12	195,000	
	IE	4,585	2012			8,513
	LU	529	2012			982
	NL	16,615	2010	2.3	38,180	
	NO	5,038	2012			9,354
	SE	9,416	2010	1.23	11,550	
Middle	CY	872	2012			1,221
	CZ	10,507	2010	2.32	24,422	
	ES	46,073	2010	0.79	47,922	
	EL	11,299	2012			15,826
	IT	60,821	2012	1.01	42,922	
	MT	417	2012			584
	PT	10,599	2007	1.51	16,000	
	SK	5,439	2012			7,618
	SI	2,055	2012			2,878

Low	BG	7,505	2010	0	0	
	EE	1,340	2011	3.76	5,041	
	HR	4,402	2012			6,099
	HU	9,962	2012			13,803
	LT	3,008	2012			4,168
	PL	38,896	2012			53,892
	RO	21,484	2009	0.39	8,475	

For most countries, the frequency count of appliances is presented for the 10 categories in old WEEE Directive 2002.

Following the data quality assessment described in Section 1.3, the data from the sources from Denmark, The Netherlands, UK, Portugal Italy, Czech Republic, Estonia, and Luxembourg is used for determining the average split for the countries without an allocation to WEEE collection categories. Similar to the collection amounts, then a conversion from 10 to 6 collection categories is applied. The Danish and Dutch studies, directly allow determination of WEEE by the 6 collection categories.

The allocation is presented in the Table 12. Noticeably, the data point from the allocation to the categories is of lower quality than the WEEE total amounts. The allocation of WEEE in waste bin is presented in the Table 13.

Table 12. Weight% of WEEE in Waste Bin, per 10 WEEE Categories

WEEE category (WEEE Directive)	Average
01	2%
02	30%
03	21%
04	22%
05	13%
06	5%
07	5%
08	0%
09	1%
10	1%

Table 13. Amounts of WEEE in Waste Bin

Year: 2012, values in kt	Temp. Exchange Eq.	Screens	Lamps	Large Equipment	Small Equipment	Small IT	Total
WEEE in waste bin	-	26	5	21	435	117	604

3.1.3 Complementary Recycling – WEEE in Metal Scrap

WEEE is often mixed with other metals, predominantly ferrous scrap metal before being sent to a metal shredder. WEEE is introduced by collectors into this stream to avoid the cost of sorting and sometimes depollution of WEEE. There is a limited number of country studies estimating the proportion of WEEE mixed with pre-shredder materials. Those available tend to focus on North West Europe, where due to an apparent overcapacity of shredder capacity, there is strong competition for the material. It is not clear whether the same proportion of WEEE in pre-shredder materials is similar in other countries, particularly in Eastern Europe.

The amount of WEEE in mixed metal scrap is not sampled in a regular or harmonised manner across the EU countries. Actual sampling data is available for five countries only. For the Netherlands, the concentration of WEEE (parts from professional and Large Household Appliances, Small Household Appliances, Central Heating and IT appliances), is estimated to be 110 kt as a minimum (Huisman et al., 2013). For Belgium, this is at least 15 kt (Wielenga et al., 2013). This is also a minimum documented value, not all volumes are likely documented in this study). For France this is 200 kt as a minimum (Monier et al., 2013) and for the United Kingdom, this is with 95% confidence interval between 381 kt and 597 kt (WRAP, 2013). Here the lower value is used to ensure a similar approach as for the Netherlands, Belgium and France plus an additional a source for the Czech Republic (Polak, 2013).

From these studies it is observed that the average amount of WEEE in the total of mixed metal scrap ranges between 0.4% and 2.2% (Wielenga et al, 2013; Huisman et al., 2013, Monier et al, 2013, WRAP, 2013, Polak, 2013). The percentage mentioned in these five studies is against the total tonnage of ferrous metal scrap, non-ferrous scrap and mixed ferrous plus non-ferrous scrap from Eurostat (Eurostat 2016). In the individual analysis, the amount of WEEE in the specific sub fraction is documented to be around 10-11% (named shredder fraction in France, light iron fraction in the UK (estimated to be around 4-5 Mt out of 21.5 Mt in Eurostat for all GBR metal scrap amounts in total) and 'pre-shredder materials' in The Netherlands). For the values against the total volume of ferrous and non-ferrous scrap, the data for the Netherlands (2.2%), France (1.5%) and the UK (2.1%) have more detailed information on the types of equipment present. As a minimum amount, an average of 1.4% of WEEE in the combined metal scrap amounts is taken and used also for estimating the amounts in countries without any sampling information as a coherent estimate, leaving upwards potential for higher amounts. For instance, WEEE parts derived from professional appliances are difficult to characterise as WEEE when this flow is sampled. See Table 14 for the results. The value of 1.4 Mt of WEEE identified is a lower more conservative estimate than the values presented in the CWIT report. There is significant upward potential.

Table 14. Minimum Amount of WEEE in Mixed Metal Scrap

Year: 2012, values in kt	Temp. Exchange Eq.	Screens	Lamps	Large Equipment	Small Equipment	Small IT	Total
WEEE in metal scrap	101	32	-	655	452	87	**1,326**

Similar to the Waste Bin data, the total amount is allocated to the collection categories for mixed metal scrap for countries without information. See Table 15. The information here is only based on the Dutch and UK studies which contain information on the type of appliances identified. Obviously, the data points from the allocation to the categories are of lower data quality than the WEEE total amounts in metal scrap and classified as 'dubious' since there are only two sources available.

Table 15. Weight% of WEEE in Waste Bin, per 10 WEEE Categories

WEEE category (Recast WEEE Directive)	Average

I	8%
II	2%
III	0.0%
IV	49%
V	34%
VI	7%

In addition, for some countries it is known that WEEE in mixed metal scrap is also reported under the official collection amounts. Here, for Bulgaria, Estonia, Sweden, Norway and Finland, the extrapolation is excluded to avoid the possibility of double counting. In Romania, there is a strong informal network for WEEE collection, mainly operated by scrap metal collections where valuable materials are removed immediately and the remaining are treated as scrap metal. This is mainly as a result of poor municipal collection services for WEEE (Quantifying Waste of EEE in Romania) (Magalini et al., 2015).

3.1.4 Complementary Recycling – WEEE Products

For some countries from individual studies (Huisman et al, 2013, Monier et al, 2013) as well as surveys with the electronics recycling industry, specific information is derived for the unreported complementary recycling of products as batches of WEEE. Unlike the approach for the waste bin amounts and WEEE in metal scrap, it is not possible to produce coherent estimates due to the lack of data. Secondly, the data is very specific for the countries involved due to highly varying reporting practices of such complementary product amounts. Table 16 provides a summary of the results.

Table 16. Complementary Recycling Products, 2012

Non-reported Complementary WEEE Recycling (products)	kt (2012)
BGR	10
ESP	5
FIN	0.5
FRA	67
ITA	0.6
NLD	59
ROU	0.5
Total	**142**

Also here, there is significant upwards potential for the actual quantities. (Huisman et al. 2015) Another 950 kt of additional non-compliant collection and treatment is estimated to be not reported, for instance professional appliances (heating and cooling installations, large IT equipment, large tools and compressors, medical equipment, etc.), commonly processed by installation companies (up to 500 kt), as well as lamps (90 kt) are unaccounted at export destinations. These lamps likely end up in, for example, glass containers. However, it would require a very large, costly survey EU wide of small, medium and large recyclers to improve the data capture assuming also willingness of the recycling industry to cooperate.

3.1.5 Scavenged Components

As in the CWIT report, it was estimated based on a market survey with contributions from members of the European Electronics Recyclers Association (EERA) that 750 kt of valuable parts do not make it to the official collection points. This includes significant amounts of refrigerator compressors (84 kt out of 300 kt were scavenged, roughly equal to the annual CO_2 emissions of 5 million cars) and cable and IT components (180 kt), all of which are commonly exported to Asia, predominantly as material fractions for treatment. In this report, due to very scattered nature of the information sources, analysis was only possible for the compressors removed from cooling and freezing appliances. From (Huisman et al., 2015) the following parameters are used in this report: in collection category I, 18% of the average weight consists of compressors. Of this, on average in the EU, 29% is not present when on arrival at recycling facilities. This data is based on 12 large recyclers and around 90 kt of fridges and freezers. The removal percentage is very recycler and country specific and ranges between 10% and 70%.

Table 17. Scavenged Compressors from Fridges, 2012.

Scavenged compressors	kt (2012)	Scavenged compressors	kt (2012)	Scavenged compressors	kt (2012)
AUT	1	FIN	1	LVA	0
BEL	2	FRA	11	MLT	0
BGR	1	GBR	10	NLD	3
CHE	1	GRC	1	NOR	1
CYP	0	HRV	1	POL	4
CZE	1	HUN	1	PRT	2
DEU	12	IRL	1	ROU	3
DNK	1	ITA	8	SVK	0
ESP	7	LTU	0	SVN	0
EST	0	LUX	0	SWE	2
				Total	76

As per Table 17, although the amounts per country are not that high, the total tonnage has a lower estimate results of 76 kt of WEEE parts with a very significant CRM value, but also environmental footprint due to the CFC emitted to air when removed. Again, there is a considerable upwards potential.

3.1.6 Export

Unfortunately, the data use for determining export (for reuse) amounts in Europe is only available for five countries, and they significantly differ from each other. The Austria study (Kopacek, 2013) focused on the flows of informally collected amounts travelling by road to Eastern Europe. The (Wielenga et al., 2011) study quantifies only minimum amounts of WEEE being exported. The United Kingdom data from WRAP (WRAP, 2011) is mainly based on modelling of discarding behaviour responses and thus covers minimum amounts of exportations. However, due to the total size of the reuse flows, much higher volumes are likely to be occurring in practice, which is also observed at receiving ports in Africa. The German study from Ökopol (Sander, 2010) provides a total minimum estimate based on inspection data of 93 kt, which could be even higher, up to 151 kt. Similar to the German study, the Dutch Future Flows study (Huisman et al., 2013) is the only other source where both inspection data and modelling of the reuse loop of appliances in a highly detailed mass balance is combined and compared with estimates from the inspection agencies and their databases and completed with documented flows from the refurbishment industry. As a result, the identified volume, around 10% of all WEEE amounts, is much higher compared with the other publications.

The documented results are displayed in Table 18. The values and the fact that exports are very country specific, do not allow for determining coherent estimates by extrapolation to other countries.

Table 18. Documented WEEE Exports (for Reuse), 2012.

Documented WEEE exports (for reuse)	kt (2012)
AUT	19
BEL	9
DEU	93
GBR	40
NLD	44
Total	201

3.2 Data Analysis for BATT

The complementary flows of BATT on which information has been sought are identified in the figure below. It is a simplified schematic of battery flows, in which reported flows are highlighted in blue, unreported flows addressed in other parts of Work Package 3 are highlighted in green, and unreported flows which are the focus of the work on BATT are highlighted in orange.

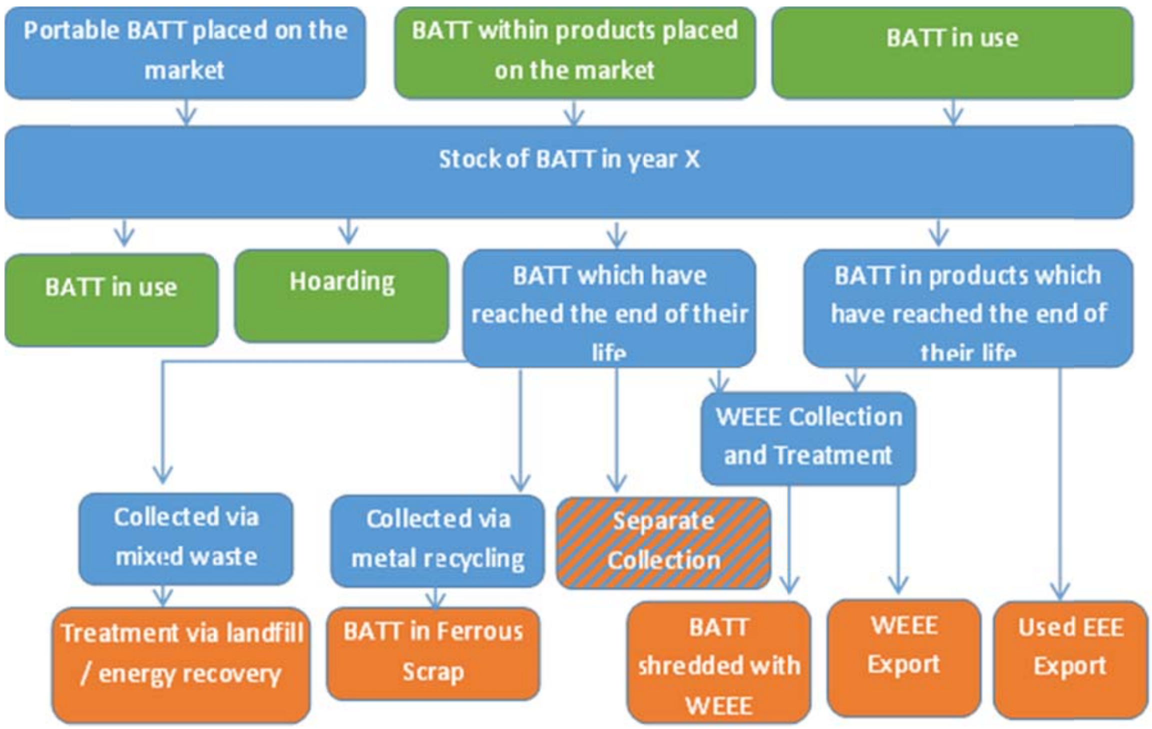

Figure 14. Simplified Schematic of Complementary Flows of Portable BATT

The schematic is based on Perchards (2014) and the ProSUM Information Network workshop which took place in April 2015 in Brussels. The workshop was the first chance to consult on the ProSUM project methodology with a wide range of stakeholders and understand project needs. The workshop secured consensus that ProSUM should identify the data gap between POM, WG, and official collected and recycled data. The data gap could represent the sum of complementary flows.

Key issues highlighted at the workshop included the complexity of the recycling system, the difficulty in sharing confidential or competitive information, the potential for legal recycling to not be reported to the relevant authority, and that complementary flows could include many of the flows identified in Figure 15, e.g. waste handled by scrap dealers, waste handled by disseminated brokers, or individuals, waste for export, waste in dustbins.

As identified in Figure 15, to identify complementary flows of BATT, direct information from organisations and literature has been sought. The first step has been to use information already assessed as part of Deliverables 3.1 and 4.1 to ensure consistency of approach, and to use this in combination with data on reported flows to infer complementary flows.

The results of this gap analysis are presented in Figure 15 below. The key data sources which infer complementary flows are discussed in the following text. Unless otherwise specified, all data relates to the EU 28 for 2012. This is then compared with other data sources to assess the degree of alignment of the results and implications of alignment or disparity.

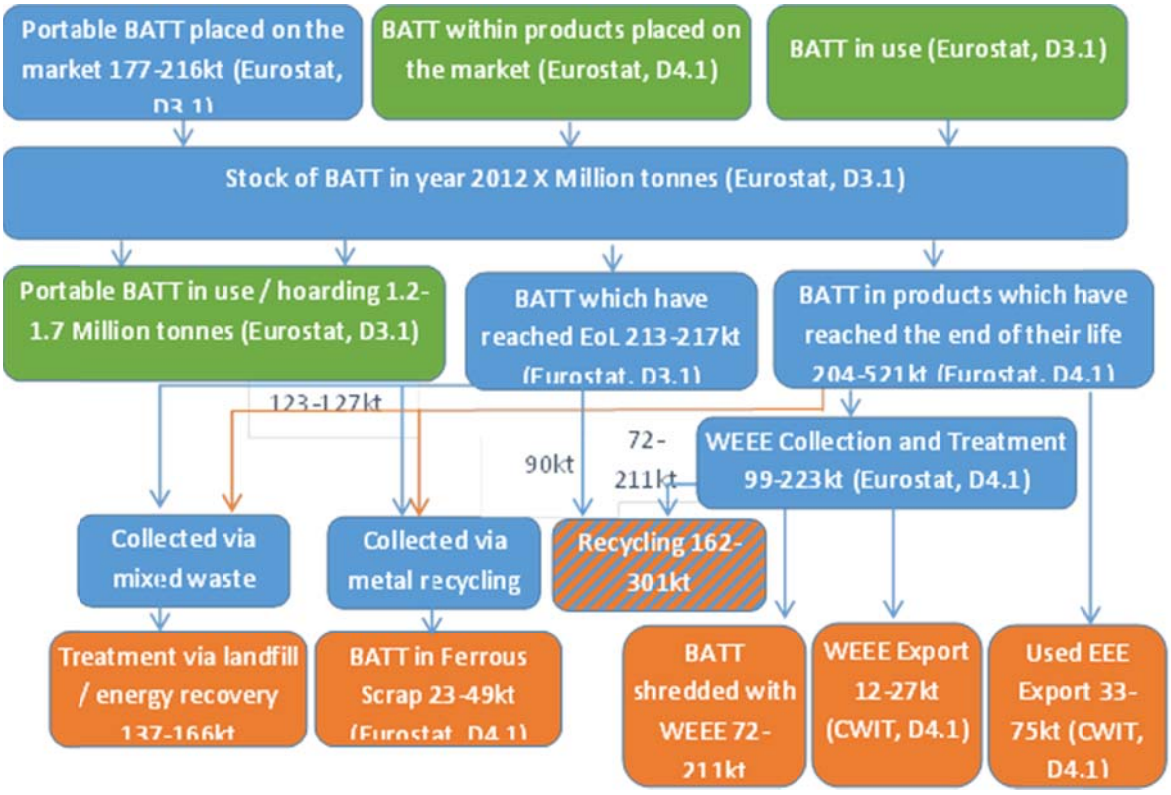

Figure 15. Gap Analysis and Inferred Complementary Flows of BATT, 2012

3.3 Data Analysis ELV

The initial literature review focused on two research papers: "End of life vehicles: Legal aspects, national practices and recommendations for future successful approach. EU Directorate General For Internal Policies, 2010" and "European second-hand car market analysis Final Report. (Oko-Institute e.V, et al., 2011)

At the later stage the research also incorporated early findings from the on-going Oeko-Institut e.V EU project on unknown whereabouts of ELV in Europe.

All the three literature sources listed confirm the existence of complementary flows of ELV.

Therefore the second stage of our analysis concentrated on examining the likely volume of missing vehicles. This can be calculated on the basis of the balance between new registrations, net export and ELVs reported by the Member States.

As seen from assessments performed for the European Commission covering years 2008, 2009, 2012 and 2013, approximately 3.4 to 4.6 million vehicles per year are not reported; they are neither registered as part of the European vehicle stock (also called “vehicle fleet” or “vehicle parc”), nor as vehicles exported from the EU (termed extra EU-Export in COMEXT), nor as ELVs (Eurostat). The figure below displays the numbers reported for the year 2013.

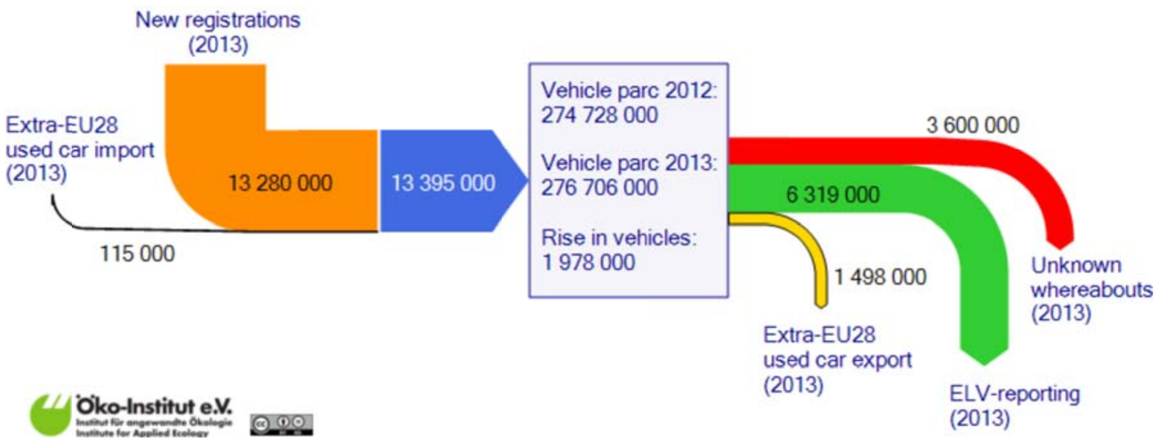

Figure 16. Vehicle Entries and Exits of the EU27-Fleet for 2008 [Source: Eurostat, ACEA] (Oeko-Institut e.V. (2016)

According to the above chart prepared by Oeko-Institut e.V Institute the unaccounted-for vehicles which have to leave the fleet in order to close the balance amounted to 3,600,000 units based on data from 2013 and represent 31% of the total vehicle exits.

Furthermore, there are gaps between the numbers of de-registered passenger cars and end-of-life vehicles in many EU Member States. In most Member States the number of ELVs represents more than 50% of the amount of de-registered passenger cars (e.g. Belgium, Italy, Spain and the Netherlands). Thus, for those countries the gap between the number of de-registered cars and ELVs is lower than 50%. In other Member States (e.g. Austria, Denmark, Finland, Sweden) the gap is higher, and there is no detailed information available on the further use of more than 50% of the de-registered cars. Germany stands out as having a major gap between the number of vehicles deregistered and the number of ELVs treated, because of its large volumes of exports of used vehicles.

The difference between the numbers of de-registrations and numbers of ELVs recorded as treated is explained by a variety of factors.

The following factors are important to explain the gap concerning the whereabouts of “De-registered” passenger cars not reported as ELVs and not exported commercially:

1. Incorrect functioning of the Certificates of Destruction (CcD) system;
2. Not reported in COMEXT private exports of used cars;
3. Exports outside of Europe by transit through EU-MS;
4. Illegal shipment of ELV;
5. Illegal disposal and recycling; and
6. Long term garaging in the country of de-registration.

Figure 17 and Figure 18 outline the various data available as well as data gaps resulting with complementary flows/unknown whereabouts of ELV.

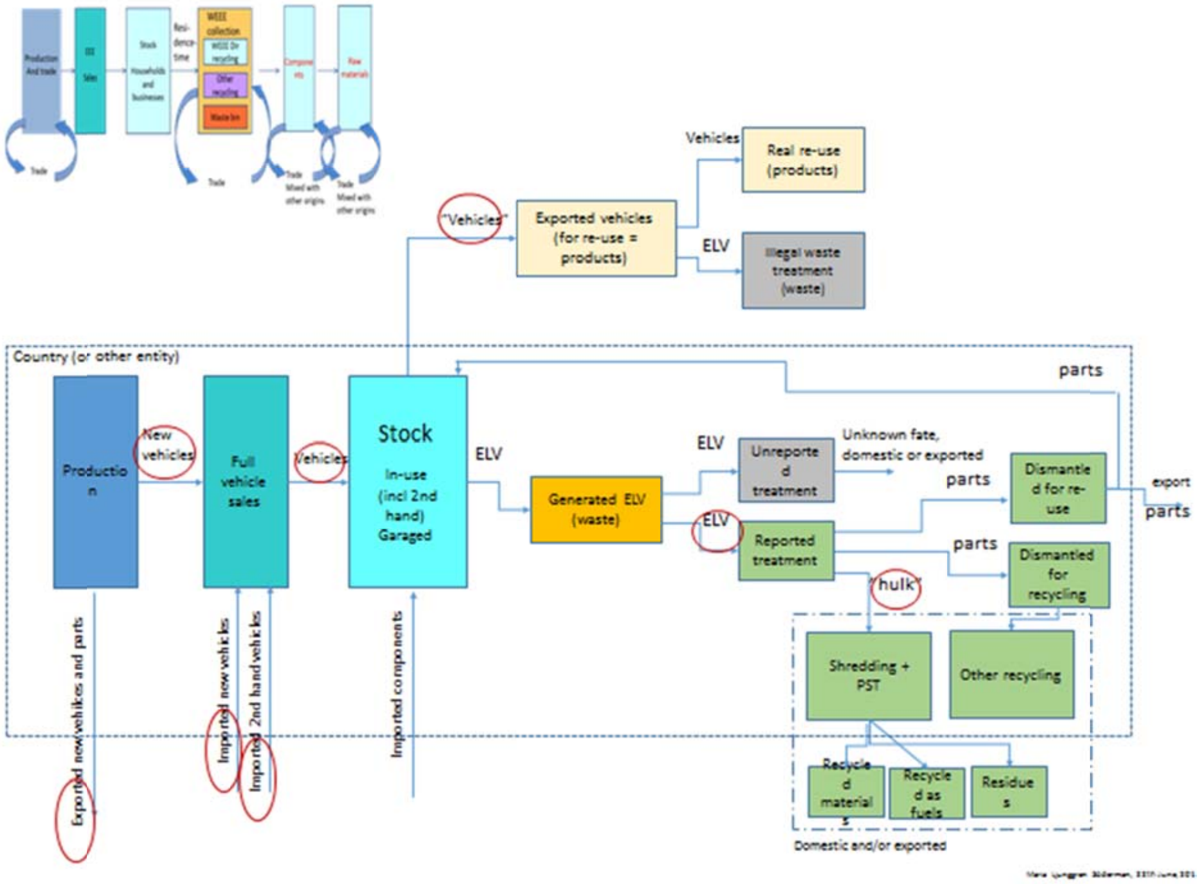

Figure 17. Data Mapping for ELV

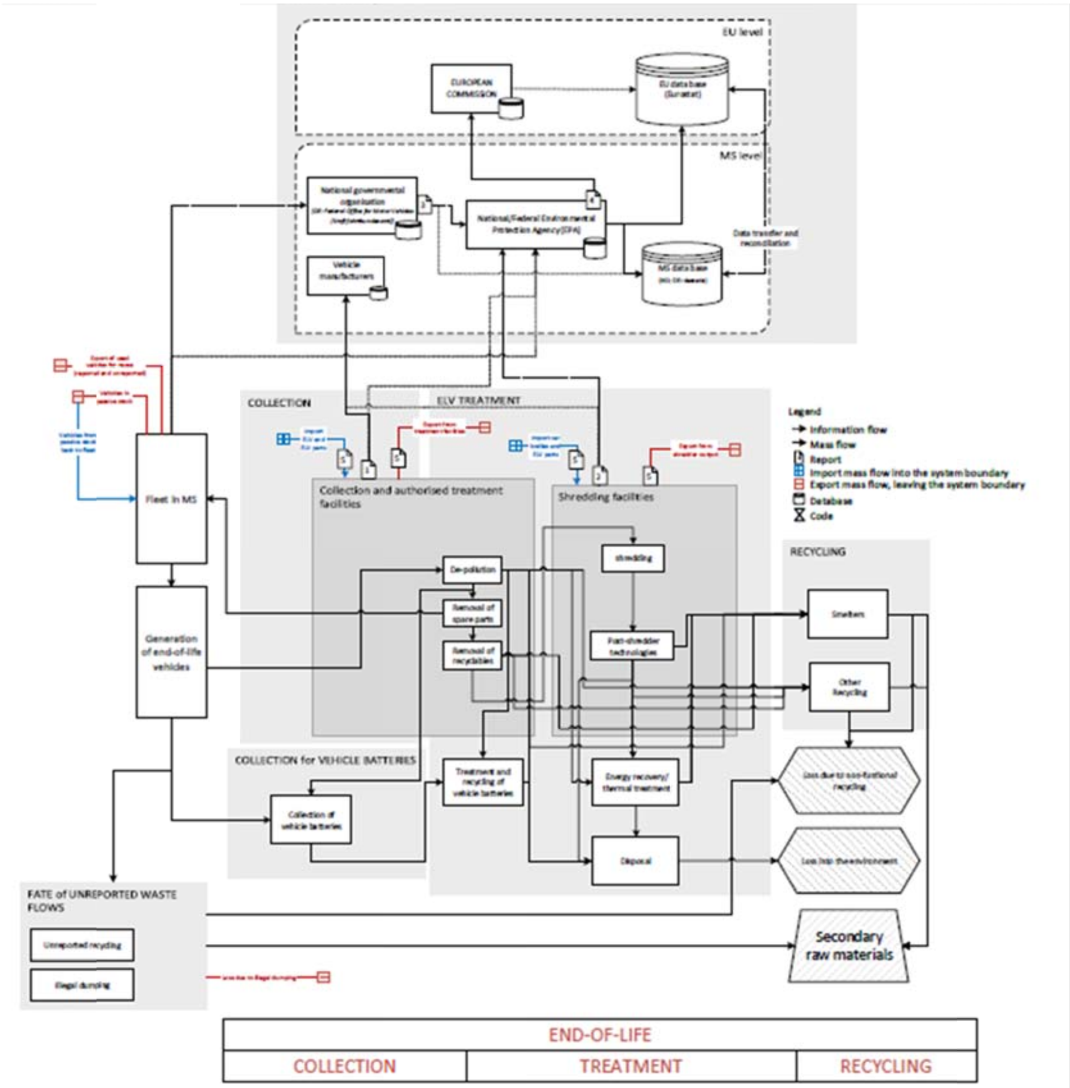

Figure 18. Data Mapping for ELV

3.3.1 Vehicles De-registration & Certificates of Destruction

There are different approaches to the de-registration of vehicles across EU Member States. For example in Austria a vehicle is de-registered as a rule with the change of ownership of a car. In some Member States (e.g. Austria, Finland) the number of Certificates of Destruction (CoDs) issued is not equal to the arising's of end-of-life vehicles. This might be due to the fact that a vehicle can be deregistered before the car owner decides that his/her car becomes waste and thus an end of- life vehicle. This creates an information gap regarding the whereabouts of de-registered vehicles.

In other countries (e.g. in the UK) vehicles are not deregistered when ownership changes. In these countries, de-registration generally takes place when the car owner wants to dispose of the vehicle. This practice seems to be better in terms of avoiding a grey area when there is no trace after a vehicle which was de-registered, not destroyed and not registered again. In these countries the vehicle may only be re-registered and put back on the road under exceptional circumstances and prior approval.

Article 5 (3) of the ELV Directive requires Member States to set up a system according to which the presentation of a Certificate of Destruction (CoD) is a condition for de-registration of the end-of life vehicle. However this is not yet in operation in all of the EU member states.

A certain number of de-registered passenger vehicles are commercially exported as second-hand cars, according to the COMEXT database, the official European Foreign Trade. (Schneider et al 2010)

The various destinations of end of life vehicles with whereabouts unknown are analysed further in the following sections.

3.3.2 ELV Exported as Used Car

Large numbers of used cars are exported from the EU each year, resulting in a reduction in the number of ELVs that require treatment. Compared to the arising's of end-of-life vehicles, the numbers of end-of-life vehicles that are exported are low.

A considerable number of vehicles which are de-registered in the Member States are exported as used cars.

There is also evidence suggesting that considerable numbers of ELVs are exported illegally from European Member States; predominantly to Africa and the Middle Eastern countries. This is supported by several press reports as well as by the results of joint activity inspections in the framework of an IMPEL-TFS project completed in 2008, where several cases of illegal shipment of end-of-life vehicles were reported – mostly to African countries.

Nigeria is a huge market for ELV, which are sold for dumping prices. These vehicles are often smuggled from Europe or North America, through over 1,400 illegal routes to Nigeria and Benin. There is no exact number of vehicles registered. From reports by the Nigerian Automotive Manufacturers Association (NAMA), the Nigerian Bureau of Statistics (NBS) and United Nations Conference on Trade and Development, there are about 400,000 vehicles on the streets in Nigeria. (Report 2012). 300,000 used cars and 100,000 new cars were imported in 2012 and circa 500,000 ELVs per year. Dr. Beate Kummer, Scholz Holding GmbH.

Exports of Used Cars to Other EU states

The re-registration statistics from the Federal Motor Transport Authority (KBA), and the foreign trade statistics of the Federal Statistical Office are the two sources of data available for determining the number of used cars exported from Germany into other EU countries.

The number of used cars exported into other EU Member States can be identified from re-registrations in those countries, which are recorded in the re-registration statistics by the Federal Motor Transport Authority (KBA). (Umweltbundesamt, 2013)

The data is obtained based on an information exchange between Member States regarding the re-registration of motor vehicles previously registered in other EU Member State, on the basis of Directive 1999/37/EC on the registration documents for vehicles. On this basis, 1,215,945 used cars were exported to other EU Member States. There was a significant increase of nearly 30% compared with 2012, with 959,251 documented exports of used cars into EU states. (Umweltbundesamt, 2013)

Exports of Used Cars to Non-EU States

Exports to non-EU states were small compared with exports to EU countries. The foreign trade statistics showed a total of around 344,551 used cars exported (passenger cars and motor homes). This meant that recorded exports dropped back to the level of 2011. The major destinations for used cars outside of Europe are West Africa (39%) and the states of the former Soviet Union (27%) (Umweltbundesamt, 2013).

Table 19. Exports of Used Cars from Germany to Non-EU states, 2013 (Umweltbundesamt, 2013)

Country	Number in 2013			
Non-EU total	344,551			
Of which states of the former Soviet Union (excluding Baltic States)	94,226	Of which	Georgia Russia Belarus	40,430 28,272 12,752
Of which West Africa[14]	134,195	Of which	Benin Nigeria	44,213 36,651
Of which Norway, Switzerland	38,319			

Prompted by the statistical gaps in the fate of finally deregistered vehicles which have been observed for a number of years now, in 2014 the Federal Ministry for the Environment and the Federal Environment Agency initiated a study under the Environmental Research Plan (UFOPLAN) to investigate the fate of these vehicles.

The objective of this on-going project is to analyse and then improve the data basis on the fate of the deregistered vehicles. Investigations will focus on identifying the possible causes for the "statistical gap" concerning the fate of finally deregistered cars, and data research into the actual fate of such vehicles in a reference year. If necessary, expedient and appropriate measures will be derived from the results of the project, which are anticipated in summer 2016 (Umweltbundesamt, 2013). The results of this study were not available in time for this report.

3.3.3 The Drivers for Exports of ELV

In countries with low average income within some European regions as well as outside the EU there is a market for very cheap cars, often in bad condition or serving as a source of spare parts. An important motive for illegal shipments of end-of-life vehicles is that the owner of an old vehicle can make some profit when selling it to a car dealer who ships it abroad, whereas there is usually no money to be made from disposing of an ELV in the country of de-registration. The drivers of export include:

- Higher costs and taxes for the treatment of ELVs or parts thereof in the country of dispatch (e.g. France exports ELVs to Spain because of lower costs for the disposal of shredder residues);
- A lack of treatment capacity in the country of dispatch (e.g. small countries have not all required treatment facilities so that they export their waste to other countries);
- The installation of specialised treatment facilities is more expensive than exporting the ELVs;
- And when the distances to treatment facilities in a neighbour country are closer than distances to treatment facilities within a country.

Figure 17 shows the destination for used cars during 2008, 30% of which were sent to Africa. Nearly 12% of used cars were exported to Belarus. Three destinations reported are Member States directly bordering Belarus, Poland, Lithuania, Latvia. Approximately 10% went to Russia and 8.5% of the used cars were exported to Kazakhstan. (Schneider et al., 2010)

One of the driving forces for illegal shipment of ELVs is that predominantly in countries with low average income, both in some European regions and outside the EU, there exists a market for very cheap cars, which are mostly in a bad technical condition or that will serve as a source of spare parts. The owner of an old vehicle can earn some profit (usually a few hundred Euros) when selling it to a trader who will ship it abroad, whereas disposing of the ELV in the country of de-registration usually does not bring any income.

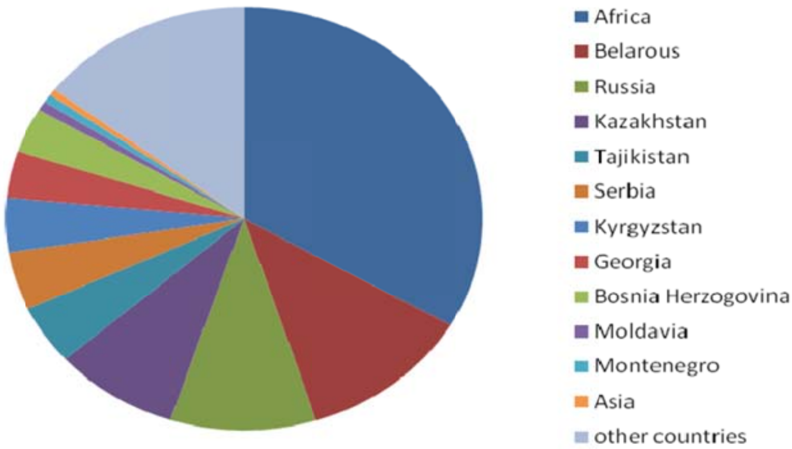

Figure 19. Main Destinations for Used Cars out of the EU-27 in 2008 (Source: COMEXT)

3.3.4 Illegal Recycling

There is evidence suggesting that end-of-life vehicles are treated illegally in some cases. However, the situation seems to be improving., compared to 2005, in recent years the numbers of authorised treatment facilities have increased significantly in some Member States (UK, BE, GR).

Vehicles can be delivered to ATFs from a variety of sources: directly from the vehicle owner or from corporate organisations (e.g. Garda, insurance companies, and local authorities). Vehicle owners may choose not to deposit their vehicle at an ATF because they are not aware of their obligations, or there is more financial gain in selling to unauthorised dismantlers.

Many consultation submissions reported that Cash-for-Scrap schemes for the ELV waste stream negatively impact on directing ELVs to ATFs.

According to the "European second-hand car market analysis" report the majority of the "unknown whereabouts" can be considered as scrapped or hoarded within EU 27 and that only a minority of "unknown whereabouts" are exported as used vehicles or as ELV used for spare parts. (Mehlhart et al., 2011)

Nevertheless, lack of sufficient evidence makes it difficult to confirm which of the complementary flows of ELV is most significant.

Analysis of ELV management and unknown whereabouts of ELV at a country level is shown below. The purpose of this activity is to look for similarities and differences in between countries in terms of how ELV systems are managed and the level of unknown whereabouts of ELV occurring as a result.

3.3.5 Country Studies

Germany

Each year Umweltbundesamt in Germany produces a detailed report on end-of-life vehicle reuse/recycling/recovery rates. The report provides information on vehicle registrations, deregistrations, used car exports, ELVs arising in Germany as well as the statistical gap in ELV vehicles fates, which constitutes the complementary flow for unknown whereabouts.

The following picture represents fates of finally deregistered vehicles in Germany. It compares data from 2013 with the previous year 2012. (Umweltbundesamt, 2013)

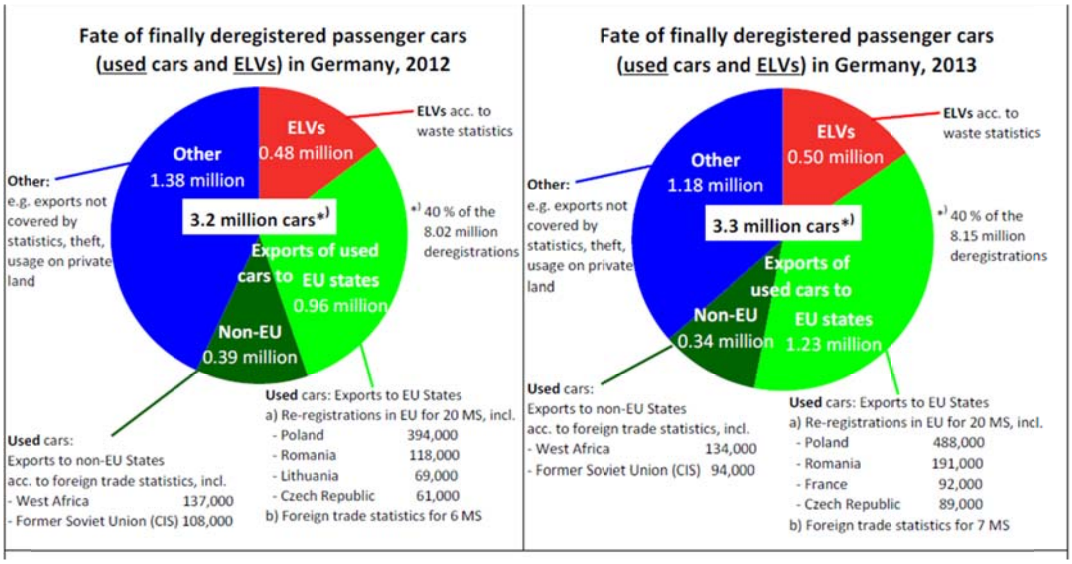

Figure 20. Fate of Finally Deregistered Cars, 2012 and 2013 (Source: (Umweltbundesamt, 2013)

The unknown whereabouts of finally deregistered vehicles, which may consist of non-ELVs and ELVs in Germany, constitute around 40% of all cars finally de-registered. (43% in 2012, or 1.38 million out of 3.2 million). (Umweltbundesamt, 2013) The number has slightly decreased in 2013 where it is observed that final fates of circa 36% of all cars are unknown

The gap, the unknown whereabouts or complementary flows of ELV shown in blue in the chart above can be understood as the difference between: the finally de-registered cars in Germany (de-registered and not registered again in Germany)

- Minus the number of recycled ELVs (0.48 million ELVs, red piece of pie): Data source: data from dismantlers on the number of cars recycled. This is not the same as the number of Certificates of Destruction (CoD), which are reported to the German Federal Motor Transport Authority KBA, because not all CoDs are handed over to the registration offices at the moment of deregistration.
- Minus the number of exported used cars (0.96+0.39= 1.35 million cars, light and dark green pieces of the pie): Data source: statistically recorded exports of used cars to non-EU-countries (foreign trade statistics) and exports of used cars to EU-countries (information on re-registrations in importing countries, under Directive 1999/37/EC).

According to the above estimation and based on a calculation by the Federal Motor Transport Agency about 8 years ago, approximately 40% of all deregistered cars are finally taken out of service (i.e. 3.2 million passenger cars out of 8 million deregistered passenger cars in 2012), where 'finally' means, that these cars were and will not be used any more on German streets. The rest (about 60% out of 8 million) are temporary deregistrations and these cars will be re-registered at some point (e.g. for seasonal reasons or after the car was sold to a new owner).

The complementary flows/unknown whereabouts that are investigated in Germany refer to the total of the chart above (new calculation of the 40%-rate of final de-registrations out of all de-registrations), which might be:

- ELVs recycled in authorised treatment facilities, may be also in unauthorised facilities; and
- Used car exports not recorded exports of used cars, e.g. exports outside of Europe by transit through an EU-MS.

End-of-life vehicles in Germany must be transferred to a dismantling or collection facility for Certificates of Destruction to be issued. Certificates of Destruction must be issued for all end-of-life vehicles.

The fates of finally deregistered vehicles, which are not delivered to official dismantling facilities in Germany, may be varied and would need further investigation. Some ELVs may arrive at the dismantling facility and then sold for further use rather than recycled. Some may be recycled illegally. Others may be exported as used cars or exported to non EU states with no further traceability.

Finland

Finland is very similar to other European countries in terms of the challenges with ELV management. A recent study shows that there is a clear lack of detailed information about the further use of more than 50% of the deregistered cars in Finland, and there is a clear need for improvements in data quality and availability of the national vehicle markets. (Heiskanen, J., 2013)

Also, only a portion of vehicles which are deregistered received a Certificate of Destruction (CoD) in Finland. The number of registered ELVs represents less than 50% of the amount of deregistered cars (Schneider et al., 2010). Thus, there is a clear lack of detailed information about the further use of more than 50% of the deregistered cars, and there is a clear need for improvements to data quality and availability for the national vehicle markets. (Heiskanen, J., 2013)

The number of registered ELVs (issued CoDs) in 2011 was greater than the amount of cars removed (deregistered) from the fleet. This indicates that a large number of cars are in an "ELV stock", that is, deregistered but not yet scrapped. In the long run the amount of cars removed from the fleet and the amount scrapped should be equal. (Heiskanen, J., 2013)

However we haven't found data or literature that provides further analysis of the final destinations of unreported vehicles in Finland.

Ireland

There is also room for improvement in the Irish ELV system. There is leakage at a number of stages in the system, which results in limited ELVs delivered to treatment facilities.

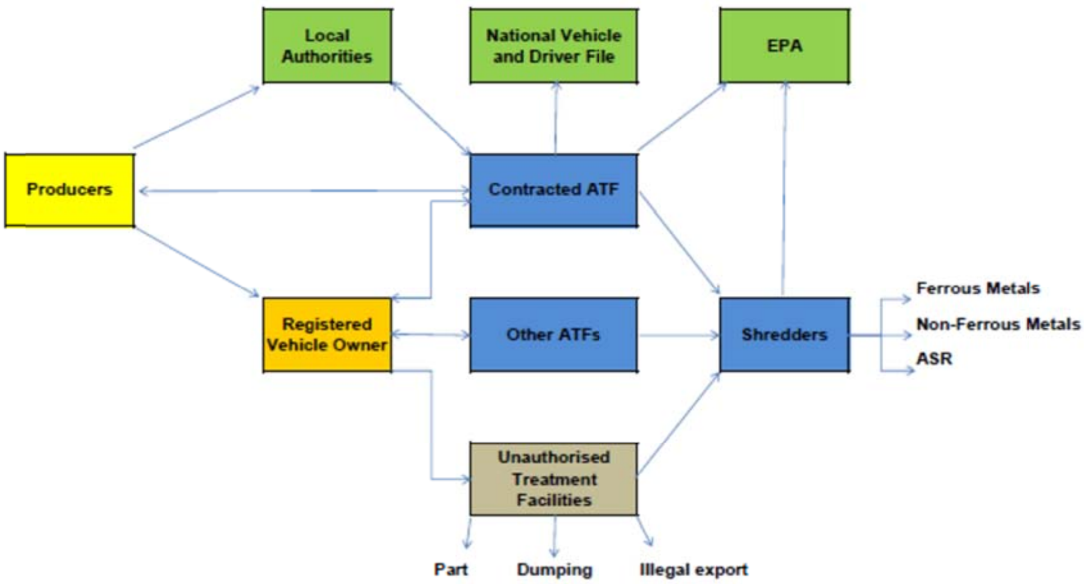

Figure 21. The Overview of Economic Operators in ELV Waste Management Sources (RPS, 2013)

The first observation is the difference between vehicles licensed and ELVs arising. If we assume an average age of 12 years for a vehicle to become an ELV then vehicles sold in 1998 would become ELVs in 2010. It will not match exactly, as not all vehicles become ELVs at the same time), the shortfall between vehicles sold in 1998 (200,083 for vehicles up to 2,033 kgs unladen weight) and ELVs recovered in 2010 (158,237) indicates that some ELVs escape the ELV system set up by the ELV Regulations. (RPS, 2013)

Furthermore in 2010, the Driver and Vehicle Computer Services Division reported that a total of 43,378 certificates of destruction were formally received from authorised treatment facilities; this is an increase of approximately 50% on the number of CoDs issued in 2009. This figure would indicate that approximately 27% of all specified vehicles recovered in 2010 received a formal certificate of destruction, again an increase of approximately 50% on 2009 figures. However, the DTTAS (Department of Transport, Tourism and Sport) indicated that there was no significant increase in CoDs issued in 2011 and the number of CoDs received from January to August 2012 was 28,224. (RPS, 2013) Factors explaining the low numbers of CoDs issued are:

- Treatment facilities continue to receive end of life vehicles but do not issue a certificate of destruction;
- Low level of awareness among the public of the need to acquire a certificate of destruction when disposing of an end-of-life vehicle;
- Difficulty enforcing car owners' obligations. Issues are also emerging with regards to the private sales of vehicles, with vehicles being purchased showing up on the NVDF records as ELVs. It is unclear how vehicles recorded as ELVs can change hands in later private transactions (RPS, 2013);

The leakage from the ELV system can occur at three stages of the ELV waste management chain in Ireland:

- Vehicle owner are not delivering their vehicles to ATFs, therefore un-authorized operators gain access to the vehicle;
- ATFs provide limited treatment, which does not meet minimum standards. ATFs may also accept ELV, but not issue a CoD and then put the vehicle on the market;
- Unpolluted or partially depolluted ELVs may be exported in breach of the ELV and TFS Regulations; and
- Vehicles first licensed in Ireland may subsequently be exported as 2nd hand vehicles. (RPS, 2013)

These leakages are not unique to Ireland but are difficult to quantify. Even the best-performing schemes have difficulty ensuring the responsible management of all ELV (not just those being recycled and recovered through the systems established for the purpose).

As highlighted by Ireland's response to the European Commission Judgement Case, unauthorised ELV dismantling was widespread in Ireland with 329 recorded unpermitted sites in 2008. These unauthorised operators remove valuable components (e.g. battery, parts) of ELVs for re-sale and remaining ELVs may be abandoned or sold in Ireland or abroad.

There are challenges in monitoring exports of ELVs. The level of treatment/depollution and the number of ELVs exported can be very difficult to determine at the point of inspection.

Sweden

Research was carried out in 2016 on behalf of the Swedish government on how end-of life vehicles and vehicle parts are dealt with in Sweden.

In this study the Swedish Environmental Protection Agency concludes that the quality with which end-of-life vehicles are treated in Sweden is variable. Some businesses comply fully with requirements imposed, others not at all. A further problem is the illegal treatment that includes both: illegal dismantling and illegal exports. (Uttjänta bilar och miljön, Redovisning av regeringsuppdrag, 2011)

The level of reporting from vehicle dismantlers to producers is around 50%. This means the information available for calculating recycling targets is also of a poor quality.

Illegal export of scrap cars happen on a large scale. However due to lack of data it is impossible to determine the scale of this activity. Exported cars, parts, waste and products that cars contain (such as refrigerators, televisions, electronics, etc.) are low quality and classified as hazardous waste / waste. (Uttjänta bilar och miljön, Redovisning av regeringsuppdrag, 2011)

The value of these goods is relatively low in Sweden, but command a value in the host country. Export of end of life vehicles (hazardous waste) without having an approved report from the Environmental Protection Agency is illegal. (Uttjänta bilar och miljön, Redovisning av regeringsuppdrag, 2011)

In Sweden a used car is not considered waste. In order to export waste from Sweden a permit from the Environmental Protection Agency and from the recipient country is required. It is prohibited to export hazardous waste (which scrap cars are classified as) to countries not included in the EU or the OECD (Uttjänta bilar och miljön. Redovisning av regeringsuppdrag, 2011)

Cars that end up in the illegal export are often of a certain type and brand – the types that are more sought after, for example, Toyota minivans and similar older model, between 10-20 years old.

The approaches are slightly different, but one way is to receive vehicle is to advertise regularly in the newspapers under the heading "Junk Cars Wanted", "Scrap Cars collected free of charge ", etc. Many car owners are unaware of the requirements that apply to ELV, that only authorized recyclers can recycle these cars, a certificate of destruction must be issued and that the care needs to be deregistered. Numerous cases of illegal export of cars were revealed in recent years in Sweden.

3.3.6 Vehicles Exports

Irish vehicles used abroad that reach ELV status may also be scrapped in other EU Member States e.g. Northern Ireland. In this case, the DTTAS generally receive notifications of these ELVs from other EU Member States but not when shipped outside the EU, which happens quite regularly.

ELVs which have been depolluted can be exported as Green List Waste under the Waste Management (Shipments of Waste) Regulations 2007. 22,060 tonnes of ELVs, containing neither liquids nor other hazardous components were exported in 2010. Vehicle wrecks that are not depolluted are not allowed for export.

Second hand vehicles are only allowed for export if there is a certificate from a motor assessor or authorised vehicle mechanic.

Nevertheless in practice it is difficult to differentiate between ELVs and used second hand vehicles that are in need of repair which leaves and opportunity for illegal exporters.

4 Results

4.1 Results for Complementary Flows of WEEE

4.1.1 Result for WEEE Total Amounts

Combining all of the data from Chapter 3 for all countries gives the following aggregated result for the EU-28+2, shown per collection category in Table 20.

Table 20. Summary of EU WEEE Flows and Destinations, 2012

Year: 2012, values in kt	Placed on Market	WEEE Generated	Reported collection	Waste Bin	WEEE in metal scrap	Compl. Recycling products	Scavenged components	Export (for reuse)	GAP
Temp. Exchange Eq.	2,122	1,436	580	-	101	28	76	26	626
Screens	970	1,347	663	26	32	14	-	87	526
Lamps	126	118	14	5	-	3	-	-	96
Large Equipment	2,949	2,876	1,040	21	655	59	-	16	1,084
Small Equipment	3,368	2,573	777	435	452	30	-	20	859
Small IT	728	757	374	117	87	7	-	52	120
Total	**10,263**	**9,107**	**3,448**	**604**	**1,326**	**141**	**76**	**201**	**3,312**

The values in the table are in some instances lower than those reported in the CWIT report due to a more conservative approach having been taken. 2012 is chosen as a reference year as it has the highest number of data points available.

Of the total determined WEEE Generation of over 9.1 Mt, around 3.7 Mt is documented as reported to the respective Ministries of Environment. Over 0.6 Mt is documented to be disposed of in the waste bin and destined for incineration and/or landfill. A significant volume of close to 1.4 Mt is WEEE likely being mixed with ferrous metal scrap, which also undergoes shredding and further treatment, but possibly at a sub-standard level. This is a conservative figure and actual values could be higher. The documented exports are identified as 0.2 Mt based on data from only 5 countries (Germany, United Kingdom, Netherlands, Austria and Belgium). Smaller amounts are identified as complementary recycling of products like professional appliances of around 140 kt and the analysis for the scavenging of compressors from fridges resulted in an estimated amount of at least 76 kt.

The two largest complementary flows that could actually be documented are the 600 kt of mainly small appliances that end up in the waste bin, with varying amounts per country of between 0.5 and 1.9 kg per inhabitant per year. The literature review covered 15 countries that were grouped into low, middle and high-income countries and the data was then extrapolated to EU28+2 totals. It also revealed that data is presented in different formats covering different years. For wealthier or larger economies, there is more data available in the literature indicating kg of WEEE per inhabitant per year. The average amounts are relatively consistent values, the allocation of these to the individual collection categories is more uncertain due to less data sources available with a detailed frequency count of appliances and scoping issues related to defining specific equipment types.

The second flow is the 20 to 40% of WEEE which is collected with mixed metal scrap, being at least 1,400 kt. This significant amount mainly comes from steel dominated appliances mixed with other ferrous metal scrap. This seems to be non-compliant with the WEEE Directive's wording on separate collection, as it should have been separately collected and reported. The uncertainty, especially on an individual country level, is high and these volumes can easily be twice as much for some countries. From the identified volumes, around 5% of WEEE is exported from EU-28 mixed with ferrous metal scrap. However, when shipped, these shipments are probably compliant with the Waste Shipment Regulation (EU Law and Regulations, 2006).

The final gap analysis is visualised in Figure 22 for all evaluated countries.

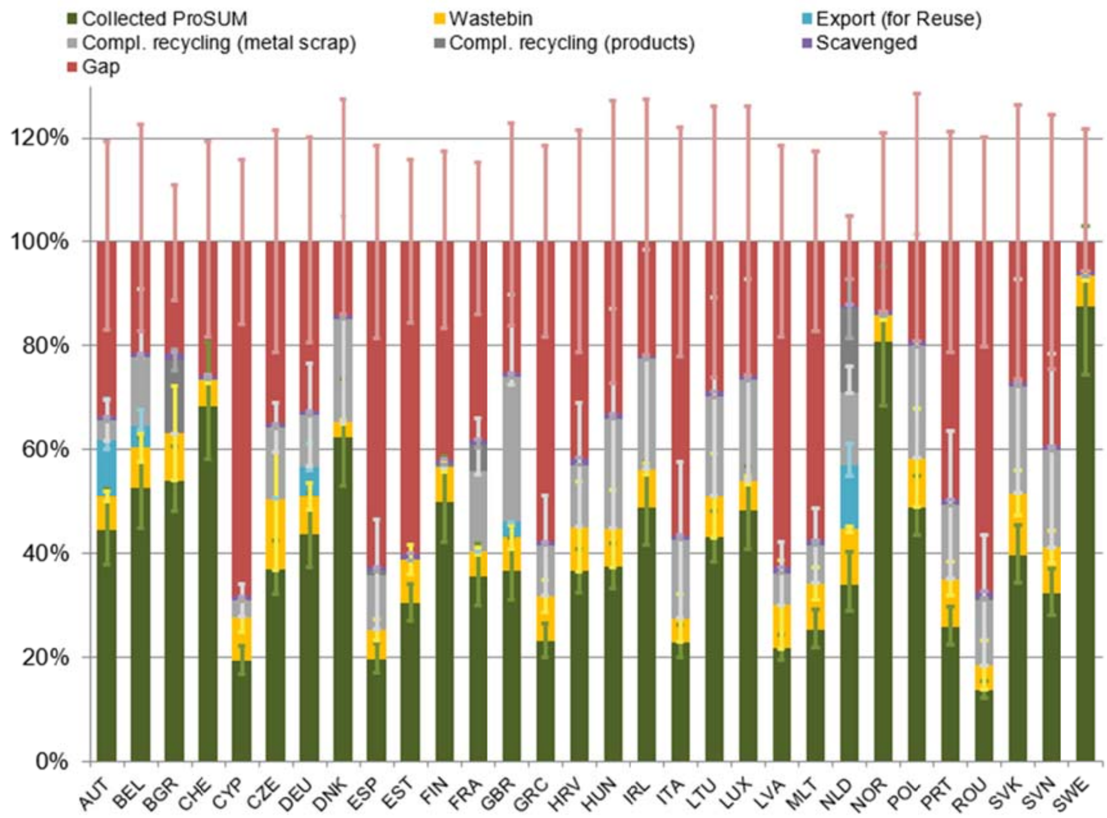

Figure 22. Collection of WEEE Compared to WEEE Generated in 2010 for All Categories

The following conclusions are made:

- Sweden and Norway, followed by Denmark and Switzerland, have the highest reported collection. For these countries, the gap is small when including the amount of e-waste in the waste bin plus estimated other recycling. Maybe small leakages are present, but much lower compared to most other countries.
- Belgium, Bulgaria, Ireland also show high reported collection levels. In Bulgaria reporting is mainly performed by the recycling industry and in contrast with the other EU member states, probably includes WEEE mixed in metal scrap, which is set at zero here.
- A number of countries, including most of the large economies are around 30-45% of collection: Austria, Czech Republic, Germany, Finland, France, United Kingdom, Hungary, Lithuania, the Netherlands and Slovakia.
- The largest gaps are found for Italy, Cyprus, Spain, Latvia, Romania and Croatia. Nevertheless, in these countries, the reported volumes are around 25% or less of the total amount of WEEE generated.

4.1.2 Temperature Exchange Equipment

The overview of the flows of the official reported data is shown in Figure 23 for every country for Temperature exchange equipment appliances.

It was found that the highest collection takes place in the Scandinavian countries (Norway, Sweden, Denmark, excl. Finland). In Sweden, the amount of temperature exchange equipment in other recycling streams is probably over-estimated, as the collected amounts exceed the 100% relative to WEEE generated. The export for reuse could only be estimated for five countries for temperature exchange equipment. In those four countries, it is 5 to 15% of the WEEE generated. The highest amount is found for the Netherlands. The export for reuse probably also takes place in other countries. However, we did not have sufficient data for robust extrapolation methods to estimate these amounts.

The largest gap is found again in the countries at the southern and eastern border of the EU. Here, the potential for illegal (or legal untraced) exports are largest. This does not mean that no additional (illegal) exports take place from other regions, where also substantial gaps exist.

The low collection amount, well below 25% in Spain and Romania are especially a concern. The available WEEE in ferrous metal scrap data also doesn't seem to contain the missing volumes here. The missing volumes are not very likely to be all exported. There seems to be much more treatment and scavenging taking place, but being severely under-reported and not monitored on a national level.

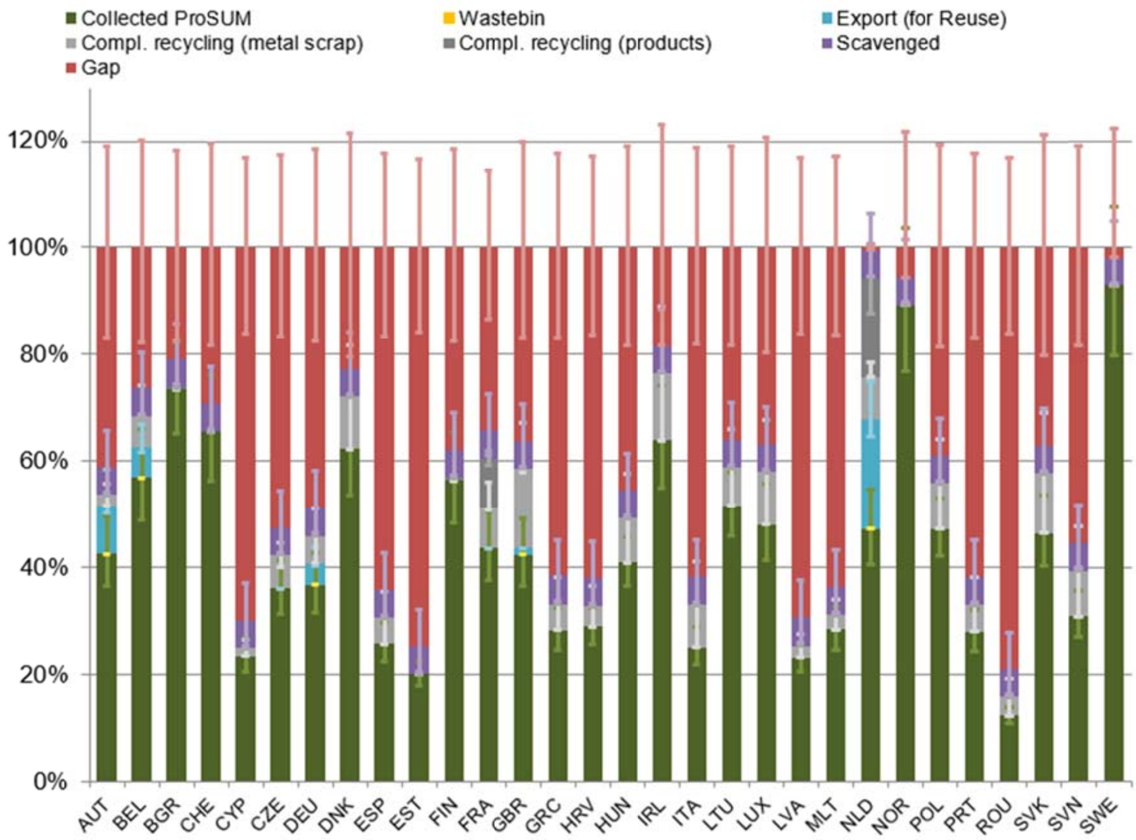

Figure 23. Collection of WEEE Compared to WEEE Generated for Temperature Exchange Equipment

4.1.3 Screens

The overview of the flows for screens is shown in Figure 24. Again, the highest collection takes place in Scandinavia, Germany and Czech Republic. Here the potential for exports (illegal and legal) seems small. For Sweden, the data exceeds the 100% relative to WEEE generated. Here, probably the WEEE generated amount could be calculated as too low, which may be caused by the so-called IKEA effect. There can be a more rapid replacement of old CRT screens due to homes more frequently being redecorated compared to other higher income countries.

The documented export (for reuse) could only be determined for five countries. Recently, these exports are mainly comprised of LCD monitors and televisions, since many receiving countries are less and less interested in CRTs. The export for reuse probably also takes place in other countries, however, we did not have robust data sources to estimate those amounts. The largest gap is found for countries at the Southern and Eastern border of the EU. Here, the potential for illegal (or legal untraced) exports are largest, seemingly due to less saturated market nearby. This may also explain for instance why Finland for this and some of the other categories deviates from the rest of Scandinavia.

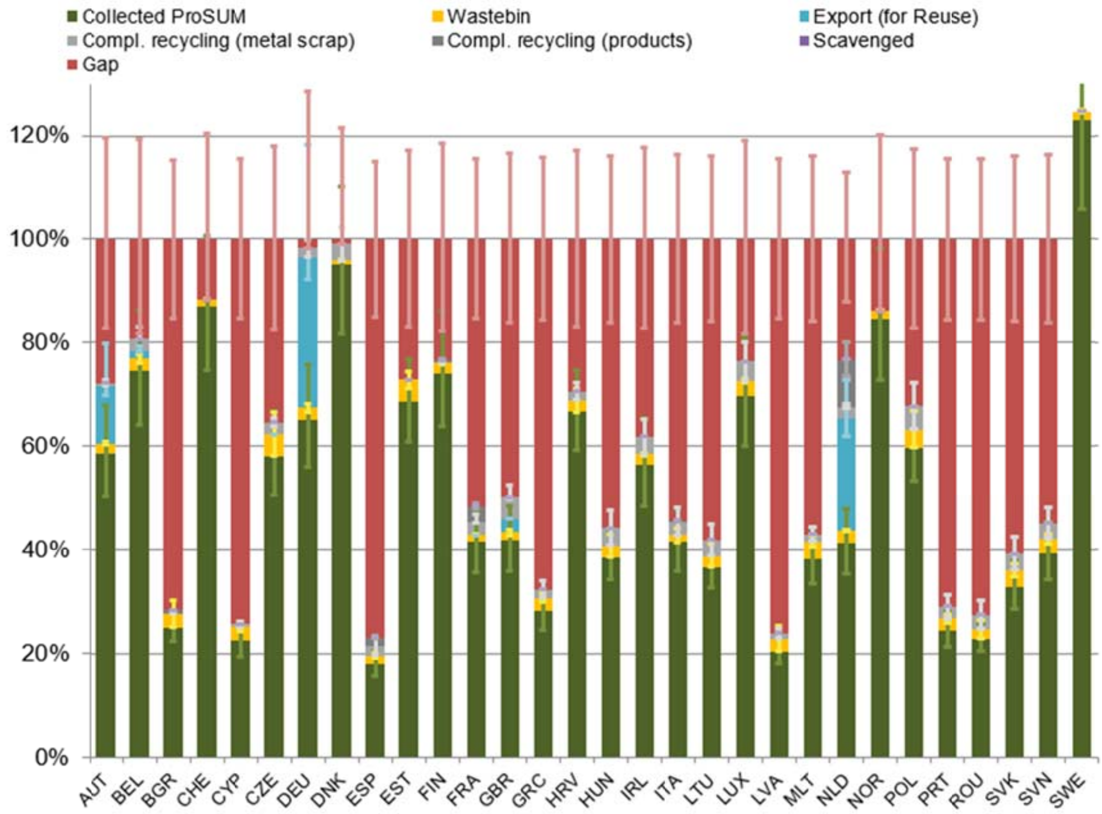

Figure 24. Collection of WEEE Compared to WEEE Generated for Screens

4.1.4 Lamps

The overview of the flows for lamps is shown in Figure 25. It is found that a significant portion of the lamps are discarded in the waste bin in the EU. This represents bad consumer behaviour and potentially leads to mercury emissions. This can be emission to the air, if the residual waste is incinerated or emissions to soil in case it is land filled. Many countries show a collection level of around 20-40%, which is also in line with similar waste types like those for BATT across Europe. In some cases, lamps from business to business sources often do not end up in national collection totals.

The analysis updated here for lamps is more coherent compared to the CWIT report. The main reason is the exclusion assigning small lamps amount to be found in mixed metal scrap (connected to luminaires). At the same time, the estimated WEEE Generated amounts may include some metal parts and luminaires, reducing the collection percentage easily. Due to their very small weight per piece, the analysis of this collection category is easily distorted by much heavier lighting products.

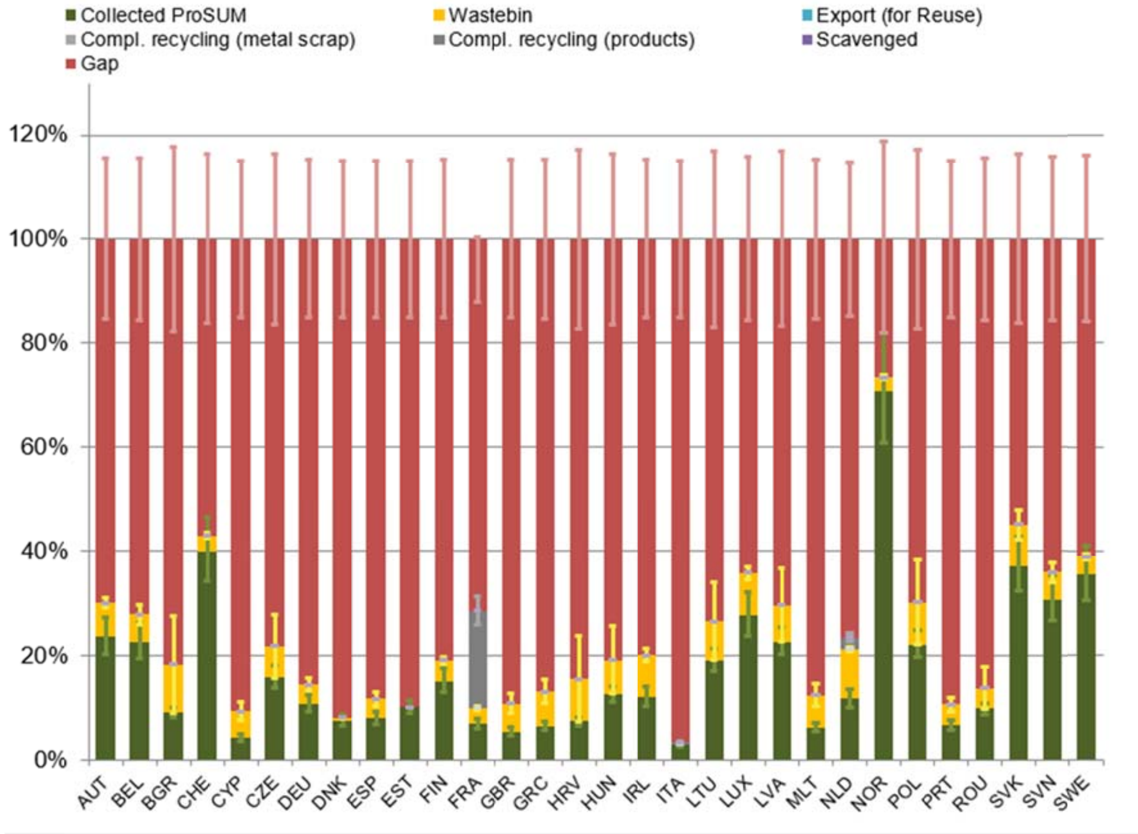

Figure 25. Collection of WEEE Compared to WEEE Generated for Lamps

4.1.5 Large Household

The overview of the flows for large equipment is shown in Figure 26. It was found that the highest reported collection takes place in Scandinavia plus Bulgaria. In the case of the latter, the amount of WEEE mixed with ferrous metal scrap is excluded to avoid double counting, as the recyclers are doing the actual collection and likely could include WEEE in this stream to the total volumes reported to the Ministry of Environment.

A fixed presence of 2% on a weight basis of WEEE in metal scrap was used to estimate these amounts. For most other countries with significant ferrous scrap metal volumes declared in the Waste Statistics Regulation, the amount of large equipment that is estimated to be recycled with metal scrap is consequently also significant. The quantity shown should be seen as a rough order to magnitude due to these assumptions. The result shows that the resulting undocumented gap has become relatively small for these large appliances in these countries.

These findings correspond also with the expectation that export for reuse is relatively minor in these cases, since the logistic costs versus reuse value do not provide much stimulus to ship these appliances towards Africa for example.

The largest gap was found for the Southern EU countries. Here, the same trend of under-reporting of both recycled volume and ferrous metal scrap lead to a more substantial gap compared to Northwest EU countries. For the United Kingdom, for which specific data was available, the mixed collection (with non-obligated WEEE) may explain the relatively high share of large equipment with ferrous metal scrap, compared to the volumes reported to the Environment Agency.

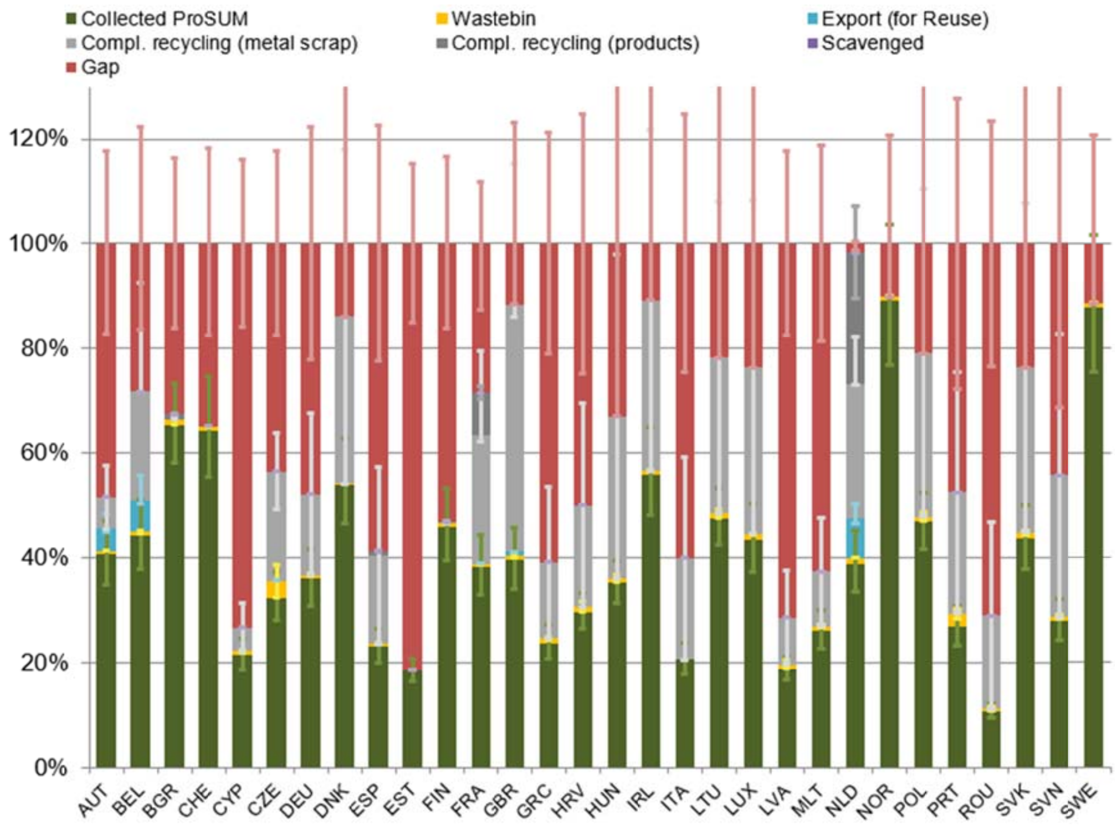

Figure 26. Collection of WEEE Compared to WEEE Generated for Large Equipment

4.1.6 Small Household

The overview of the flows for small equipment, excluding small IT items, is shown in Figure 27. Here the gap is relatively large especially substantial for Southern EU again. Interestingly, the highest combined total for reported collection plus waste bin is found in Eastern Europe. Possibly the smaller appliances in Northwest EU are more interesting to be traded eastwards. Alternatively, a reason can be that the data for these appliances discarded in the waste bin in the lower income countries is less reliable. Although this information is merely extrapolated from other countries, the factual information provided by official reports from the countries is less comprehensive. Again, it is observed that the largest gap appears for countries more closely neighbouring countries with less saturated markets, suggesting significant trade potential in these cases, which makes sense from a reuse value versus logistics costs perspective as well.

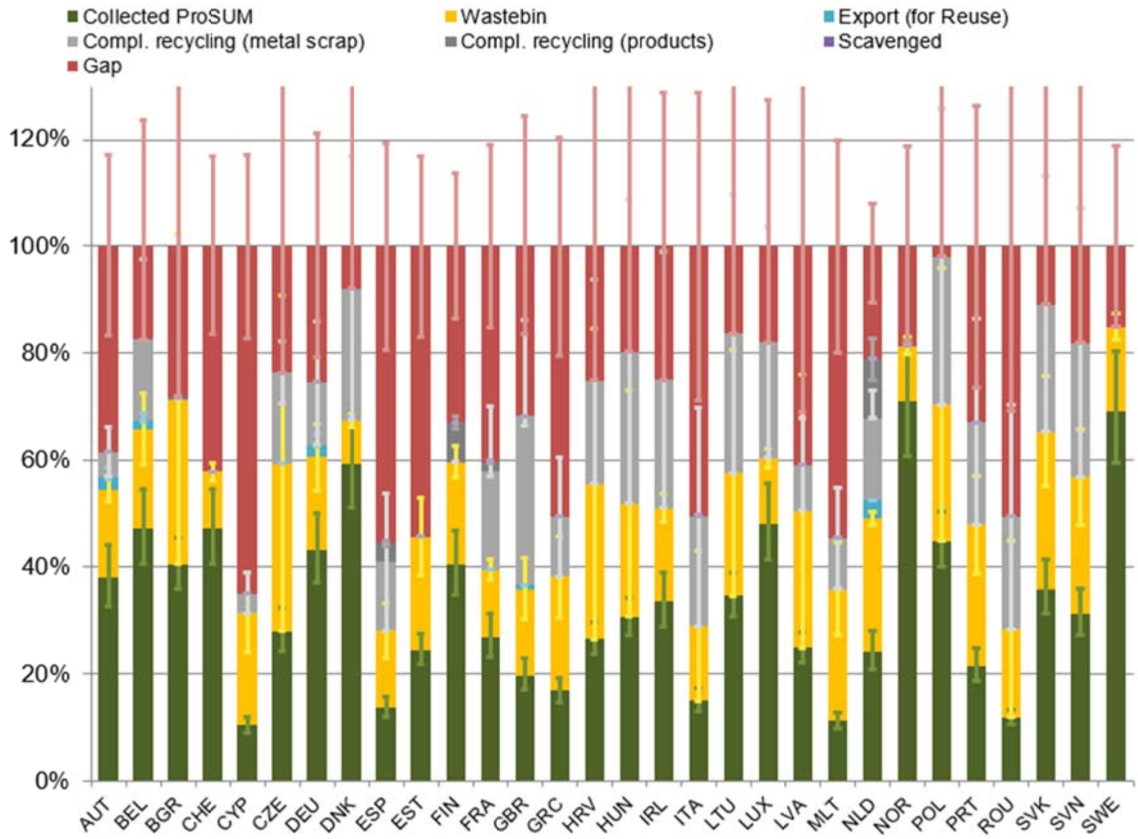

Figure 27. Collection of WEEE Compared to WEEE Generated for Small Equipment

4.1.7 Small IT

The overview of the flows for small IT equipment is shown in Figure 28. For most countries, the gap is similarly large compared to small equipment. Noticeably this is the most valuable WEEE stream per ton and the most susceptible to trading and export. This is also confirmed by the documented export volumes for the five countries that have data available in these flows and in particular for Austria and the Netherlands, Eurostat (2013), Huisman, J. (2012).

The official collection amount for Switzerland exceeds 100% of WEEE Generated. The reasons are not completely understood, except that both countries have a well-established collection system for these appliances. Alternatively, too low an estimate of the (past) EEE input to the common methodology report could also explain this. Since both Switzerland and Norway are not EU members, the common methodology is lacking domestic production (from Prodcom) data and alternative data sources are not compatible with the UNU keys.

All above graphs are also presented in Annex 2 for the years 2010, 2011, 2013 and 2014.
The visualisation developed also makes it possible to see the time series per country and collection category individually. Here, also all charts can be produced with and without coherent estimates. This enables showing all original sources and displays the general lack of data on these unreported complementary flows.

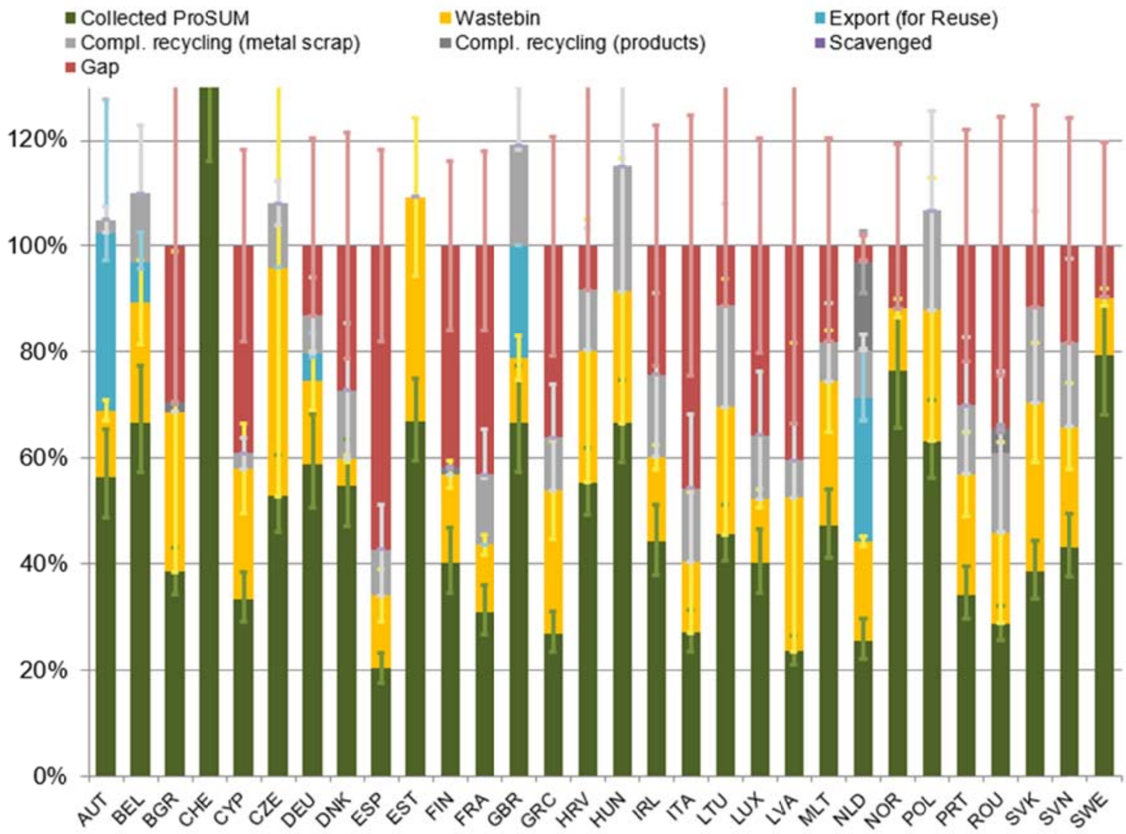

Figure 28. Collection of WEEE Compared to WEEE Generated for Small IT Equipment

For most countries, the gap is similarly large compared to small equipment. Noticeably this is the most valuable WEEE stream per ton and the most susceptible to trading and export. This is also confirmed by the documented export volumes for the five countries that have data available in these flows and in particular for Austria and the Netherlands. (Eurostat, 2013) (Huisman, J., 2012)

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4.2 Results for Complementary Flows on BATT

Based on the literature review, interviews with stakeholder and the review and analysis of the data identified, the following complementary, unreported flows of BATT are distinguishable:

Portable BATT

- BATT disposed into municipal solid waste flows destined for incineration and landfill both on its own and in WEEE;
- BATT embedded in and recycled with WEEE;
- BATT legally and illegally exported with EEE and WEEE; and
- Hoarded.

Industrial BATT

- Industrial BATT mixed with portable BATT reporting due to challenges in distinguishing between industrial and portable battery at a collection stage;
- BATT legally and illegally exported outside Europe for use or reuse (possibly with industrial equipment i.e. UPS); and
- BATT legally and illegally exported for recycling.

Automotive BATT

- BATT legally and illegally exported outside Europe for use or reuse within a vehicle; and
- BATT legally and illegally exported for recycling.

(Perchards, 2015)

Portable BATT which have Reached the End of Their Life

Eurostat provides data on primary cells and BATT which have been sold, imported and exported in any given year. This is presented in terms of the number of BATT and their weight. However, these two sets of information are only available through separate searches. Furthermore, although the weight of imports and exports is recorded, the weight of production is not. It is therefore necessary to use the weight/number of BATT imported and exported to estimate the weight of BATT produced in the EU28, and therefore the weight of BATT sold in the EU28.

Deliverable 3.1 identifies that the average life of a portable battery is approximately 6 years. Data on stocks of BATT has been 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 were made available for ProSUM after signature of a non-disclosure agreement. Like for the data on BATT placed on the market, agreements will be found and signed to enable the use of aggregated data for ProSUM. The amount of BATT discarded in 2012 should therefore be similar to the BATT consumed in the EU28 in 2006.

Table 21 shows the estimate of primary cells and primary BATT sold in the EU 28 from 2006-2012. Given the annual change in balance of imports, exports and sold production, the ratio of the high to low estimate varies over time.

Table 21. Estimate of Weight of BATT Sold in the EU 28 2006-2012 (Source: Eurostat)

Year	Low estimate (tonnes)	High estimate (tonnes)
2006	213,433	217,473
2007	235,078	249,488
2008	245,200	383,914
2009	186,014	360,457
2010	189,055	300,169

2011	176,038	232,357
2012	177,466	215,589

Assuming that the weight of BATT purchased in 2006 is equal to the weight of BATT discarded in 2012, this suggests that 213-217,000 tonnes of portable BATT were discarded. As can be seen in Table 21, any variation in lifetime could lead to significant variation in the quantity of portable BATT discarded. In addition to this, the life duration of primary portable BATT is much shorter than that of rechargeable BATT. Therefore, if the ratio of primary and rechargeable BATT changes the average lifetime of a battery will also change. These figures should therefore be viewed with caution and seen as a snapshot rather than a stable figure. The stocks and flows of BATT are explored further in ProSUM Deliverable 3.3.

BATT Recycled from Households, in Ferrous Scrap and Residual Waste

The Eurostat data on BATT collected for waste management does not differentiate further than 'BATT'. All chemistries and applications are treated as a single unit of analysis. This means that although BATT discarded by sector are available, it is not possible to differentiate between automotive, industrial and portable BATT.

Eurostat identifies that 90,000 tonnes of BATT were collected from households for recycling in the EU 28 in 2012. Assuming that these were all primary BATT, and that households are the main customers for primary BATT, this suggests a complementary flow of 123-127,000 tonnes of portable BATT discarded by households with other waste (e.g. mixed waste, metal recycling)

Eurostat identifies 74.4 Mt of ferrous scrap arising in 2012. Deliverable 4.1 suggests that, based on data for Belgium, the Netherlands, Belgium, France and the United Kingdom, WEEE in ferrous scrap comprises 62% large items, 20% small items, 8% temperature exchange equipment, 6% small IT and 3% screens. Of these, only small items and small IT are likely to contain BATT. D4.1 suggests that small IT may contain 10-22% BATT, and small (consumer) items may contain 5-10% BATT. This therefore suggests that 1.6-3.3% of the weight of WEEE discarded with ferrous scrap is BATT.

Given that Deliverable 4.1 also estimates that WEEE comprises 2% of the weight of ferrous scrap, although the proportion of BATT is low, the tonnage is still appreciable. Using the percentages above suggests 23,491 to 48,744 tonnes of BATT in WEEE products will be discarded as ferrous scrap. The flow of separated BATT within ferrous scrap can be assumed to be negligible, as this would require citizens to deliberately discard of BATT with ferrous scrap. It is therefore possible that the entire complementary flow of separate portable BATT is discarded as residual waste.

BATT in Products which have Reached the End of Life

Eurostat provides data on separately collected WEEE by category for 2012, and ProSUM Deliverable 4.1 suggests the proportion of the product weight within each category which comprises BATT. Assuming that products are discarded by their last owner containing BATT, this suggests that separately collected WEEE contains 91-206,000 tonnes of BATT.

ProSUM Deliverable 3.1 also identifies the median age of products at the point of disposal. This can be used in combination with data for products placed on the market to infer the quantity of electrical products which reach the end of their life in 2012. This is presented in Table 22, and suggests 3.1 Mt of electrical items containing 105,000-298,000 tonnes of BATT are exported or discarded with residual waste or ferrous scrap in 2012.

As identified in the analysis of WEEE Huisman et al (2015) estimates that the amount of WEEE exported outside of the EU is 1.5 Mt. WEEE exports (devices generally including BATT) occur both legally, via Approved Exporters for recycling and reuse, and illegally (hazardous waste disguised as re-usable equipment, e.g. to West Africa). The 1.5 Mt includes 200 kt of documented export of used equipment. The remaining 1.3 Mt includes 900 kt of undocumented, used but functioning used equipment and 400 kt of WEEE. The proportion of this which constitutes a complementary flow of BATT can be identified using Deliverable 4.1.

Huisman et al (2015) does not estimate the amount of BATT embedded or otherwise in the WEEE and UEEE that is exported. For the purposes of ProSUM task it is assumed that the composition of electrical products exported is similar to the composition of electronic products discarded (i.e. that 1.6 -3.3% by weight is BATT. This suggests that exports of UEEE and WEEE contain 45,000-102,000 tonnes of BATT.

For IT and communications equipment, data on waste is not disaggregated to the level of UNU codes. The tonnages shown in Table 22 are for all IT and communication equipment. The lifetimes for specific products (UNU codes 0305 and 0306) are applied to the POM arising in the year 2012 minus median age, alongside an average tonnage for all IT and communication equipment over the period 2006-2013. It can be seen that the total inferred waste using the average weight is approximately equal to the average of the tonnes using product specific lifetimes (1.28 Mt compared to 1.36 Mt). This is considered to be sufficiently similar to suggest that the average inferred waste is representative of IT and communications equipment.

Table 22. Inferred Quantities of WEEE and Associated BATT in Residual Waste Stream

UNU Code	Product Category	Proportion of BATT by weight (low)	Proportion of BATT by weight (high)	Median Life (years)	Total inferred products at end of life 2012	Reported separate collection	Inferred difference	Low estimate BATT	High estimate BATT
0302	IT and telecommunications equipment	10%	22%	8.40					
0303	IT and telecommunications equipment	10%	22%	7.30	1,360,587	582,310	778,277	77,828	171,221
0305	IT and telecommunications equipment	10%	22%	5.80	1,013,244	582,310	430,934	43,093	94,805
0306	IT and telecommunications equipment	10%	22%	4.40	1,565,348	582,310	983,038	98,304	216,268
0601	Electrical and electronic tools	2%	18%	12.20	522,323	75,992	446,331	8,927	80,340
0401	Consumer equipment	5%	10%	7.50	897,524	626,217	271,307	13,565	27,131
0701	Toys, leisure and sports equipment	2%	9%	3.50	224,277	14,799	209,478	4,190	18,853
	Total BATT in discarded items not separately collected				3,004,711	1,299,318	1,705,393	104,509	297,544
	*Of which exported as used EEE**						*1,100,000*	*33,279*	*74,945*
	Of which, in ferrous scrap						*381,732*	*23,491*	*48,744*
	Of which net residual							*47,739*	*173,855*
	BATT in separately collected WEEE*					3,474,182		99,017	223,107
	*Of which exported as WEEE**					*400,000*		*12,101*	*27,253*
	Total BATT in discarded items							203,526	520,651

*this tonnage and associated battery quantities relate to total WEEE.

For product groups where the UNU code is in italics, the data in Eurostat for the relevant year is either not available or appears anomalous in the context of surrounding figures. For these product groups, an average weight of products placed on the market per year from 2006-2013 has been used.

4.2.1 BATT in Municipal Waste

Data reporting requirements for Eurostat do not require a breakdown of the composition of mixed waste streams. A review was therefore undertaken to identify municipal waste composition studies which could provide estimates for BATT within mixed waste.

Table 23 shows data estimates identified through this review. Although few countries are covered, the data appears to support the view that countries with high battery collection rates have lower levels of BATT in the residual waste stream.

Table 23. Percentage of BATT in the Household Residual Waste Stream

Country / Geography	BATT as a % of household residual	Source
England	0.11%	Defra (2012)
Flanders	0.05%	VVSG (2013)
Flanders	0.02%	OVAM (2015)
Belgium	0.024%	Bebat and Mobius (2012)
Spain	0.01%	Chemical Engineering Department, University of Salamanca (2011)

The latest estimates of household waste arisings in England comes from Defra's 2011/12 survey. It estimated that there were approximately 0.13% of BATT in kerbside collected residual waste. The analysis was based on the results of 106 collated kerbside sampling studies from 2008 to 2012. The report does not detail how battery estimates were compiled within the studies included. It is therefore not clear whether or not BATT in WEEE are included.

The data from Flanders is the result of sorting analysis carried out at different periods of the year, since 2011 on samples of residual waste. Each year has shown a consistent proportion of BATT in the residual municipal waste stream. It estimates that 0.05% of residual waste is BATT.

Other sampling analysis in Flanders is carried out by OVAM, the Flemish waste management administration. Its last survey was conducted on four occasions between autumn 2013 and summer 2014. A total of 442 tonnes of wet residual waste recovered from the survey, from across Flanders was sorted in the regions only MBT plant. It recovered a total of 71.2 kg of BATT, equating to 0.02% BATT as a percentage of residual waste.

Perhaps the most detailed study was conducted on behalf of Bebat and Recupel in 2011. It collected bags of residual waste from across Belgium (excl. Brussels) and involved sorting 44.7 tonnes of waste by hand. BATT present in WEEE were also included in the analysis. In total the report estimated that 0.024% of BATT are present in residual waste. (RDC Environmental, 2011)

Eurostat data on the weight of separately collected BATT found in the municipal waste stream in EU-28 total just over 90,000 tonnes in 2012. However, there are significant concerns regarding the accuracy of this data. A cursory look at the time series of battery data by country shows sharp jumps between years with some often recording zero BATT arising.

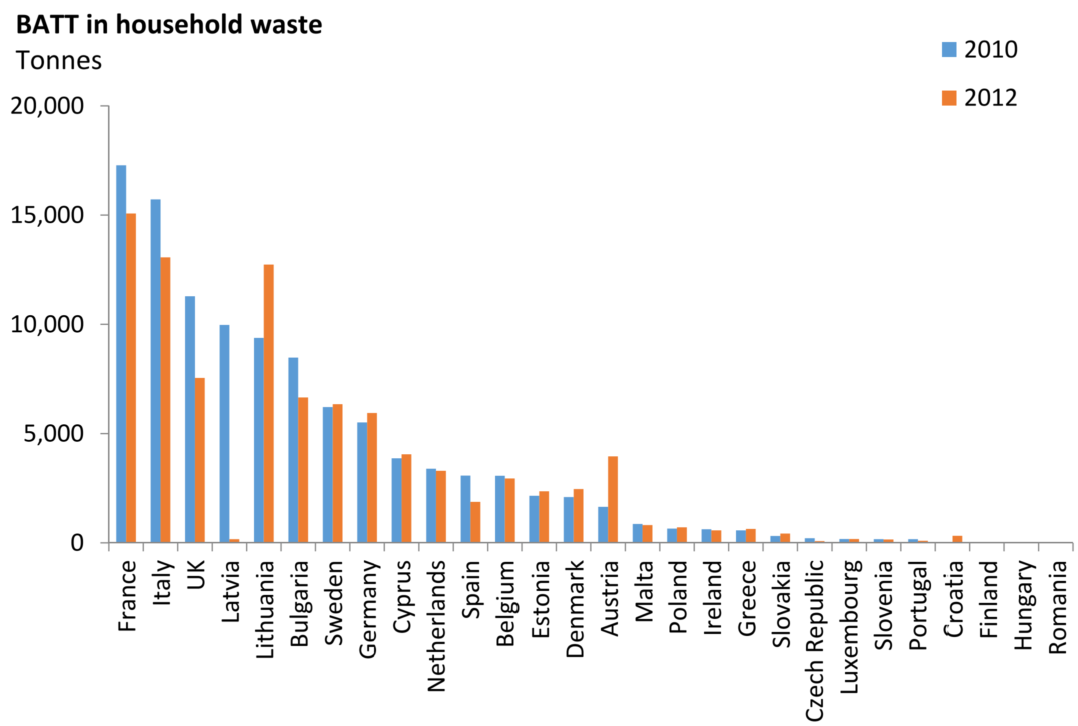

Figure 29. BATT Found in Municipal Waste Stream for EU-28 (Source: Eurostat)

Eurostat data suggests that municipal waste generated in the EU-28 is estimated at 213.4 Mt in 2012. Based on the range using national compositional estimates of WEEE in batteries presented in table 24, BATT could account for 2,000 to 230,000 tonnes. The reason for this wide range is explained in section 4.2.3. This is wider than the range estimated via the gap analysis, and contains both the upper and lower estimate from the gap analysis.

Without more extensive sampling of BATT in the household waste stream and on a consistent basis across the EU it would be erroneous to place too much weight on the results of sampling. Given Belgium's extensive battery collection network this estimate should be seen as a maximum rather than a central estimate.

Household and municipal waste composition analysis involves a high margin of error. As small and infrequent waste items, BATT may be detected in small scale, irregular sampling, and perhaps in one region or from one plant. Furthermore, the studies identified represent a small proportion of EU member states who may not be representative of the EU-28, either in terms of the number of waste BATT or their disposal routes.

As with other areas of this research the difference in collection system performance will have an impact on the percentage of BATT in the residual. High collection rates should, everything else being equal, mean that there is low levels of BATT in the residual waste stream.

It’s noted that the maturity of the BATT collection schemes in Europe is very dependent on the date it has been implemented: some countries where the collection schemes are recent have much larger unidentified flows than countries where the collection schemes have more than 10 years of experience and better efficiency.

4.2.2 BATT in Ferrous Scrap

No separate data beyond ProSUM Deliverables 3.1 and 4.1 has been identified against which estimates of BATT in ferrous scrap may be made.

4.2.3 Analysis of BATT Recycled with WEEE

The WEEE Directive recast (Article 8(2) and Annex VII) requires that as a minimum, BATT have to be removed from any separately collected WEEE, and that this has to be done in such a way "that environmentally-sound preparation for reuse and recycling of components or whole appliances is not hindered". A condition of approval of AATFs is that they should remove all the BATT during treatment unless the whole item goes for reuse.

WRAP (2015) attempted to obtain data on BATT that are not recovered at WEEE AATFs in the UK. It has only been possible, however, to obtain anecdotal evidence, rather than firm data on the practice of shredding of BATT. Since this may be deemed illegal, unless the recycler reports about the recycling efficiency according the Battery Directive, industry experts from the sector were understandably reluctant to share any data. Further data collection and analysis would be required to determine the full scale of BATT lost through this route.

WRAP (2015) suggests that BATT are not always removed from WEEE prior to recycling. It appears that some practices either do not comply with the WEEE Directive requirements or at least potentially create a hazard and limit the number of complete BATT that can be effectively reprocessed for material recovery. There is no firm data around the quantities involved. Representatives from the IT asset management industry have noted that this remains a big issue, observing first-hand WEEE operators shredding batches of smartphones as standard practice.

Battery re-processors have noted that some AATFs will manually remove the BATT and send them on to battery recycler or similar for reprocessing. This results in a good low-contamination stream of recognisable BATT.

Meanwhile, some recyclers do test BATT taken from WEEE prior to shredding and sell these on as re-usable BATT if suitable. Other AATFs shred/smash the WEEE and then handpick any 'battery-looking' items from the resulting material. This results in a stream consisting of BATT, capacitors and other components. The BATT may have had their labels removed, which makes them hard to sort, and some may have been cracked open, which is a significant hazard/fire risk. Anecdotal feedback from this sector indicates several fires at WEEE processing sites.

It is also worth noting that WRAP (2015) found that AATFs in the UK only record weights of BATT sent on for reprocessing, not the number of battery units. Some AATFs separate by battery chemistry type but not by equipment type or by B2C versus B2B and hence the level of data breakdown required for this BATT flows project was not available.

Table 24 shows estimates of the percentage of BATT present in WEEE from a number of European countries, and applies these to the data from Eurostat for separately collected WEEE. The same caveats apply to WEEE, as with household waste when considering this evidence. As with analyses of BATT in residual waste, battery composition in WEEE analysis involves a high margin of error. Battery composition studies tend to be based on small scale, irregular sampling, even perhaps taken from just one region or plant.

Table 24. Percentage of BATT in WEEE

Country	BATT as a % of WEEE	Source	Separately collected WEEE (tonnes EU 28 2012) (Eurostat)	Inferred EU-28 battery content using national estimates (tonnes)
Sweden	2.1%	Avfall Sverige (pers comm)	3,019,731	63,414
Germany	1.3% *	GRS Batterien (pers comm)		39,257
Romania	0.6%	ECOTIC (Pers comm)		18,118

Estonia	0.5% *	EEE Ringlus (pers comm)		15,099
Ireland	0.41%	WEEE Ireland (pers comm)		12,381
England and Wales	0.06%	Environment Agency (2016)		1,812
Average	0.8%			25,013
Prosum D4.1	3%-7%			91,358-205,740

*WEEE categories 2 and 3 only

It is clear that the different national estimates lead to markedly different estimates for the weight of BATT in WEEE. However, all are notably below the estimate based on ProSUM Deliverable 4.1.

One possible explanation for this is if there has been an increase in the proportion of WEEE containing BATT over time. Eurostat provides data on WEEE arisings for all EU-27 member states from 2007 onwards, and the EU-28 from 2011. The proportion of WEEE which constitutes small household appliances, IT and telecommunications equipment, consumer equipment and electrical and electronic tools is shown in Table 25. This suggests that there has not been a significant change in the proportion of WEEE containing BATT between the years in which the national compositional studies and the ProSUM review were undertaken.

Table 25. Estimate of WEEE Containing BATT

Year	WEEE (EU 28)	WEEE Containing BATT	Percentage
2007	2,530,005	866,064	34%
2008	3,141,288	1,202,416	38%
2009	3,428,350	1,427,491	42%
2010	3,507,196	1,478,741	42%
2011	3,553,519	1,545,909	44%
2012	3,474,177	1,508,453	43%
2013	3,490,823	1,477,853	42%

Another possible explanation for the difference in the percentages identified for each country is genuine differences in the composition of WEEE between different countries. Table 26 shows the correlation coefficient between the studies which estimate the proportion of BATT in WEEE and WEEE which contains BATT. There is no correlation between the two data sets, suggesting that differences in the composition of WEEE are not the reason for the different estimates. The difference between Sweden, and England and Wales is particularly marked. While both have similar proportions of WEEE which could contain BATT, Sweden has 35 times more BATT in WEEE. Possible explanations could include greater segregation of battery containing items in the UK, meaning less arrive in the WEEE stream. Further research would be required to test this hypothesis.

Table 26. Correlation between WEEE Containing BATT and BATT as a Proportion of WEEE

Country	BATT as a % of WEEE	Battery-containing WEEE as a % of WEEE, 2012)
England and Wales	0.06%	51%
Ireland	0.41%	42%
Estonia	0.50%	64%
Romania	0.60%	44%
Germany	1.30%	63%
Sweden	2.10%	50%
Correlation Co-efficient	0.16	

Further review of the data suggests that there may be discrepancies in national data or nation-specific changes occurring. For example, the proportion of WEEE containing BATT for Cyprus rose from 18% of WEEE to 45% from 2009 to 2011.

Comparison of the estimates from national compositional studies and ProSUM Deliverable 4.1 suggests that estimates of BATT in WEEE should be considered as highly uncertain and interpreted with caution.

As with other areas of the research the difference in collection system performance will have an impact on the percentage of BATT in the residual. High collection rates should, everything else being equal, mean that there are low levels of BATT in the WEEE stream. As the previous analysis in this section highlights BATT should be removed prior to WEEE treatment. However, WRAP (2015) suggests that this does not necessarily take place. Given the range of estimates given by different countries and given the uncertainties underlying the data, it would be more appropriate to estimate the amount of BATT removed from WEEE by applying a range based on the estimates given. Information can also be obtained from the battery collection organisations, where the BATT collected from the WEEE organisations can be identified in some cases. Based on the percentages in table 24, the amount extracted from WEEE is likely to be towards the lower bounds of this range drawn from ProSUM Deliverable 4.1.

The above estimate of BATT in WEEE informs, but does not constitute, a complementary flow by our definition. The BATT extracted are still likely to be recycled through official treatment routes. By definition, given its possible illegality it is impossible to get verifiable data quantifying the amount of BATT not extracted from WEEE.

For some years now, producer compliance schemes who are members of the WEEE Forum have been using WF-RepTool, a software tool that allows them and their suppliers to report recycling and recovery results and de-pollution of WEEE in accordance with the WEEELABEX standards.

Attempts have been made to access WF-RepTool data to assess and compare quantities of BATT in WEEE between European countries. However due to confidentiality issues the data could not be released for the purpose of ProSUM project.

Nevertheless during May and June 2015 the WEEE Forum carried out a survey with its members in Europe, mainly WEEE producer compliance schemes (PCS) to establish availability of data that could be used in ProSUM. A number of PCS surveyed indicated a willingness to share data on the quantities of BATT found in WEEE, often using the statistics that have been provided by recyclers through WF-RepTool.

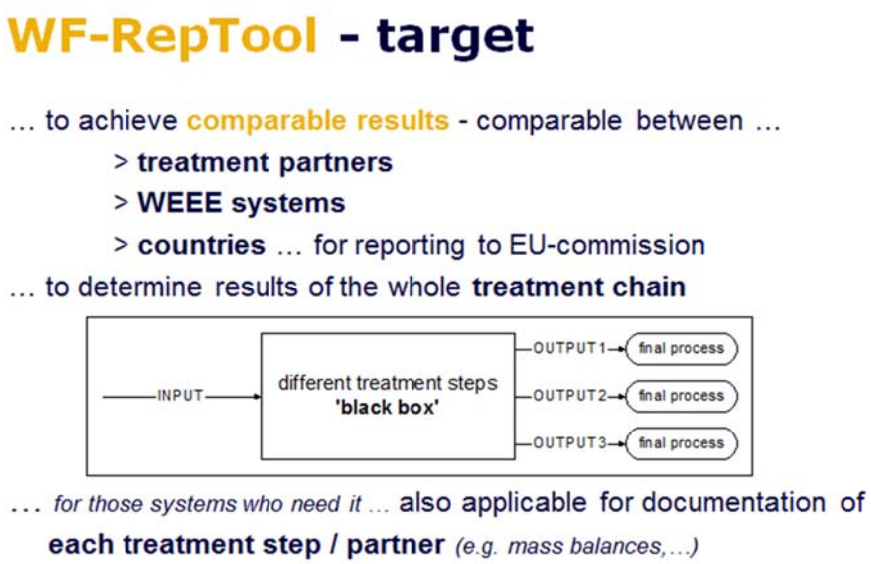

Figure 30. WEEE Forum Rep Tool (Source: WEEE Forum)

Some countries in Europe such as Ireland, France, Netherland and Italy are also increasing their WEEE recycling, depollution and consequently rates of BATT removed from WEEE prior to recycling through introduction of the WEEELABEX standard. WEEELABEX Certification has developed a single pan-European procedure to enforce the respect of these standards, which are assessed by highly qualified and trained auditors.

Below is a best practice example of how WEEE depollution is performed in Belgium. WEEE processors in Belgium are subjected to strict specifications about the processing, and the accompanying depollution, of WEEE including removal of BATT from WEEE. The process results in nearly 100% of batteries being removed from WEEE prior to recycling.

Case Study: In Belgium like in any other EU country WEEE depollution must comply with the conditions stipulated in Annex VII of the European Directive 2012/19/EC of 4 July 2012.

In Belgium the depollution is done in the two separate steps Step 1: Manual separation of the hazardous components including all BATT, with the exception of BATT that are permanently connected to a device. Step 2: Further disassembling when other BATT than those mentioned above are selectively disassembled and collected for recycling or removal as an identifiable flow.

The net weight of each monthly receptacle is determined and reported to the producer compliance scheme. Reporting is done in WF-RepTool a database application, developed by WEEE forum, to determine treatment results for WEEE in a transparent, traceable manner and to achieve comparable results.

The monitoring of the quality and the quantity of the hazardous waste happens in three different ways: self-control of the processor, depollution audits by an external company and depollution samplings. Self-control: In case of deviation of a condition concerning depollution, the processor shall report this on its own initiative and shall to give a written explanation for his deviation. The processor must be able to demonstrate compliance with this self-control and adjustment.

Depollution audits: PCS carries out unannounced control of the depollution and its results by a third party. Every processor has at least 4 unannounced controls per year. During these controls samples of depolluted WEEE is checked to see if the depollution happened following the specifications of PCS. PCS follows up these results and gives feedback to the processors. If any non-conformity noted, extra controls are performed and the processor is asked to undertake the necessary actions.

Sampling of the fraction OTH is proceeding by two different third party organizations. It performs a sampling of the various materials flows prior to their transportation to a processor by a bulk transporter. The samplers depollute the WEEE in the same way as it is done by the operators in a manual way. The total amount of depolluted material is registered for each transport. PCS compares the sampling result with the results of the processors.

The quantity of batteries shredded with WEEE or separately recycled is not clear. The flow of batteries from AATFs to batteries recycling facilities cannot be easily identified from reported data. Through Eurostat it's only possible to identify intra-waste sector battery flows, which amounted to 500 kt in 2012. This includes industrial and automotive batteries.

In the absence of standards price may be the only factor which informs recycling practices. This may drive behaviours which do not include separation of BATT, particularly where BATT may be integrated into devices, and therefore difficult to remove. There is also a need for consistent reporting, for example through the use of the Rep Tool.

4.2.4 Export Flows of BATT

The export of BATT embedded in second hand products is one of the main sources of complementary battery flows identified.

The primary analysis in section 3.3 is based on CWIT (2015). However, as noted in previous sections of this report such results should be considered indicative at best. Using the export percentages shown in Figure 31 in place of ProSUM Deliverable 4.1 would significantly alter the export flow estimates.

Product specific data could also yield additional insights. For example, as part of WRAP (2015) a UK based IT Asset Management Company were consulted and stated that particularly high proportions of smartphones from the UK are destined for overseas emerging economies, including items with cracked screens which still have inherent value. These are mostly destined to repair shops outside of the EU (e.g. Bangladesh and China) and targeted by very active buyers in the damaged stock/post-consumer market. BATT therefore leave the UK via this export market. This view of one well-placed industry representative has shared how greater than 80% of smartphones are destined for these markets, with less than 20% of BATT from smartphones staying in the UK. Given their characteristics (i.e. small and valuable) smartphones are easily packaged and posted to anywhere in the world.

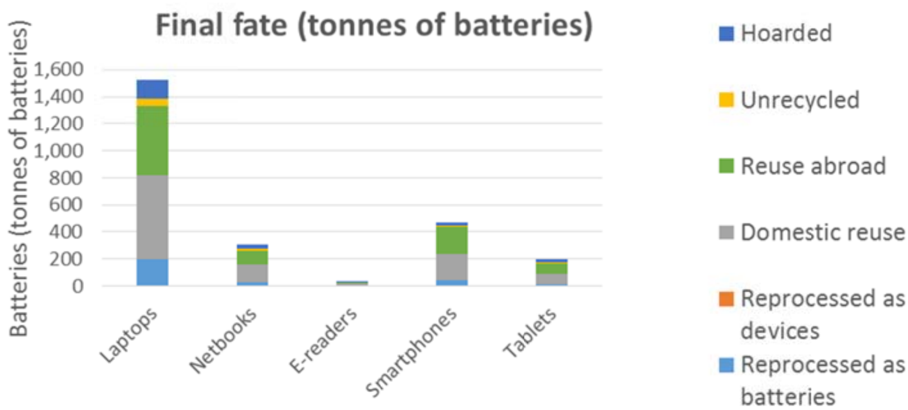

Figure 31. Final Fates of End-of-Life BATT in the UK by Weight (Source: WRAP, 2015)

Meanwhile, the amount of BATT embedded in larger products (from power drills in the case of portable BATT to fork lift trucks in the case of industrial BATT), either new or second hand and then exported inside and outside of the EU is also not adequately captured. This complicates the analysis in that the balance of trade in electrical goods intra and extra Europe has a bearing on the amount of BATT arising in the country that placed them on the market.

There is insufficient research available on intra-EU WEEE flows from which the amount of BATT can be estimated with confidence. Digital Europe (2014) investigated trans-boundary movements of waste and used goods to understand what impact the changes to the Basel Convention may have. The aim of the research was to support the development of solutions that eliminate illegal e-waste shipments but allow the legitimate global repair and refurbishment industry to flourish. This research was based on a survey Digital Europe conducted with its members and was also carried out into supply chains.

The findings show that about 118,000 tonnes of devices and parts are shipped trans-boundary per year for the purposes of repair and refurbishment globally. In comparison to the 10 Mt of WEEE generated in the EU annually, this amount seems tiny.

Drawing from the results of Digital Europe (2014), it has become clear that the majority of the shipments from EU-Member States are intra-European. A portion of the used products/service parts are also shipped to the Asian-Pacific region as well as North and Central America. However this research doesn’t have enough detail on the type of products shipped and is not representative enough in order to draw conclusions for the quantities of BATT shipped.

As with other flows of BATT, collection of reliable data through surveys and compositional analysis is challenging due to the diffuse and small nature of BATT within products and waste streams. In order to better understand the flows of BATT alternative means of identifying data may prove more effective.

4.2.5 Industrial and Automotive BATT

Spent Lead Acid BATT have a positive market value. Their recycling works well because it is profitable, it is illegal to dispose the BATT without recycling, the battery disassembly is simple because of the standard design used, and the battery chemistry does not require segregation and the recycling process is simple.

Eurobat estimates that close to 100% of all automotive and industrial BATT POM in the EU, are taken back at their end-of-life for further reprocessing. (Perchard, 2015) Similar research looking at the recycling rate of lead acid BATT in the US also shows recycling at 99%. (Battery Council International, 2014)

Unlike portable BATT, industrial BATT already appear to have commercially viable recycling routes for some of their chemistries such as nickel based and lead BATT. Producers and distributors of industrial BATT are aware of their high value and ensure that this value is recovered at the end of the battery's life. Supporting this there is already a very well established infrastructure of primary and secondary lead smelters across Europe where end-of-life industrial BATT can be recycled.

Industrial BATT – Discrepancies in Data Reporting

The BATT Directive requires member states to register producers of industrial BATT. However as there are no collection targets established for industrial BATT, there is no direct obligation for member states to record POM volumes through reporting obligations for producers.

Eucobat compiles data from a number of compliance organisations across Europe, but since there is no requirement to report data on industrial BATT POM data is incomplete.

According to Avicenne data industrial BATT POM in 2013 are estimated at just over 850,000 tonnes, equal to 1.7 tonnes per capita. (Perchard, 2015)

Table 27. Industrial BATT POM by Type in 2013

	ebikes	HEV	PHEV	EV	forklift, handling equpt.	Telecom	security lighting	UPS	grids	Military/space	Medical	Others industrial	**Total**	
Lead	92.1	0.0	0.0	0.0	275.0	170.2	0.0	142.4	28.3	31.0	41.5	49.5	**829.9**	96.9%
Li-ion	3.7	0.2	0.5	2.5	0.2	0.4	0.0	0.2	0.6	0.1	1.6	0.6	**10.6**	1.2%
Nickel	0.0	2.3	0.0	0.0	0.0	0.0	1.2	3.5	0.0	0.6	0.0	2.3	**9.8**	1.1%
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	**6.4**	0.8%
Total	**95.8**	**2.5**	**0.5**	**2.5**	**275.2**	**170.7**	**1.2**	**146.1**	**28.9**	**31.6**	**43.1**	**58.9**	**856.8**	
	11%	0%	0%	0%	32%	20%	0%	17%	3%	4%	5%	7%		

Source: Avicenne Report

Spent lead industrial BATT received by lead recyclers and smelters are typically mixed with lead pipes, sheet and cable sheathing and recycled as a single stream. This leads to difficulties in capturing exact data on collected volumes of lead industrial BATT. Smelters may be able to identify the existence of BATT within their feedstock but are not according to this research able to ascertain the source of those BATT, either by country or application that they were previously embedded in. Indeed interviews with smelter operators revealed that they have little idea of the composition of the lead scrap that they receive, i.e. the proportion that is BATT and the original source of the lead arising. Data on battery flows may be potentially commercially sensitive as a flow from a producer to smelter may represent just one business.

In addition, the diverse lifetime of industrial BATT makes it difficult to assess how many may become available for collection. In a stationary application where battery lifetime can be 20 years, in traction application where forklift track in the warehouse is running 24 hours a day and the battery will not make more than one year. There may be the same forklift from the same supplier and forklift is running on a day the battery will run for 10 or 15 years.

No publicly available reports or publications exist that identify any complementary, unreported flows of industrial and automotive BATT in Europe.

Industrial BATT are heavy and valuable; there is plenty of recycling infrastructure in Europe making exports of spent industrial BATT outside of Europe unattractive.

Potential of Mixed Stream of Hybrid and Electric Car BATT and Lead Acid BATT

This issue is being addressed in the United States by the Society of Automotive Engineers and in Europe by EUROBAT. Both groups have active working groups attempting to better define and find solutions to the problems of cross-contamination of battery types in recycling streams. An IEC standard is under discussion to identify the need of a specific chemistry labelling aiming at a clearer identification.

At a minimum, those BATT that could be recycled together should have at least one distinguishing feature in common, and conversely, one to differentiate them from those that need to be recycled in a different way. Mechanisms would be in place to return all BATT at the conclusion of their useful lives. (Gaines, L., (2014)

Challenges related to portable and industrial battery definition lead to inconsistencies in reporting.

After several years of experience in the Member States, it seems that there is a particular problem in distinguishing industrial from portable BATT without the help of defined additional criteria such as the weight. The distinction is important for the calculation of the collection target, as the target only applies to portable BATT.

Also, the different interpretations in the Member States have a serious impact on reported collection rates making it difficult to compare figures across countries.

Furthermore, experience shows that the application of inappropriate criteria to distinguish the collected BATT leads to unrealistic collection rates in some Member States. Whilst in most countries, the reported return rate for portable lead BATT is a plausible 100%, some implausible lead return rates were reported in the UK, where the return rate for lead portable BATT was 478%, and that of all other chemistries 5% in 2013. (Perchards, 2015)

In the UK BATT weighing between 4 and 10kg can be identified as either 'portable' or 'industrial' depending on their characteristics. Defra have announced in an update on the National Packaging Waste Database (NPWD) that the new definition has removed this grey area. From January 2016 any battery weighing over 4kg will be classified as 'industrial', although a battery that weighs less than 4kg may still be classified as industrial if it is designed exclusively for industrial use.

The main criteria to distinguish industrial BATT from portable BATT as per the battery directive is the intended use of these BATT "designed for exclusively industrial or professional uses" For the BATT put on the market, the decision on the classification is taken by the producers as per the above.

However for the collected BATT, it is impossible for sorting or recycling facilities to know the use of the battery so they use other criteria which differ from country to country. These include weight (varying per country from 1kg to 5 kg); collection point (industrial collection points or consumer collection points), and pro rata approaches (proportion industrial, portable BATT is the same for collection as for POM).

Greater coherence in the classification of the BATT put on the market and collected BATT could for this reason be achieved by a fundamental review of these definitions. Several options are discussed to improve this classification, including a review of the definitions. Another solution could be a clear guidance that is easily applicable for the producers and for the operational actors.

Analysed data indicates that a large majority of the collected BATT from households have a weight till 3 kg. The weight of 3 kg corresponds to certain reality and could be used as a first criterion. However weight criterion is not absolute, as some BATT of more than 3 kg that are typically used by consumers should be considered as portable.

In order to ensure that the collected BATT are classified in the same way as the BATT put on market declared by producers, Eucobat 2013) proposes that the BATT above 3 kg that cannot be used in private households are considered industrial BATT.

A key future challenge will be the potential for mixed streams of industrial BATT with portable lead BATT due to lack of consistent guidance on how to distinguish industrial battery at the collection stage. There is the potential for a mixed stream of lead acid BATT from vehicles and large format lithium BATT from hybrid electric vehicles, as identified in the US.

4.2.6 Trends Regarding the Observed Complementary Flows

Complementary flows, particularly for portable BATT are likely to increase in the future. This is because of the increasing amount and fast replacement rates of portable ICT devices which are exported as second hand equipment and will never become waste in the country where they were originally placed on the market but also increased levels of hoarding of BATT by end-users. However this growth is not discernible during the period in which WEEE data has been collected across EU Member States.

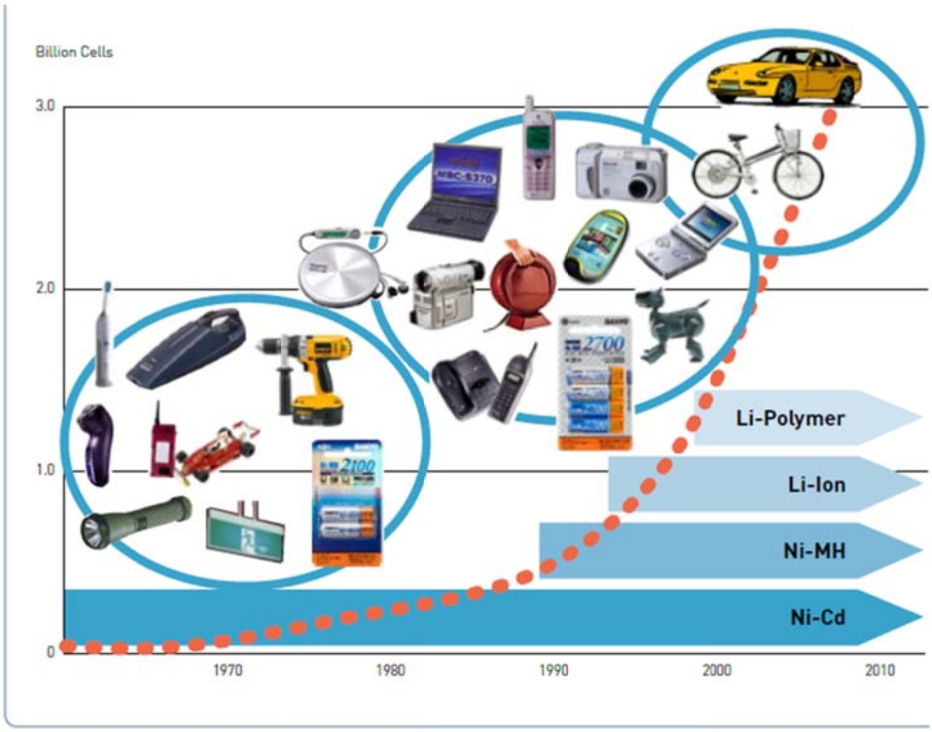

Figure 32. Growth of Different Battery Technologies (Eurometaux 2010, in UNEP 2013)

This consistency over time may also be due to products containing BATT substituting for each other (e.g. fewer digital cameras, fewer personal music players, more mobile phones with cameras and music incorporated) rather than adding to the total amount of items containing BATT.

There remain several concerns about the relevance of the collection rate as a performance measure of these schemes. The most notable are:

Varying interpretations of the definition of 'portable' battery: Lead BATT, are difficult or impossible to distinguish as portable or industrial BATT at the collection stage. This results in some organisations applying weight thresholds to facilitate the identification of portable BATT. These thresholds differ between countries. The interpretation challenges, including weight thresholds and their potential to optimize collection rates and costs can be expected to increase with the growth of larger BATT for e-bikes and new battery applications.

The difficulty in distinguishing lead industrial battery from lead portable battery leads to overstated amounts of lead portable BATT in waste battery collection volumes. Compliance organisations and member states need to carefully filter them out of portable battery collection reports.

Whilst the placing on the market volume of new BATT follows the distinction of 'portable', 'industrial' and 'automotive' BATT, the waste battery categories in the Waste Framework Directive's European Waste Catalogue distinguish only battery chemistries: thus, the licensing requirements for the waste BATT management activities (e.g. collection, transport, treatment) do not allow identifying per se those waste BATT that should count towards the portable BATT collection rate. This complicates the identification of collection volumes.

For example, Placed on the Market (POM) data, and waste data on BATT, from UK sources relating to Battery Regulations compliance and treatment (AATFs and battery recyclers), only provide aggregated data for ‘other’ chemistries (non Pb-acid and Ni-Cd) under a wide ranging portable battery category and do not break down to the Li Ion level or by device type.

There are uncertain estimates of battery volumes POM embedded in EEE: 37% of all portable, and 76% of rechargeable portable BATT by weight are placed on the market in EEE. The accuracy of reporting POM of embedded BATT is often a challenge. In the absence of ’collected’ (reported) POM data, the European Commission allows Member States to base their calculation of POM volumes on ‘statistically significant estimates based on collected data’. Detailed data from several countries would be needed to improve the accuracy of national assumptions underlying such estimates, but these are not available.

Data from the few battery organisations that require producers to indicate separately the volume of BATT placed on the market in EEE, suggest that BATT in EEE contribute around 20% to 30% of portable BATT placed on the market. Few comparable data are available on a country basis and the share of portable BATT POM volumes of portable BATT as a percentage of EEE POM show wide variations: On average, the BATT volume is 2.4% of EEE volume. In 2010 it ranged from 1% - 1.5% in SK, LU, PT, GR, BE to above 3% in SE, LT, EE). (Perchards, 2015)

Public and confidential data from organisations suggest the share of BATT removed from WEEE is on average 7% in the 19 countries investigated, and ranges from 1% to 20% (on the basis of individual systems, shares are much higher for a few systems).

GRS Batteries report estimated that BATT comprised 1.3% of German WEEE (categories 3 and 5) with lithium BATT 0.3% of overall WEEE tonnage (23% of BATT by weight found in WEEE are estimated to be lithium). No year for this research is given.

Hoarding and increasingly longer life rechargeable BATT Studies from Belgium and the Netherlands indicate that at least 40% of BATT placed on the market do not become available for collection. While one reason for this is ‘hoarding’ by end-users, others are the increasing share of longer life rechargeable BATT.

Exports of BATT with (W)EEE

Studies suggest up to 40% of WEEE and used EEE may be improperly treated in or outside the country in which the EEE was originally placed on the market. As the portable BATT collection rate methodology includes BATT in EEE and WEEE, the uncertainty about cross border flows of used EEE and WEEE adds to the concerns about the relevance of the waste portable BATT collection rate as a performance measure of a waste portable battery collection scheme. The amount of waste BATT becoming available for collection as a percentage of POM can be expected to decrease in the future as improved battery technologies drive the widespread adoption of new applications (cordless power tools, garden equipment, small personal mobility, standby, energy storage).

4.3 Results for Complementary ELV Flows

The number of vehicles of unknown whereabouts in 2013 in Europe amounted to 3,600,000 units and this represent 31% of the total vehicle exits. (Oeko-Institut e.V., 2016)

The observation needs to be made about the difference between vehicles licensed and ELVs arising. If we assume an average age for a vehicle to become an ELV is 12 years it becomes possible to compare numbers of vehicles sold and ELV arising’s. While it is unlikely that there will be an exact match, the shortfall between vehicles sold and ELVs recovered seem to indicate that some ELVs escape the ELV system set up by the ELV Regulations.

Only a part of vehicles which are deregistered receive a certificate of destruction (CoD). There is a clear lack of detailed information about the further use of a large part of deregistered cars.

The existence of unknown whereabouts of ELV is common in a number of countries in Europe, but they are difficult to quantify. Even the best-performing schemes have difficulty ensuring the responsible management of all ELVs.

The complementary flows of ELVs vary between countries and are hard to investigate due to lack of data but predominantly consist of:

- ELVs recycled in not-authorized treatment facilities;
- ELV exported as 2nd hand vehicles;
- Unrecorded exports of used cars, e.g. exports outside of Europe by transit through EU-MS;
- There are also ATFs accepting ELV, not issuing a CoD, but then putting the vehicle on the market;
- Not depolluted or partially depolluted ELVs exported in breach of the ELV and TFS Regulations;
- And illegal export of scrap cars.

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5 Conclusion, Recommendations and Next Steps

5.1 Conclusions WEEE

Waste statistics in general and particularly those for WEEE are known to have a high degree of uncertainty. This unique EU wide analysis of WEEE flows has comprehensively reviewed all available data to go further than any other previous work. The reconstruction of historic and current market input data and the resulting WEEE Generation figures (narrowed to roughly 15% uncertainty) provides a relatively solid starting point for the analysis of the resulting WEEE flows. Furthermore, the data gathering and analysis resulted in an important input to the common methodology study for the European Commission's DG Environment and in respective e-tools for EU Member States (Magalini et al., 2016) enabling them to determine their own WEEE Generation in future years.

The quantification of complementary flows is even more complicated than the already inherently complex quantification of WEEE statistics. Nevertheless, the determination of the amount of WEEE generated, and thorough review of reported collected amounts, provides a clear range for the quantities of complementary flows such as: appliances in residual waste; WEEE mixed with other metal scrap; unreported recycling of (professional and B2B) appliances; and exported amounts. The data gathering and processing of all the information produced in Deliverables 2.2, 3.1 and 4.1 has resulted in an important and well-structured overview of all available complementary flow information in Europe for the six main types of complementary flows for 2010-2014covering all known instances with information being available. Moreover, data has been quality assured and screened following the protocol outlined in Section 1.3. This protocol defines a new robust, harmonised system for defining data quality and uncertainty levels. The consolidation and review of the reported collection volumes reported by Eurostat together with WEEE Forum data, individual studies and national registers provides a complete EU overview. See Figure 33 for the 2012 status, which has the highest number of sources available, for all collection categories combined.

For some countries it has not been possible to use estimates because they did not meet the minimum data quality requirements. There are only a few countries with significant information on the whereabouts of the complementary flows as visualised in Figure 24 where some countries have a number of flows and some countries only have data on collected amounts and gaps.

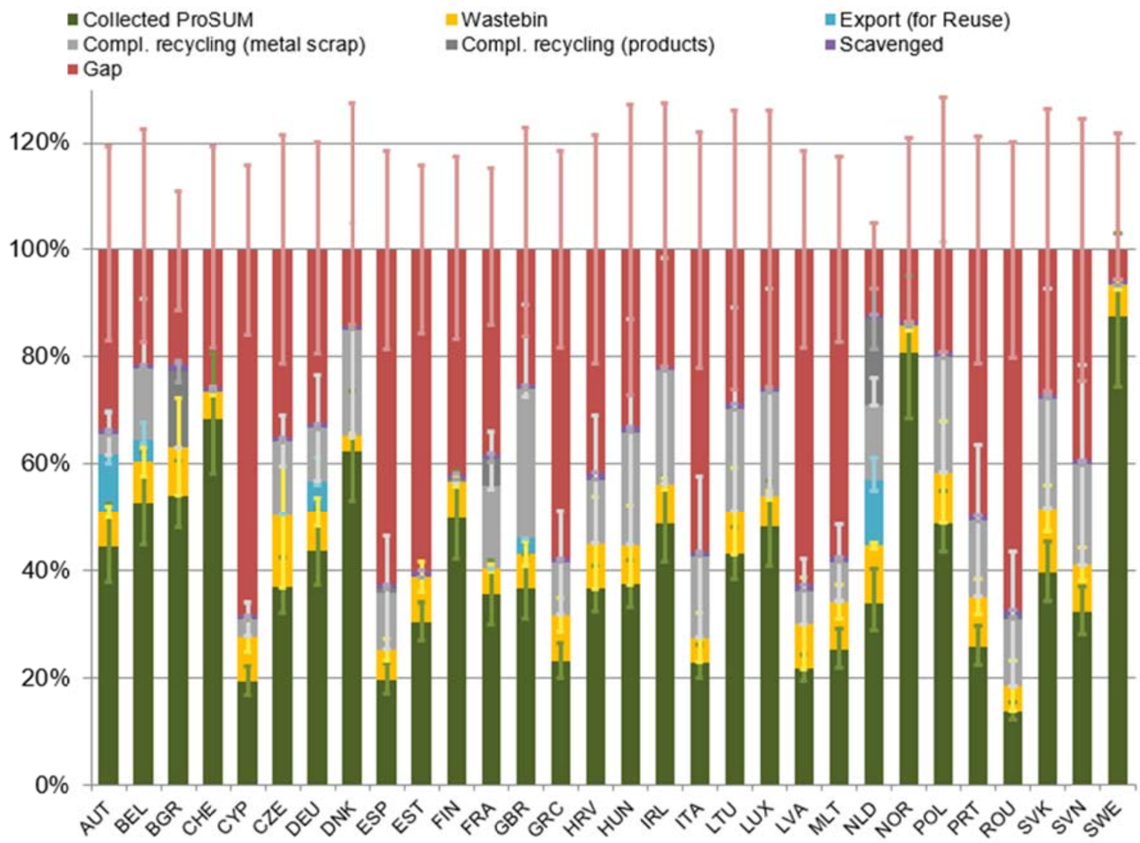

Figure 33. Collection of WEEE Compared to WEEE Generated 2012, Measured Data Only

Of the six types of complementary flows, the waste bin and metal scrap flows have been quantified comprehensively, albeit with data quality concerns in the case of the latter. For the waste bin data, there are original studies available for 14 countries with the value per inhabitant ranging between 0.5 kg and 1.9 kg of predominantly small appliances. The metal scrap data ranges between 0 kg and about 4.5 kg per inhabitant, excluding the UK with 6.1 kg/inh. Here only five original studies are available which results in poor data quality for most member states. For both types of flows, detailed allocation to the collection categories is difficult.

For the complementary recycling of products, few additional data points have been found for some member states which hasn't allowed for any extrapolation to generate estimates. There is the potential to conduct additional well-designed surveys with the recycling industry in Europe to better estimate these non-compliant flows. It has only been possible to produce estimates for scavenged components from compressors for collection category I (Temperature Exchange Equipment), with considerable uncertainty ranges. For additional CRM rich components like cable and IT components insufficient data is available to assess these.

For exports, there are only five studies available, of which, only two have sufficient data to allocate quantities to individual collection categories and only for the years 2010 and 2012. Coherent estimates cannot be constructed with the limited data for the other countries and other years. The same counts for distinguishing between legal and illegal exports. The highest share for (illegal) trade is related to products with a reuse value. It is not feasible to substantially survey the reuse markets as they are too dispersed. The same holds for informal collectors like small scrap collectors and thieves which obviously do not register and report their quantities.

In this Deliverable 3.2, the flows of WEEE for all individual European countries have been mapped utilising a range of reports and information sources. Documenting unreported WEEE remains intrinsically difficult and not harmonised. The amount of WEEE treated from complementary flows and not reported to national authorities ranges from that which is recycled to the same standards but not reported to that which is recovered using substandard processes and standards. When the term non-compliant is used, it does not necessarily imply substandard treatment, but rather refers to these quantities not being declared through the official channels for producer compliance. In the case of WEEE mixed with other metal scrap, these amounts cannot be ‘classified’ as separate collection and treatment as prescribed in the WEEE Directive. In reality the shredding and further separation of scarp is not very different from the shredding of LHA separately collected and classified as such.

5.2 Conclusions BATT

Complementary flows, particularly for portable batteries, are likely to increase in the future. This is because of the increasing amount and fast replacement rates of portable ICT devices which are exported as second hand equipment. They will rarely become waste in the country where they were originally placed on the market and also there are increased levels of hoarding of batteries by end-users. However this growth is not discernible during the period in which WEEE data has been collected across EU Member States.

It is also likely that there will be fewer digital cameras, fewer personal music players, and more mobile phones with cameras and music incorporated rather than adding to the total amount of items containing batteries. Further research would be required to test this hypothesis.

Lead batteries, are difficult or impossible to distinguish as portable or industrial batteries at the collection stage. This results in some organisations applying weight thresholds to facilitate the identification of portable batteries. These thresholds differ between countries. The interpretation challenges, including weight thresholds, and the potential to optimise collection rates and costs can be expected to increase with the growth of larger batteries for e-bikes and new battery applications.

The difficulty in distinguishing a lead industrial battery from a lead portable battery leads to overstated amounts of lead portable batteries in waste battery collection volumes. Compliance organisations and member states need to carefully filter them out of portable battery collection reports. Whilst in most countries, the reported return rate for portable lead batteries is 100% some implausible lead return rates have been reported. For example in the UK the return rate for lead portable batteries was 478%, and that of all other chemistries 5% in 2013.

Inconsistent definitions in the Waste Framework and Battery Directives complicate data collection and enforcement. New batteries placed on the market are defined as ‘portable’, ‘industrial’ and ‘automotive’ batteries. The waste battery categories in the Waste Framework Directive’s European Waste Catalogue distinguish only battery chemistries. Therefore, the licensing requirements for waste batteries management activities (e.g. collection, transport, treatment) do not allow for the identification of those waste batteries that should count towards the portable batteries collection rate. This complicates the identification of collection volumes.

37% of all portable, and 76% of rechargeable portable batteries by weight are placed on the market as components within EEE products. The accuracy of reporting POM for embedded batteries is often a challenge. In the absence of ’collected’ (reported) POM data, the European Commission allows Member States to base their calculation of POM volumes on ‘statistically significant estimates based on collected data’. Detailed data from several countries would be needed to improve the accuracy of national assumptions underlying such estimates but these are not available.

Data from the few battery organisations that require producers to indicate separately the volume of batteries placed on the market in EEE, suggest that batteries in EEE contribute around 20% to 30% of portable batteries placed on the market. Little comparable data are available on a country basis and the share of portable batteries POM in EEE by volume shows wide variations.

On average, the batteries volume is 2.4% of the EEE volume. In 2010 it ranged from 1% - 1.5% in SK, LU, PT, GR, BE to above 3% in SE, LT, EE.

Public and confidential data from various organisations suggest the share of batteries removed from WEEE is on average 7% in the 19 countries investigated, and ranges from 1% to 20%. Needless to say, that this is at odds with the legal text of the WEEE Directive in Article 8(2) and Annex VII.1

Studies from Belgium and the Netherlands indicate that hoarding and increasingly longer life rechargeable batteries mean that at least 40% of batteries placed on the market do not become available for collection.

Studies suggest that up to 40% of WEEE and used EEE may be improperly treated inside or outside the country in which the EEE was originally placed on the market. As the portable batteries collection rate methodology includes batteries in EEE and WEEE, the uncertainty about cross border flows of used EEE and WEEE gives further concern on use of the waste portable batteries collection rate as a performance measure of a waste portable battery collection scheme. The amount of waste batteries becoming available for collection as a percentage of POM can be expected to decrease in the future as improved battery technologies drive the widespread adoption of new applications (cordless power tools, garden equipment, small personal mobility, standby, energy storage).

5.3 Conclusions ELV

The number of vehicles of unknown whereabouts in 2013 was 3,600,000, representing 31% of the total vehicles taken out of use. In many EU countries there is a high incidence of vehicles with unknown whereabouts.

Challenges exist in relation to differences in the interpretation of ELVs and used cars between various EU states. It is very difficult to distinguish between a used car and ELV in practice. This leads to challenges in tracking fates of ELV as well as in quantifying complementary flows of ELV.

The quantification of complementary flows is inherently different. It consists primarily of:

- ELVs recycled in unauthorised treatment facilities;
- Those exported as second hand vehicles;
- Exports of vehicles outside the EU via another MS;
- ELVs accepted for destruction at authorised treatment facilities that are sold on as used vehicles;
- Illegal exports of vehicles which have not been depolluted or only partially depolluted;
- And illegal export of scrap cars.

This Deliverable sought to better quantify the flow and fate of these ELVs. This has been difficult to do due to the lack of reporting and inherently illegal aspects of some of these flows. Some specific country studies do exist and offer a model for future work.

There is an obvious incentive for exports of used cars and ELVs. In countries with low average income in some European regions as well as outside the EU there is a well-developed market for very cheap cars, often in bad condition or serving as a source of spare parts.

There is also evidence suggesting that ELVs are treated illegally in some cases in the country of origin. However, the situation seems to be improving. This can also be seen from the fact that the numbers of authorised treatment facilities have increased significantly in some Member States (UK, BE, GR) in recent years.

According to the “European second-hand car market analysis” report the majority of the “unknown whereabouts” can be considered as scrapped or hoarded within EU 27 and that only a minority of “unknown whereabouts” is exported as used vehicles or as ELV used for spare parts. (Mehlhart et al., 2011) Nevertheless, lack of sufficient evidence makes it hard to confirm for certain which of the complementary flows of ELV is most significant.

The CoD system in Europe is not fully working as a system to determine the fate of vehicles. This has been a severe limitation to measuring complementary flows of ELV. However what would be particularly useful based on our analysis is the detailed examination of the CoD system in European countries and how this system could be improved to ensure a better tractability of ELV in Europe.

5.4 Recommendations and Next Steps

The following activity will be undertaken to improve the analysis of WEEE complementary flows to support the stocks and flows modelling:

1. Structured surveying will be undertaken with the recycling industry and WEEE Forum members to better determine the extent to which components are scavenged from whole units.
2. The structured data produced in this Deliverable, and specifically the final mass balances, will be reconciled by the use of additional modelling tools. Both will continue to be compared with the available data in this report and further upcoming iterations of national WEEE flow models applied for instance in the UK and the Netherlands using simulation models. Further sensitivity analysis and/or Monte Carlo analysis will be undertaken to determine the probability levels for unreported flows from WEEE, batteries and ELV disposal.
3. This next analytical step will be aligned with the more detailed determination of stock levels derived from the upcoming Deliverable 3.3 and in particular also to elaborate on the level of scavenged components for which more information from Deliverable 4.2 will be provided.

Further data gathering will be possible following the outputs of future deliverables:

4. Complement the analysis for scavenged components like coils and electron guns from CRT screens, circuit boards and drives from small IT equipment and cables from all types of appliances. Here additional information from WP4 will be included in later stages. Although this will represent a minor weight percentage overall, the influence on the overall mass balances for particular CRMs may be affected.

The analysis of complementary flows of batteries will be improved by:

1. The BATT structured data produced in this Deliverable, and specifically the final mass balances, will be reconciled by the use of additional modelling tools. The available data in this report will continue to be compared with further upcoming iterations of flow models and with additional information from other work packages (especially WP4). The flow models will deliver further information on gaps, i.e. on the amounts of batteries that can be assumed to be in complementary flows.
2. Sampling and analysis campaigns are necessary to improve the data validity, for instance to get a more comprehensive picture on different types of batteries and where they are present in EEE/WEEE. The sampling needs to be representative and periodically repeated.
3. Mandatory reporting undertaken by the batteries recycling industry already contains the information about the total amount per chemistry of batteries treated, and the recycling efficiency per process. Consolidation of these data, used with the proper modelling tool, will

clarify the amounts of industrial and automotive BATT recycled in Europe, and consequently allow a better understanding of the BATT complementary flows.

4. Given the nature of BATT in residual waste (light, infrequently occurring, small) it is always likely that compositional studies will underestimate their presence. Future work in this area could be improved through development of modelling approaches and a better understanding of the time between a battery being placed on the market and its subsequent disposal.
5. It is assumed that more single portable BATT are entering the residual waste stream than recycling. This is in line with the reported values as part of the BATT directive. Further efforts to divert BATT to options further up the waste hierarchy could therefore increase the proportion that is captured within separate data without the need for further compositional analysis. Improvements to collection infrastructure and advice to businesses and household may also be beneficial.

The analysis of complementary flows for ELVs will be improved by:

1. Alignment of the analytical next step with more detailed determination of stock levels derived from upcoming Deliverable 3.3 and in particular also to elaborate on the level of scavenged components with information from Deliverable 4.2.

2. More research is needed on the final fates of unreported ELV. National statistics could help greatly to quantify the size of unreported flows of ELV. Also, there is a need to improve the ELV reporting system as it is likely that statistical gaps in data occur due to issues with ELV reporting rather those illegal activities.

3. There are currently other projects underway further investigating the likely fates of unreported ELVs in Europe. The results of these projects will bring further intelligence to the analysis of unreported flows of ELV. The reports below will be reviewed and relevant data used to improve the estimates for ELVs for the EU.
    a. The German Federal Environment Agency is currently carrying out a study to trace the deregistered vehicles. The objective of this on-going project is to analyse and then improve the data base on the fate of the deregistered vehicles.
    b. The Oko-Institute e.V is currently carrying out a study focused on the unknown whereabouts of ELV in Europe. The outcome of the public consultation Oko-Institute e.V is carrying out as part of the project will help to update intelligence on complementary WEEE flows.

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6.1.1 Data Quality WEEE key sources

Tmp Meta-data ID	Data sources of complementary flows for WEEE	Data quality
POM Stock WEEE		
15	Habib; et al; (2016)	Confident
26	Magalini, F. (2016).	Confident
48-51	WEEE Forum, Key Figures (2010-2014)	Confident, judgement is country dependent
Collected		
14	Eurostat (2005-2013)	Confident except Italy for 2011-2013 its less confident
48-51	WEEE Forum, Key Figures (2010-2014)	Confident, judgement is country dependent
Waste Bin		
18	Huisman, J. (2015)	Confident
5	Bigum, M. (2013)	Less confident
7	BAFU, (2012)	Confident
36	Sander, K., et al., (2010)	Less confident
10	Dimitrakis, et al., (2009)	Less confident
38	Skatteverket (2012)	Confident
30	Pannuzzo, B. (2014)	Confident
14	Eurostat (2013)	Less confident, source is confident. The use of total residual waste amounts multiplied with the % of WEEE as a result is less confident.
54	WRAP. (2011)	Less confident
1	Avfall Sverige (2015)	Confident

17	Huisman, J. (2012)	Confident
27	Monier, V. (2013)	Less confident
11	Dvoršak, S. (2011)	Dubious
28	Montejo, C. (2011)	Less confident
48	WEEE Directive in Sweden (2009)	Less confident
24	Magalini, F. (2012).	Dubious
11	Dvoršak, S. (2011)	Less confident
Metal Scrap		
16	Eurostat Waste statistics (2010, 2012)	Dubious, the source data is confident. The use of total metal crap amounts multiplied with the % of WEEE (1.4%) as a result is dubious and very country dependent.
52	Wielenga, K., (2013)	Less confident
25	Monier, V. (2013)	Less confident
56	WRAP (2013)	Confident
19	Huisman, J. (2012)	Confident
32	Polák, M. (2012	Less confident
Complementary Recycling Products and Scavenging		
18	Huisman, J. (2015)	Confident
25	Monier, V. (2013)	Less confident
17	Huisman, J. (2012)	Confident
Exports		
25	Monier, V. (2013)	Less confident
19	Huisman, J. (2012)	Confident
52	Wielenga, K., (2013)	Less confident
23	Kopacek, B., (2013)	Less confident
34	Sander, K., et al., (2010)	Confident

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6.2.1 Data Quality BATT Key Sources

Data Sources for Complementary Flows of BATT	Data Quality
Eurostat data on POM and separate waste flows	High Confidence
Prosum Deliverable 3.1	Confidence
Prosum Deliverable 4.1	Less Confidence (sample for one EU member state)
Huisman et al (2015) CWIT	Less Confidence
Perchards (2015)	Confidence
WRAP (2015)	Less Confidence (data for one EU member state).
IHS (2014c)	Less Confidence
DEFRA (2012)	Less Confidence (due to age)
Avfall Sverige (2015)	Less Confidence
GRS Batterien	Less Confidence
ECOTIC	Less Confidence
EEE Ringlus	Less Confidence
WEEE Ireland	Less Confidence
Environment Agency (2016b)	Less Confidence

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6.3.1 Data Quality ELV Key Sources

Schneider, J., (2010)	Confidence
Mehlhart, G. et.al, (2011)	High Confidence
Oeko-Institut e.V. (2016)	High Confidence
Annual report on end-of-life vehicle reuse/recycling/recovery rates in Germany for 2013, Germany pursuant to Art. 7 (2) of the End-of-life Vehicles Directive 2000/53/EC	High Confidence

Annexes

ANNEX 1 General Terms, Definitions and Abbreviations

Annex 1.1 List of Abbreviations

ACEA	European Automobile Manufacturers' Association
ASR	Automotive shredder residue
ATF	Authorised Treatment Facility, as defined in the ELV Directive
B2B	Business to Business
B2C	Business to Customers
BATT	BATT
CoD	Certificate of Destruction, as defined in the ELV Directive
COMEXT	Statistical database on trade of goods managed by Eurostat
CWIT	Countering WEEE Illegal Trade
EEAB	External Expert Advisory Board
EEE	Electrical and Electronic Equipment
ELV	End-of-Life Vehicle
EoL	End-of-Life
EPA	Environmental Protection Agency
EPBA	European Portable Battery Association
EBRA	European BATT Recyclers Association
ESAP	Electrical Sustainability Action Plan
EU-UMKDP	Urban Mining Knowledge Data Platform
Eurostat	European Statistics Association database
EU28+2	Austria (AUT), Belgium (BEL), Bulgaria (BGR), Cyprus (CYP), Czech Republic (CZE), Germany (DEU), Denmark (DNK), Spain (ESP), Estonia (EST), Finland (FIN), France (FRA), United Kingdom (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)
HH	Households
inh	Inhabitant
ILA	International Lead Association
kg	Kilogram
kg/HH	Kilogram/household
kg/inh	Kilogram/ inhabitant
kt	Kilotonnes
Mt	Mega tonnes (Million Tonnes)
MWh	Megawatt hours
pcs	Pieces
pcs/HH	Pieces/household
pcs/inh	Pieces/inhabitant
POLK	Part of IHS Automotive. IHS is the leading source of information and insight on the automotive industry.
POM	Put on Market/ Placed On the Market
PV	Photo voltaic
UEEE	Used Electrical and Electronic Equipment
WF	WEEE Forum
WF-KFP	WEEE Forum- Key Figures Platform

WEEE	Waste Electrical and Electronic Equipment
WG	Waste Generated

Annex 1.2. General Terms and Definitions

BATT (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).

Best available techniques
Best available techniques as defined in Article 2(11) of Directive 96/61/EC (Directive 2008/98/EC).

Broker
Any undertaking arranging the recovery or disposal of waste on behalf of others, including such brokers who do not take physical possession of the waste (Directive 2008/98/EC).

Coherent estimates
A Coherent estimate describe the strength of association between two series of data where the possible dependence between them is not limited to simultaneous values but may include primary, covered and smoothed relationships (Everitt, B.S. 2002)., The Cambridge Dictionary of Statistics, CUP. ISBN 0-521-81099-X.

Complementary flows
The term mainly refers to all waste flows that are not reported by the official compliance systems and others to a national level specified according to the ELV, BATT and WEEE Directives. A certain portion of these flows ends up being exported, incinerated or landfilled. The term also includes non-compliant treatment like recycling with other waste streams, for instance with mixed metal scrap. The amount of WEEE and BATT treated this way is very difficult to quantify.

For ELV the complementary flows are referred to as unknown whereabouts of ELV. These are vehicles which are not reported; they are neither registered as part of the European vehicle stock (also called "vehicle fleet" or "vehicle parc"), nor as vehicles exported from the EU (termed extra EU-Export in COMEXT), nor as ELVs (Eurostat). (Mehlhart, G. et.al, (2011).)

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

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

Data uncertainty
The range of possible values within which the true value of the measurement lies (Oxford English Dictionary, 2015).

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

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

Directive 2012/19/EU on waste electrical and electronic equipment (WEEE); known as 'WEEE Directive'. The WEEE Directive sets minimum requirements for the first treatment facilities. Moreover, it defines collection categories according to which data have to be reported.

Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment OJ L 174 of 1 July 2011 (Roh's Directive).

Legislation concerning WEEE on Member state level is directly linked to the WEEE Directive which is completed by compositional specifications and Commission Decisions 2004/249/EC and 2005/369/EC which lay down a questionnaire for the implementation report that Member States have to submit to the EC.

Commission Decision 2005/369/EC of 3 May 2005 laying down rules for monitoring compliance of Member States and establishing data formats for the purposes of Directive 2002/96/EC of the European Parliament and of the Council on waste electrical and electronic equipment (notified under document number C(2005) 1355).

Commission Decision 2004/249/EC of 11 March 2004 concerning a questionnaire for Member States reports on the implementation of Directive 2002/96/EC of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE) (notified under document number C(2004) 714).

Directive 2000/53/EC on end-of life vehicles (known as "ELV Directive") defines a legislative framework to minimise the impact of ELV on the environment, to harmonise requirements for collection and treatment, and to set reuse/recycling and reuse/recovery targets for end-of-life vehicles.

Commission Decision 2005/293/EC down detailed rules on the monitoring of the reuse/recovery and reuse/recycling targets set out in Directive 2000/53/EC on end-of-life vehicles and the minimum data required for reporting.

Directive 2005/64/EC on the type-approval of motor vehicles with regard to their reusability, recyclability and recoverability and amending Council Directive 70/156/EEC applies to vehicles belonging to the categories M1 and N1, which are defined in Directive 70/156/EEC, ANNEX II, and to new or reused components of M1 and N1 vehicles. It establishes rules and provisions to make sure vehicles and vehicle components maintain the required safety standards when being reused.

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.

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

Eurostat
Eurostat is the statistical office of the European Union. Its task is to provide the European Union with statistics at European level that enable comparisons between countries and regions. Eurostat is actually the only provider of statistics at European level and the data Eurostat issue are harmonised as far as possible (Eurostat, Eurostat - what we do, 2016). Eurostat contains reported data on flows on sold production, imports and exports of BATT and battery-containing items as well as information on separately collected BATT and battery containing items for the EU-28. All data is collected following standard definitions and criteria. This can be used to identify complementary flows.

Gap
The gap is non-accounted or the unknown whereabouts of the end of life vehicles (ELV), waste batteries (BATT) and Waste Electrical and Electronic Equipment (WEEE).

For this report, the WEEE Gap is defined as the difference between the WEEE generated, the WEEE officially reported, and sum of complementary flows as expressed in the following formula:

WEEE Gap= generated- officially reported- sum of complementary flows

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

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

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).

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

Preparing for reuse
Checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be reused without any other pre-processing (Directive 2008/98/EC).

Prevention measures taken before a substance, material or product has become waste, that reduce: (a) the quantity of waste, including through the reuse of products or the extension of the life span of products (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of harmful substances in materials and products (Directive 2008/98/EC).

(Product) Stocks
Material reservoirs (mass) within the system analysed that have the physical unit of kilogrammes and tonnes (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).

Producer Compliance Scheme
A Producer Compliance Scheme is usually a limited company, through which producers will meet their obligations to register with the appropriate authority and finance the cost of collection, treatment, recovery and environmentally sound disposal.

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

Recovery
Any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II sets out a non-exhaustive list of recovery operations (Directive 2008/98/EC).

Recycling
Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations (Directive 2008/98/EC).

Removal
Manual, mechanical, chemical or metallurgic handling with the result that hazardous substances, mixtures and components are contained in an identifiable stream or are an identifiable part of a stream within the treatment process. A substance, mixture or component is identifiable if it can be monitored to verify environmentally safe treatment (Directive 2012/19/EC).

Reuse
Any operation by which products or components that are not waste are used again for the same purpose for which they were conceived (Directive 2008/98/EC and Directive 2000/53/EC).
Separate collection The collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment (Directive 2008/98/EC).

Scrap
Scrap consists of recyclable materials left over from product manufacturing and consumption, such as parts of vehicles, building supplies, and surplus materials. Unlike waste, scrap has monetary value, especially recovered metals, and non-metallic materials are also recovered for recycling (Oxford English Dictionary, 2016).

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

Treatment

Any activity after the end-of life vehicle [or any other product or good] has been handed over to a facility for [mechanical, chemical, thermal, biological pre-processing, such as] depollution, dismantling, shearing, shredding, [sorting], recovery or preparation for disposal of the shredder wastes, and any other operation carried out for the recovery and/or disposal of the end-of life vehicle and its components (Directive 2000/53/EC). It is not the recovery or disposal operation itself but rather the preparation prior to recovery or disposal (Directive 2008/98/EC).

Unified Data model
A unified data model is an abstract model that organizes elements of data and standardizes how they relate to one another (Len Silverstone & Paul Agnew 2008).

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). 70

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 BATT (WBATT)
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 Bin
WEEE or waste BATT put in the waste bin and not separately collected for recycling but typically landfilled or incinerated includes household waste and mixed bulky waste.

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). WEEE is grouped in categories outlined in Annexes I to IV of the WEEE Directive.

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 generation
WEEE Generated in a Member State corresponds to the total weight of discarded products (waste) as a result of consumption within the territory of that Member State in a given reporting year, prior to any activity (collection, preparation for reuse, treatment, recovery (including recycling) or export) after discarding. Waste arising from private, business and industrial sector. Waste generated is not the same as waste collected, since other non-compliant waste flows and processing exist. Moreover, a differentiation between excluding und including major mineral waste is made in Eurostat statistics.

Waste holder
The waste producer or the natural or legal person who is in possession of the waste (Directive 2008/98/EC).

Waste management
The collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker (Directive 2008/98/EC).

Waste producer
Anyone whose activities produce waste (original waste producer) or anyone who carries out pre-processing, mixing or other operations resulting in a change in the nature or composition of this waste (Directive 2008/98/EC).

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, and 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, and ELV Directives. 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 BATT.

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

Annex 1.3 BATT Specific Terms

Automotive BATT
Any battery or accumulator used for automotive starter, lighting or ignition power (Directive 2006/66/EC).

Battery recycling efficiency
The recycling efficiency of a recycling process means the ratio obtained by dividing the mass of output fractions accounting for recycling by the mass of the waste BATT and accumulators input fraction expressed as a percentage (Regulation (EU) No 493/2012).

Battery recycling process
Any reprocessing operation as referred to in Article 3(8) of Directive 2006/66/EC which is carried out on waste lead-acid, nickel-cadmium and other BATT and accumulators and results in the production of output fractions as defined in point 5 of this Article. The recycling process does not include sorting and/or preparation for recycling/disposal and may be carried out in a single facility or in several facilities (Regulation (EU) No 493/2012).

Industrial BATT
Any battery or accumulator designed for exclusively industrial or professional uses or used in any type of electric vehicle and also include BATT and accumulators used in electrical vehicles, such as electric cars, wheelchairs, bicycles, airport vehicles and automatic transport vehicle (Directive 2006/66/EC).

Input fraction
The mass of collected waste BATT and accumulators entering the recycling process as defined in Annex I (Regulation (EU) No 493/2012).

Output fraction
The mass of materials that are produced from the input fraction as a result of the recycling process, as defined in Annex I without undergoing further treatment, that have ceased to be waste or that will be used for their original purpose or for other purposes, but excluding energy recovery (Regulation (EU) No 493/2012).

Preparation for recycling
Treatment of waste BATT and/or accumulators prior to any recycling process, which shall, inter alia, include storage, handling, dismantling of battery packs or separation of fractions that are not part of the battery or accumulator itself (Regulation (EU) No 493/2012).

Registration bodies
National authorities or with national producer responsibility organisations authorised by Member States where the registration of producers of BATT and accumulators shall take place (Directive 2006/66/EC and 2013/56/EU).

Annex 1.3 ELV Specific Terms

Automotive shredder residue (ASR)
Residues from ELV treatment after de-pollution, dismantling and shredding of the hulk, with or without mechanical post-shredder metal separation (Vermeulen et al., 2011).

Certificate of Destruction

A Certificate of Destruction (CoD) is a document issued to a registered Authorised Treatment Facility (ATF). Legally, all cars recycled by an ATF must be issued with a CoD.

COMEXT

Statistical database on trade of goods managed by Eurostat

De-pollution
Removal or treatment of components listed in ANNEX I of Directive 2000/53/EC, such as BATT, liquefied gas tanks; removal or neutralization of potential explosive components (e.g. air bags), removal and separate collection and storage of fuel, motor oil, transmission oil, gearbox oil, hydraulic oil, cooling liquids, antifreeze, brake; fluids, air-conditioning system fluids and any other fluid contained in the end-of-life vehicle, unless they are necessary for the reuse of the parts concerned; removal, as far as feasible, of all components identified as containing mercury (Directive 2000/53/EC).

Dismantling
Treatment operations in order to promote recycling as listed in ANNEX I of Directive 2000/53/EC, including removal of catalysts, removal of metal components containing copper, aluminium, and magnesium if these metals are not segregated in the shredding processes, removal of tyres and large plastic components (bumpers, dashboard, fluid containers, etc.), if these materials are not segregated in the shredding process in such a way that they can be effectively recycled as materials, and removal of glass. 16

Economic operators
Producers, distributors, collectors, motor vehicle insurance companies, dismantlers, shredders, recoverees, recyclers and other treatment operators of end-of-life vehicles, including their components and materials (Directive 2000/53/EC).

ELV Guidance
Guidance How to report on end-of-life vehicles according to Commission Decision 2005/293/EC describes the scope of the ELV directive and provides guidance to compile a quality report covering the ELV rates for reuse/recovery and reuse/recycling.

Export/ Import of used vehicles

A vehicle running in a foreign country with registration plates from the country of origin is not considered as exported unless it is re-registered in the country of destination. Most MS apply the rule that all residents must register their vehicles in the country of their main residence.

Extra-EU trade
Refers to transactions with all countries outside of the EU: the rest of the world except for the EU.

Fleet of motor vehicles
A total number of vehicles on the roads. The 27 European Union (EU-27) member countries had a fleet of over 256 million in 2008, and passenger cars accounted for 87% of the union's fleet. The five largest markets, Germany (17.7%), Italy (15.4%), France (13.3%), the UK (12.5%), and Spain (9.5%), accounted for 68% of the region's total registered fleet in 2008.[13][14] The EU-27 member countries had in 2009 an estimated ownership rate of 473 passenger cars per 1000 people.[15]

Hulk
Car body after de-pollution and dismantling.

Intra-EU trade
Refers to transactions occurring within the EU.

POLK
Polk is now part of IHS Automotive. With the addition of Polk, IHS Automotive provides expertise and predictive insight across the entire automotive value chain from product inception-across design and production-to the sales and marketing efforts used to maximize potential in the marketplace. No other source provides a more complete picture of the automotive industry. For more information about IHS Automotive, please visit www.ihs.com/automotive.

Producer
A vehicle manufacturer or the professional importer of a vehicle into a Member State (Directive 2000/53/EC).

Registration/ de-registration/ re-registration
These terms are not applied in the same manner across the EU and within different domains (e.g. vehicle registration according to Article 3(1) of Directive 1999/37/EC and ELV treatment according to Article 5(3) of Directive 2000/53/EC). Definitions for the purpose of this questionnaire:

- ‘Registration’ should be understood as the administrative authorisation for the entry into service in road traffic of a vehicle, involving the identification of the latter and the issuing to it of a serial number, to be known as the registration number[1]. ‘Registration’ is applied for the first registration of a vehicle;
- ‘Re-registration’ is applied for two cases: 1) when a vehicle is temporarily de-registered (see below) and registered again in the same country; 2) when a vehicle is transferred to another country and re-registered in this new country.
- ‘De-registration’ should be understood as a ‘cancellation of a registration’, which means the cancellation of a Member State’s authorisation for a vehicle to be used in road traffic[2].
- ‘Temporary de-registration’[3] means that a vehicle is temporarily (for certain limited time) either fully or in limited manner not permitted to be used in road traffic. ‘Temporary de-registration’ is typically applied by dealers when they keep used vehicles on private ground (in this case vehicles may obtain special dealer plates) but also can be applied by private person in order to avoid paying tax for a vehicle when the vehicle is not in use
- ‘Permanent cancellation of registration’ occurs when a vehicle has been treated as an ELV[4]. A Certificate of Destruction (CoD) is a condition for de-registration of the ELV[5]. ‘Final de-registration’ is used as a synonym term.

Shredder

Any device used for tearing into pieces or fragmenting end-of life vehicles, including for the purpose of obtaining directly reusable metal scrap (Directive 2000/53/EC).

Treatment
Any activity after the end-of life vehicle has been handed over to a facility for depollution, dismantling, shearing, shredding, recovery or preparation for disposal of the shredder wastes, and any other operation carried out for the recovery and/or disposal of the end-of life vehicle and its components;

Unknown whereabouts of ELV
The complementary flows are referred to as unknown whereabouts of ELV. These are vehicles which are not reported; they are neither registered as part of the European vehicle stock (also called "vehicle fleet" or "vehicle parc"), nor as vehicles exported from the EU (termed extra EU-Export in COMEXT), nor as ELVs (Eurostat). (Mehlhart, G. et.al, (2011).) http://elv.whereabouts.oeko.info/index.php?id=58

Used Car
A used car, a pre-owned vehicle, or a secondhand car, is a vehicle that has previously had one or more retail owners. Used cars are sold through a variety of outlets, including franchise and independent car dealers, rental car companies, leasing offices, auctions, and private party sales.

Vehicle registration certificate
An official document providing proof of registration of a motor vehicle. It is used primarily by governments as a means of ensuring that all road vehicles are on the national vehicle register, but is also used as a form of law enforcement and to facilitate change of ownership when buying and selling a vehicle. In the European Economic Area vehicle registration certificates are govern by the European directive 1999/37/EC.[1].The data on numbers of registered vehicles in Europe are available from official sources, i.e. Eurostat

Vehicle deregistration
Cancelling your vehicle's registration removes the vehicle from the Motor Vehicle Register, which means the vehicle owner can no longer lawfully use the vehicle on the roads. Vehicle deregistration may occur only at the request of the vehicle's registered person or an insurance company.

Vehicle park
European vehicle stock or vehicle fleet

Annex 1.4 WEEE Specific Terms

Complementary flow
All flows of WEEE that are discarded through other channels, collected and recycled are called complementary flows (Wielenga et al., 2011).

Clearing House
A central agency for the collection, classification, and distribution especially of information. Clearing houses may be of public or private nature. In the context of this report, their aim is to coordinate the activities of Compliance Schemes (for BATT and WEEEs) at national level.

Collection
The gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport to a waste treatment facility (Directive 2008/98/EC).

Dealer

Any undertaking which acts in the role of principal to purchase and subsequently sell waste, including such dealers who do not take physical possession of the waste (Directive 2008/98/EC).

Disposal
Any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I sets out a non-exhaustive list of disposal operations (Directive 2008/98/EC).

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

Harvesting or Scavenging
Removal of valuable components, only considering reuse or material value in e.g. compressors from temperature exchange equipment, hard disks, memory and other small IT components. Harvesting implies pre-treatment in a regulated environment. Scavenging implies theft from whole units in storage.

Mono flows of WEEE (pure WEEE flow)
A mono-flow contains devices which are financially attractive to the market. Mono-flows of WEEE are scrap metals flows that (almost) exclusively contain WEEE products (Wielenge et al., 2011).

Non-treatment
The term non-compliant does not necessarily imply substandard treatment, but rather refers to these quantities not being declared to national/ EU levels. Other terms commonly used are complementary treatment or unreported treatment.

Registered (reported) Flows/Collection
The quantities of WEEE reported to national registers and Eurostat WEEE database are called registered flows (Wielenga et al., 2011).

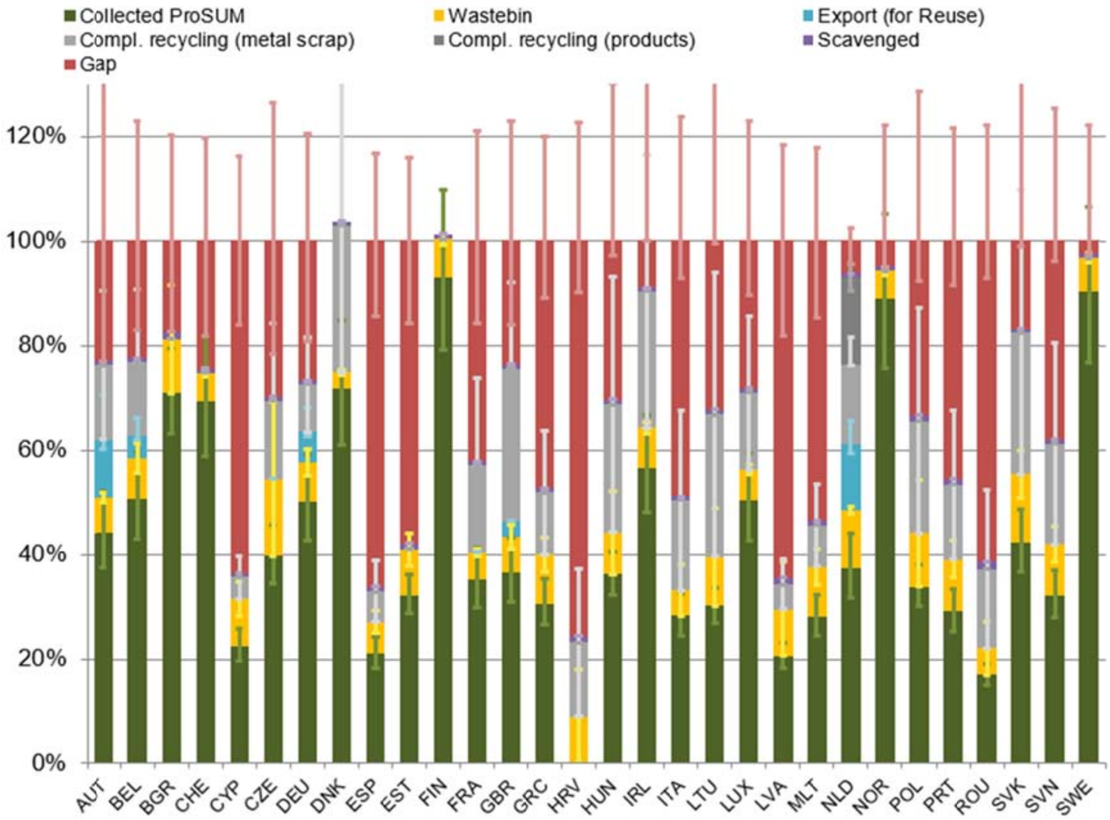
Unreported flow
The unreported flows are declared to regional authorities under different reporting regimes.

WEEE in mixed metal scrap (WEEE in light iron fraction, pre-shredder material)
Mixed flows (pre-shedder material) can contain metals from all possible sources ad these mostly contains limited percentage of WEEE (Wielenge et al., 2011).

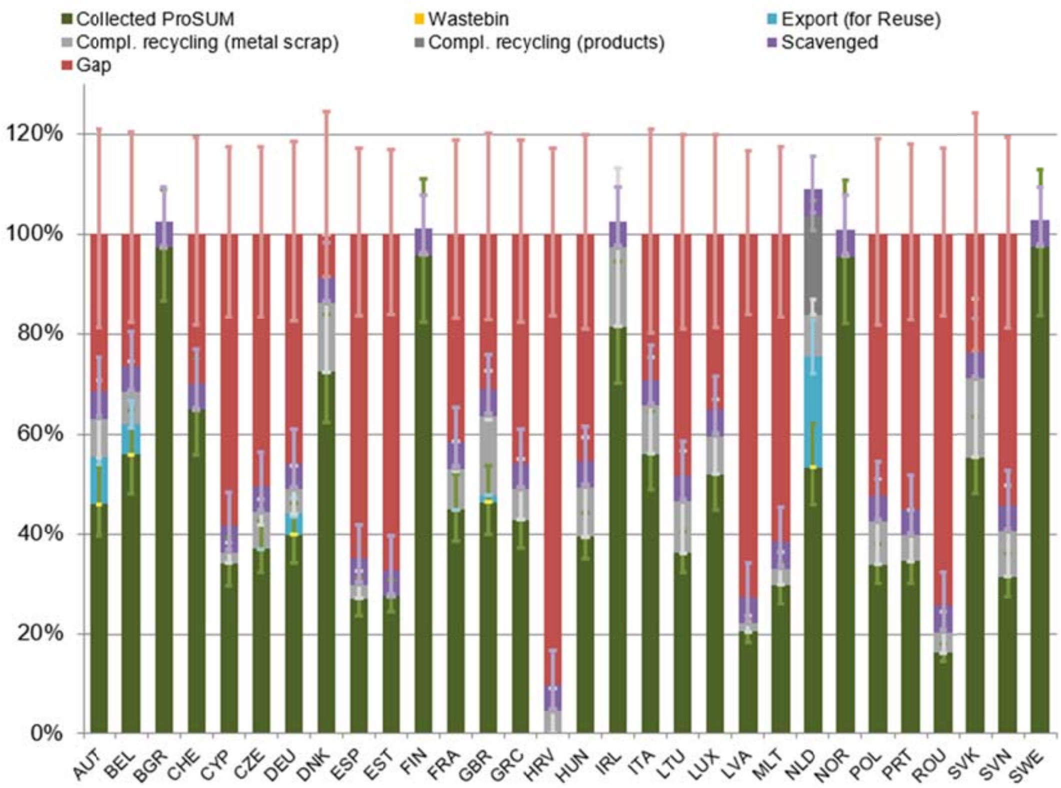
WEEE from private households
WEEE which comes from private households and WEEE which comes from commercial, industrial, institutional and other sources which, because of its nature and quantity, is similar to that from private households. Waste from EEE likely to be used by both private households and users other than private households shall in any event be considered to be WEEE from private households (Directive 2012/19/EC).

ANNEX 2 Complementary Flows Diagrams for 2010-2014

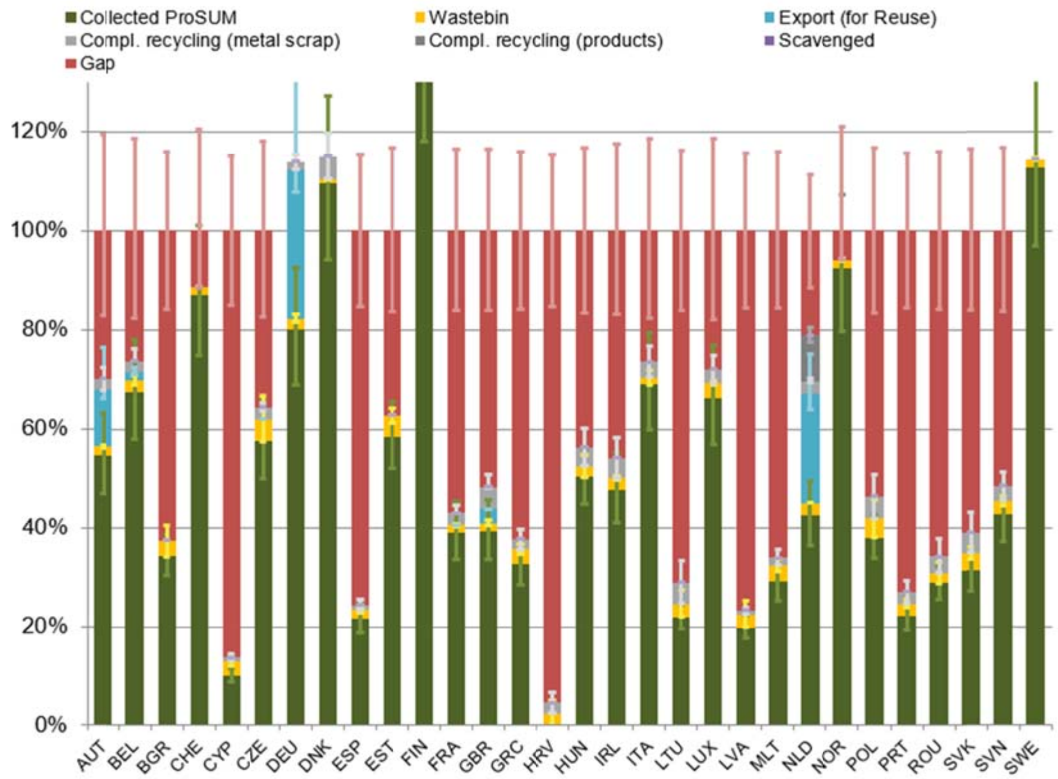
Annex 2.1 Total all collection categories, 2010



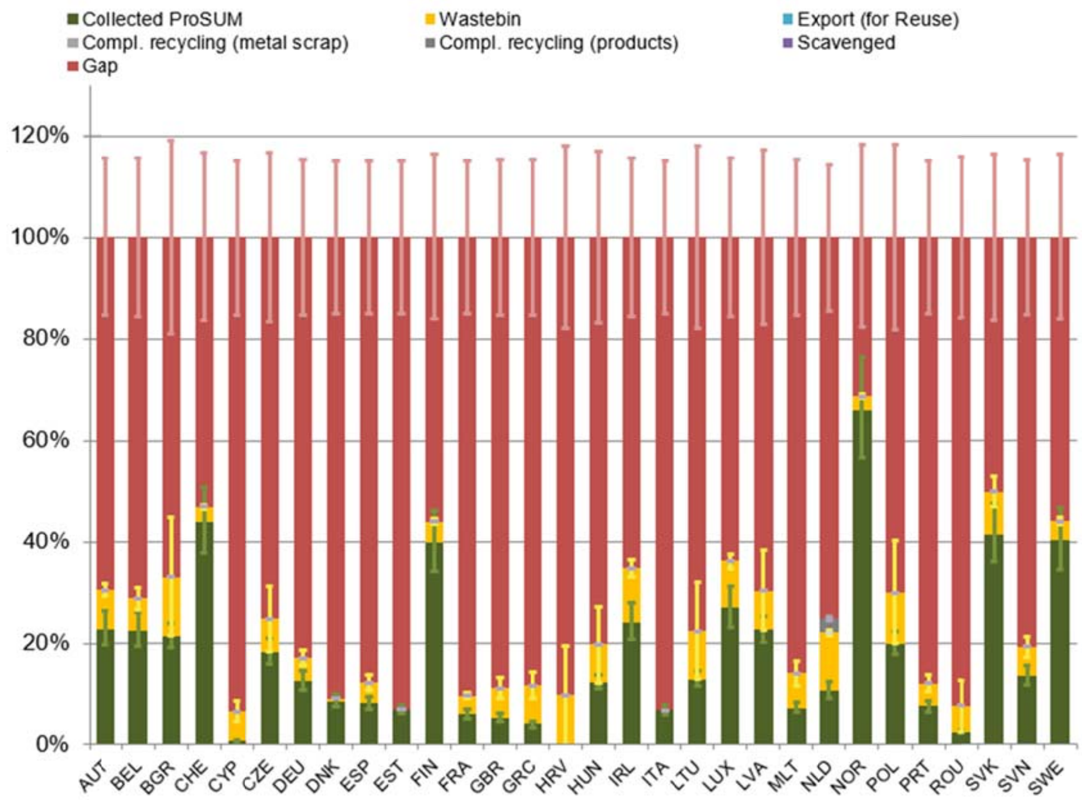
Cooling and Freezing, 2010



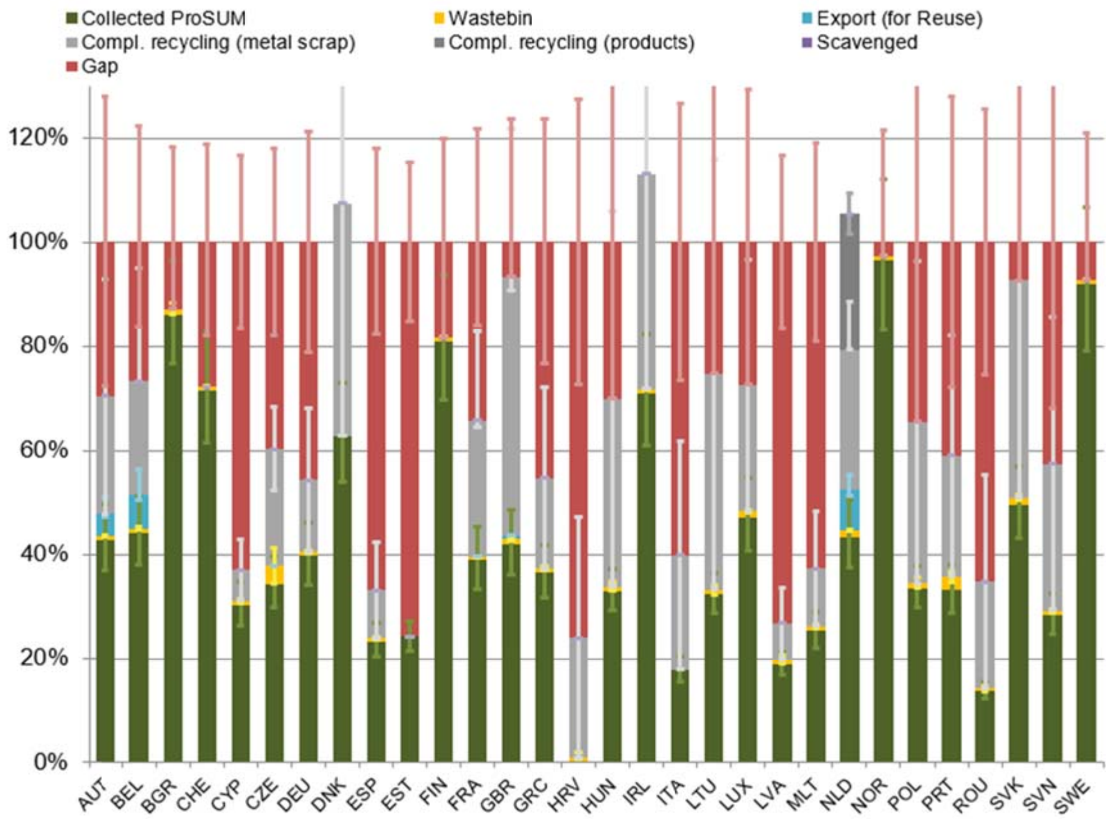
Screens, 2010



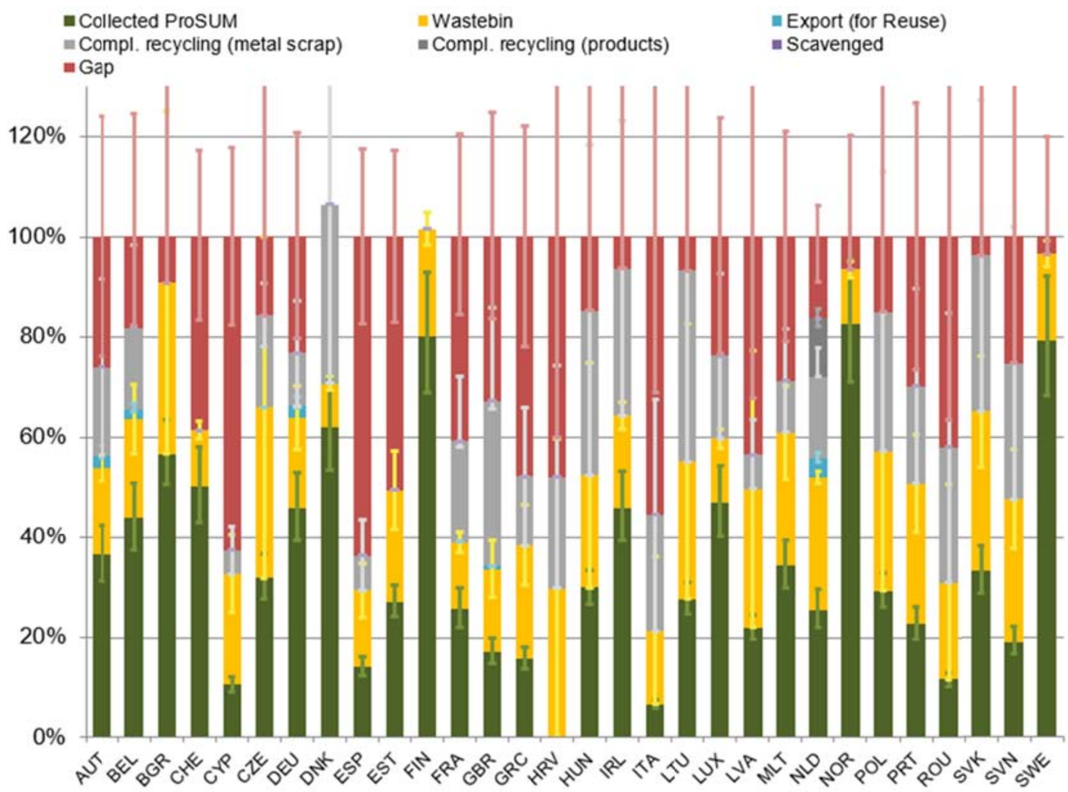
Lamps, 2010



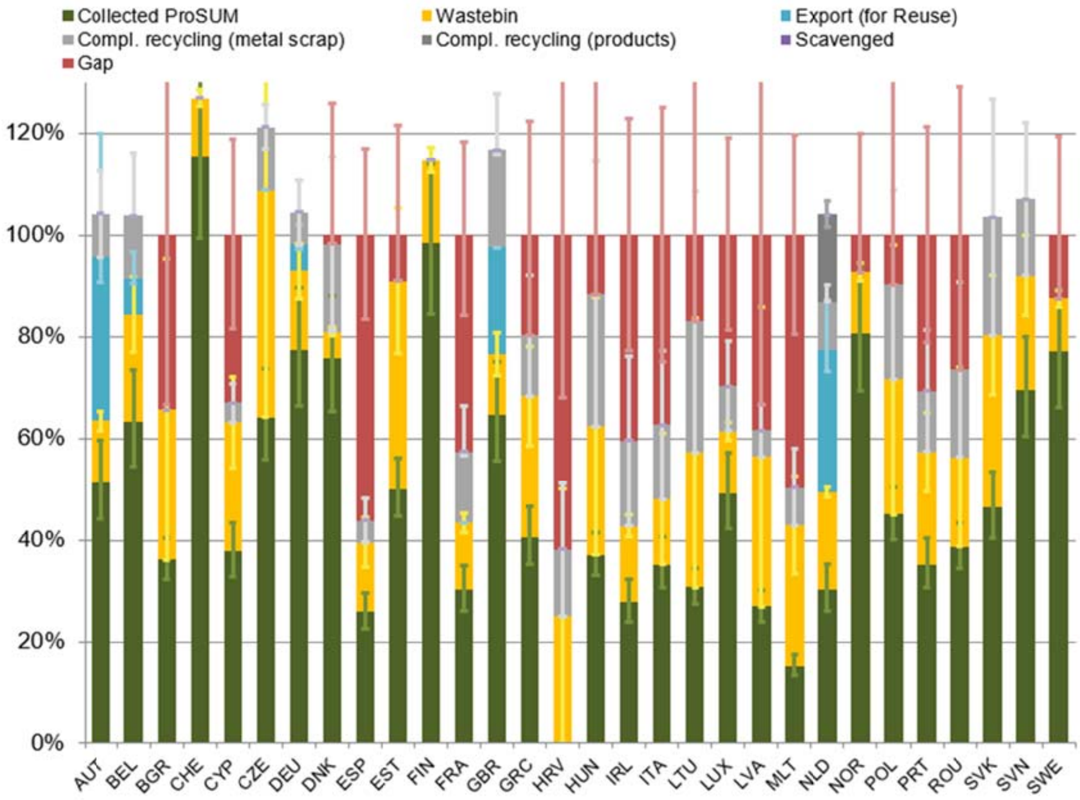
Large Household, 2010



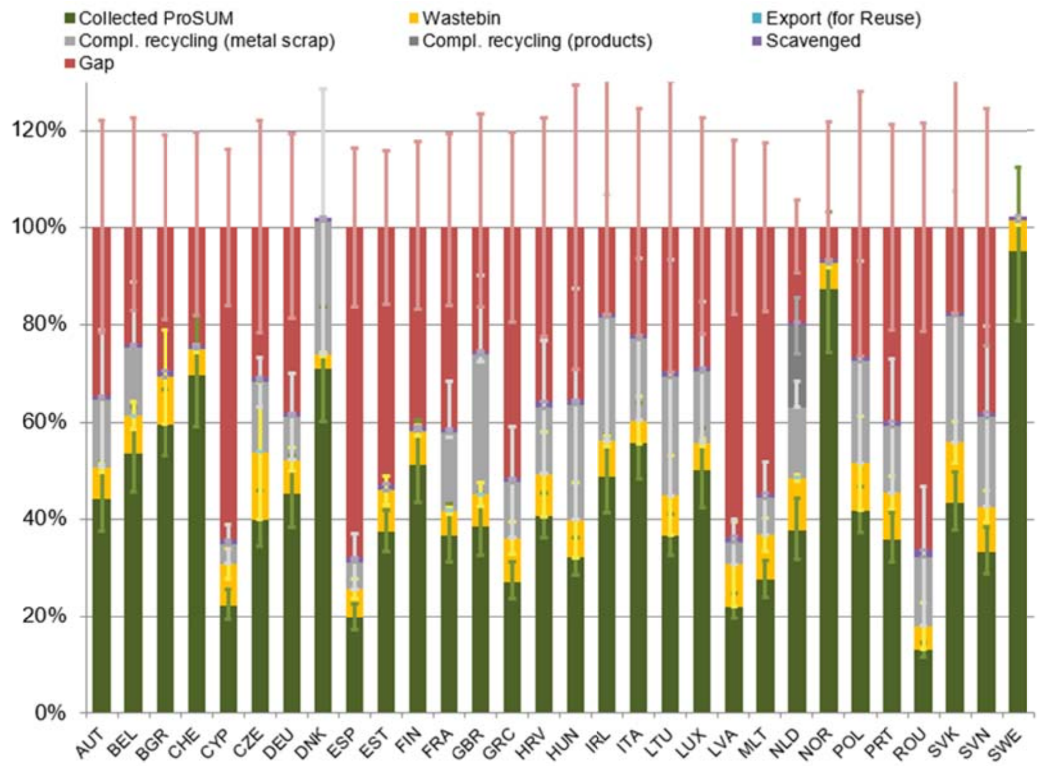
Small Household, 2010



Small IT, 2010

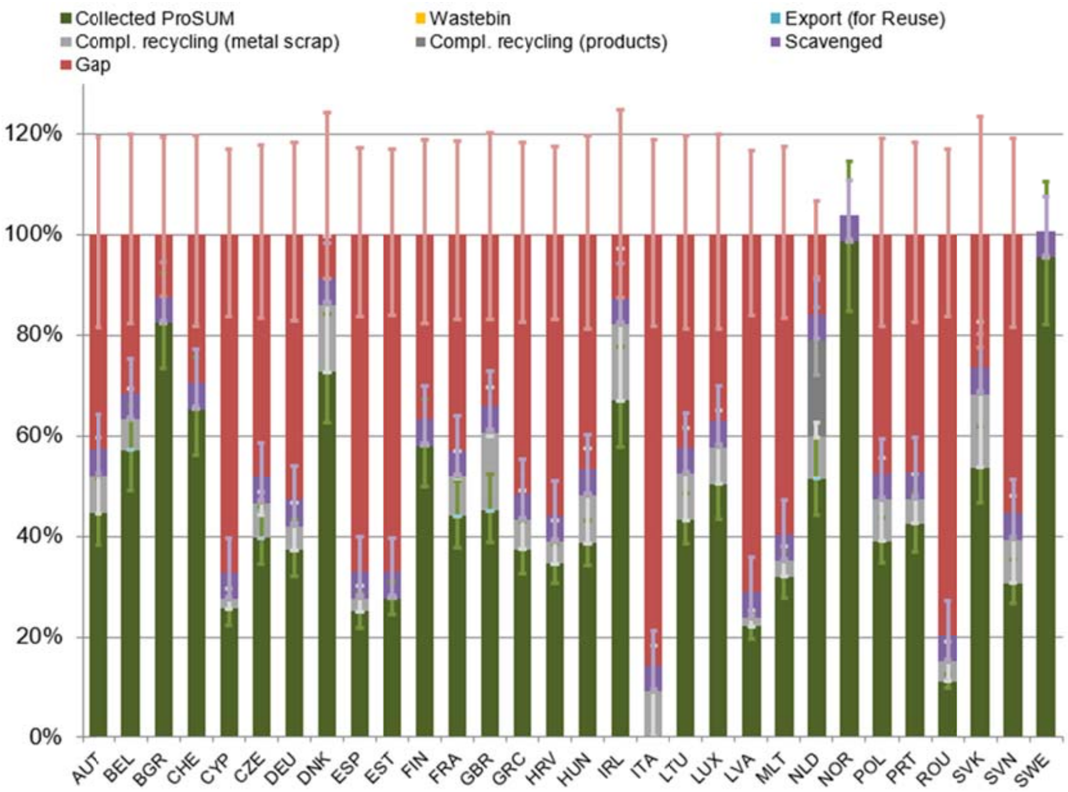


Annex 2.2 Total All Collection Categories, 2011



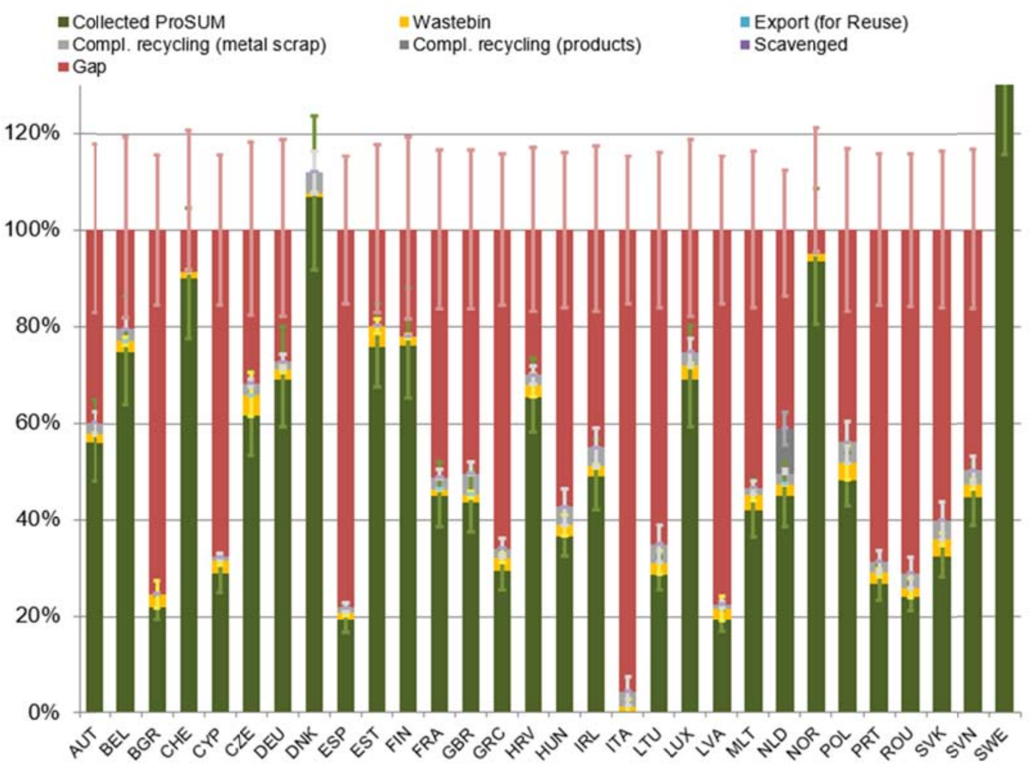
* CHE 2011, Source is WEEE Forum Key Figures. ITA collected is not included. Data is only available in 10 collection cat.

Cooling and Freezing, 2011



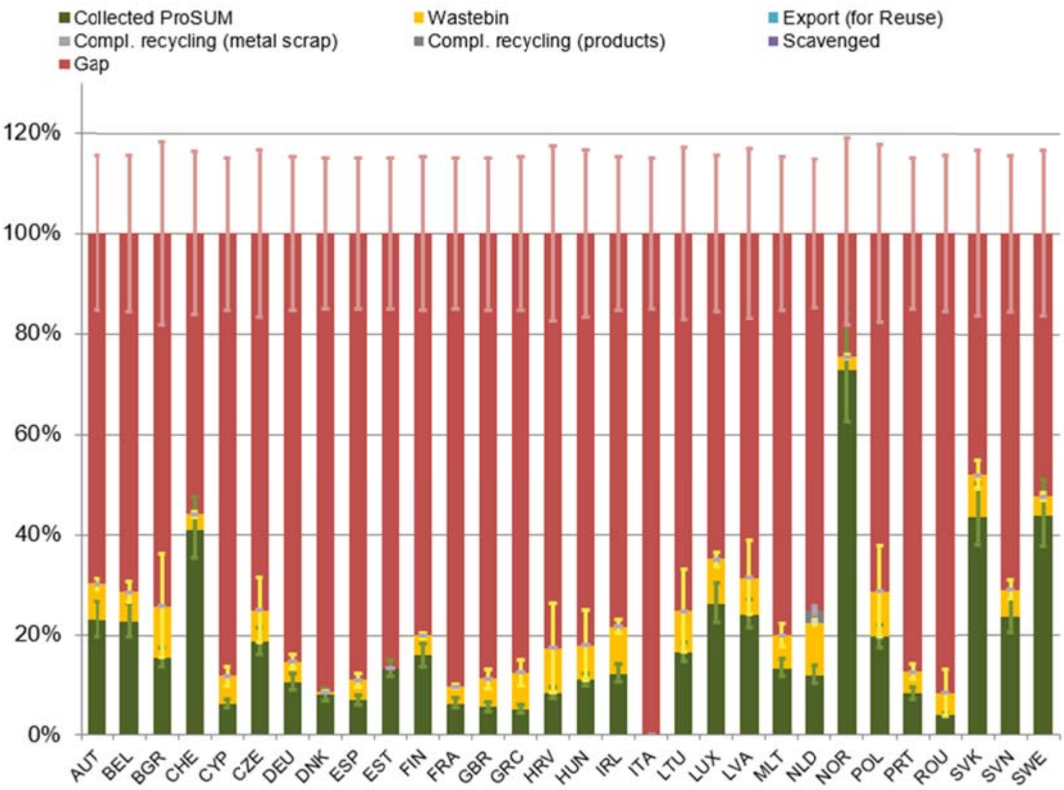
* CHE 2011, Source is WEEE Forum Key Figures. ITA collected is not included. Data is only available in 10 collection cat.

Screens, 2011



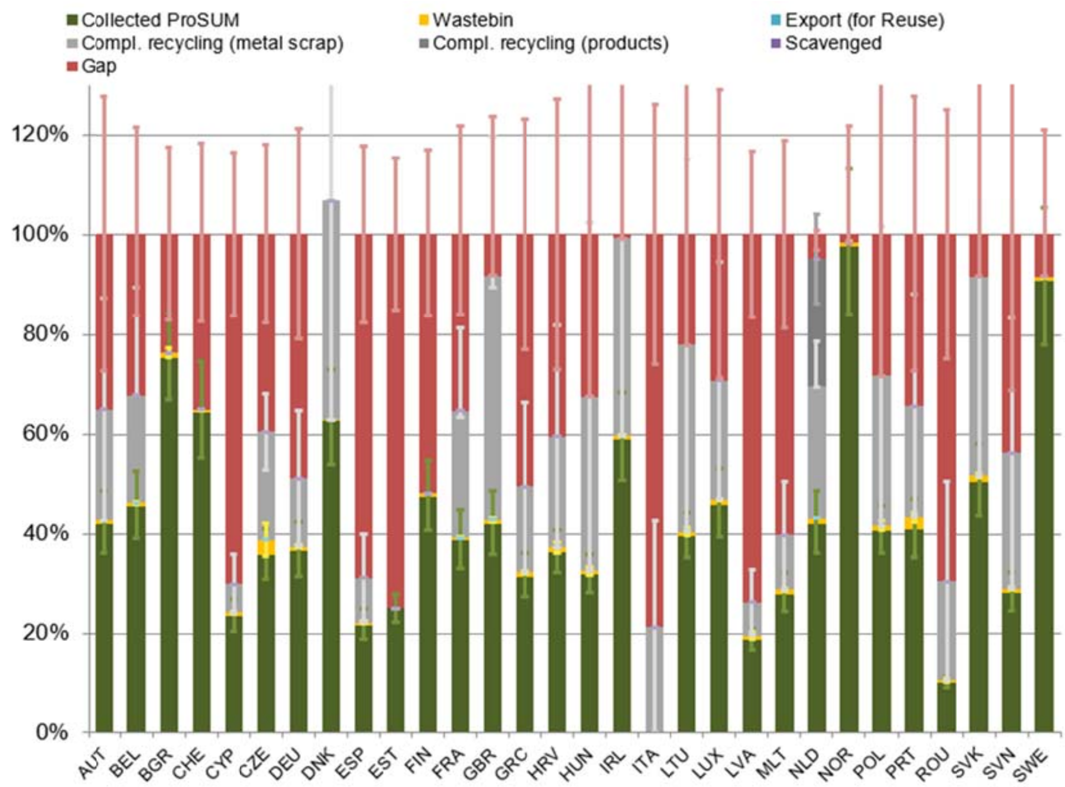
* CHE 2011, Source is WEEE Forum Key Figures. ITA collected is not included. Data is only available in 10 collection cat.

Lamps, 2011



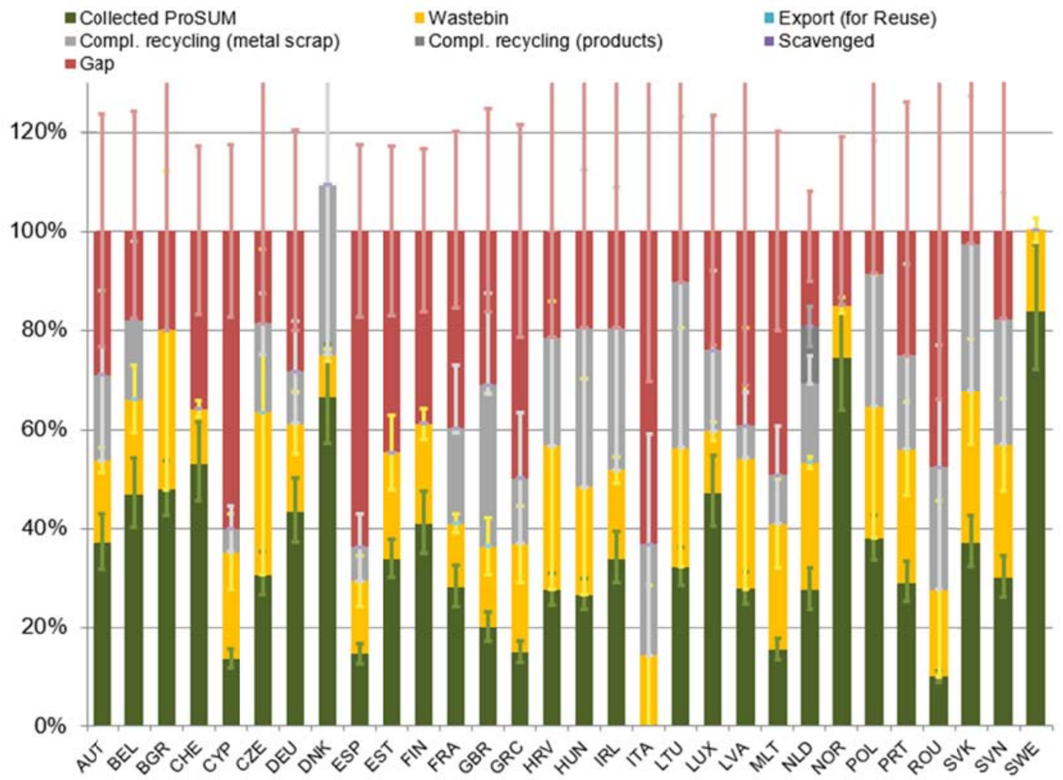
* CHE 2011, Source is WEEE Forum Key Figures. ITA collected is not included. Data is only available in 10 collection cat.

Large Household, 2011



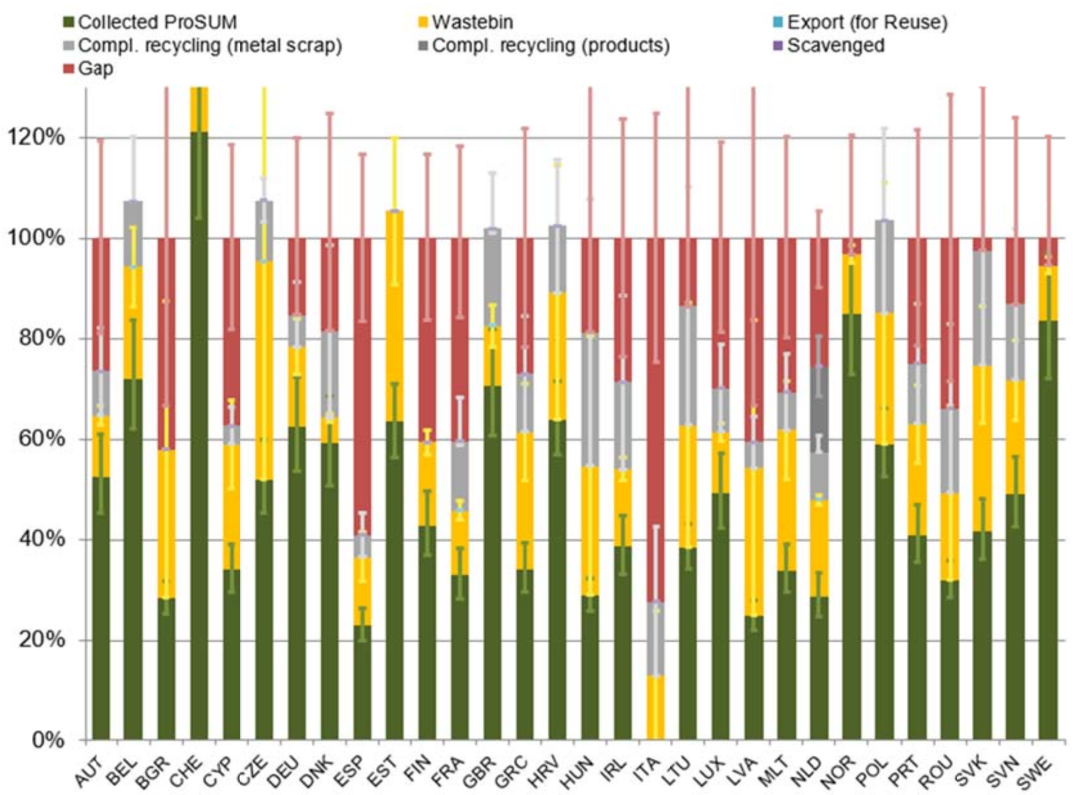
* CHE 2011, Source is WEEE Forum Key Figures. ITA collected is not included. Data is only available in 10 collection cat.

Small Household, 2011



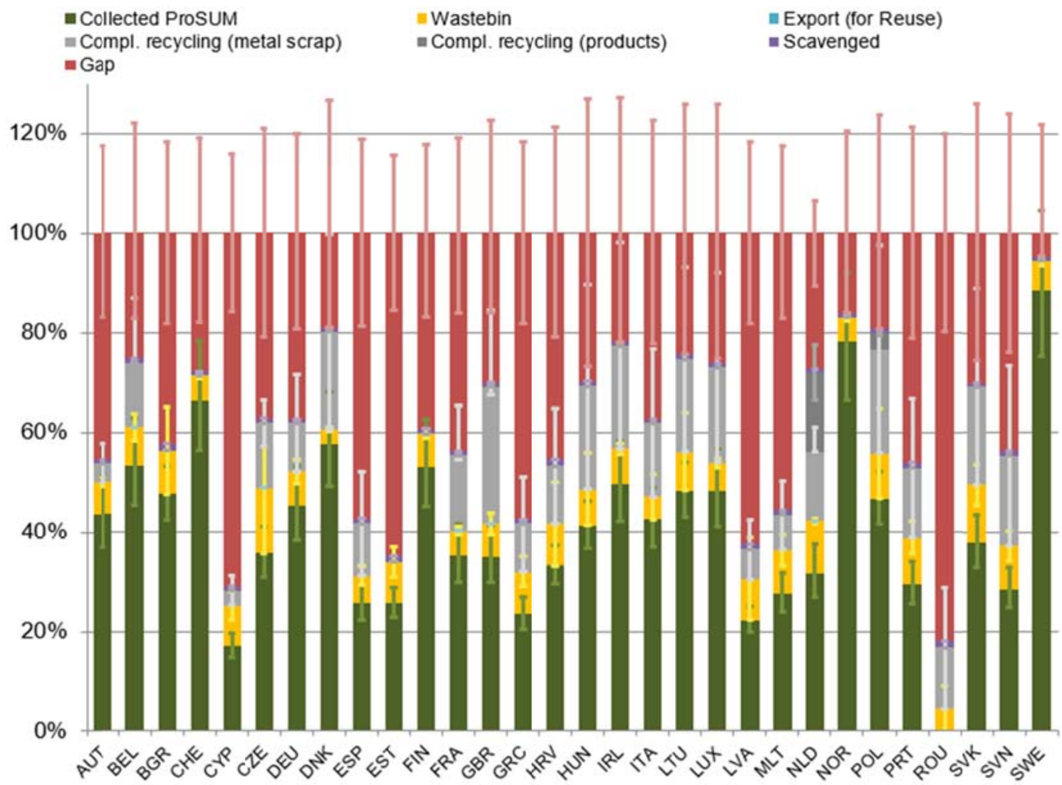
* CHE 2011, Source is WEEE Forum Key Figures. ITA collected is not included. Data is only available in 10 collection cat.

Small IT, 2011



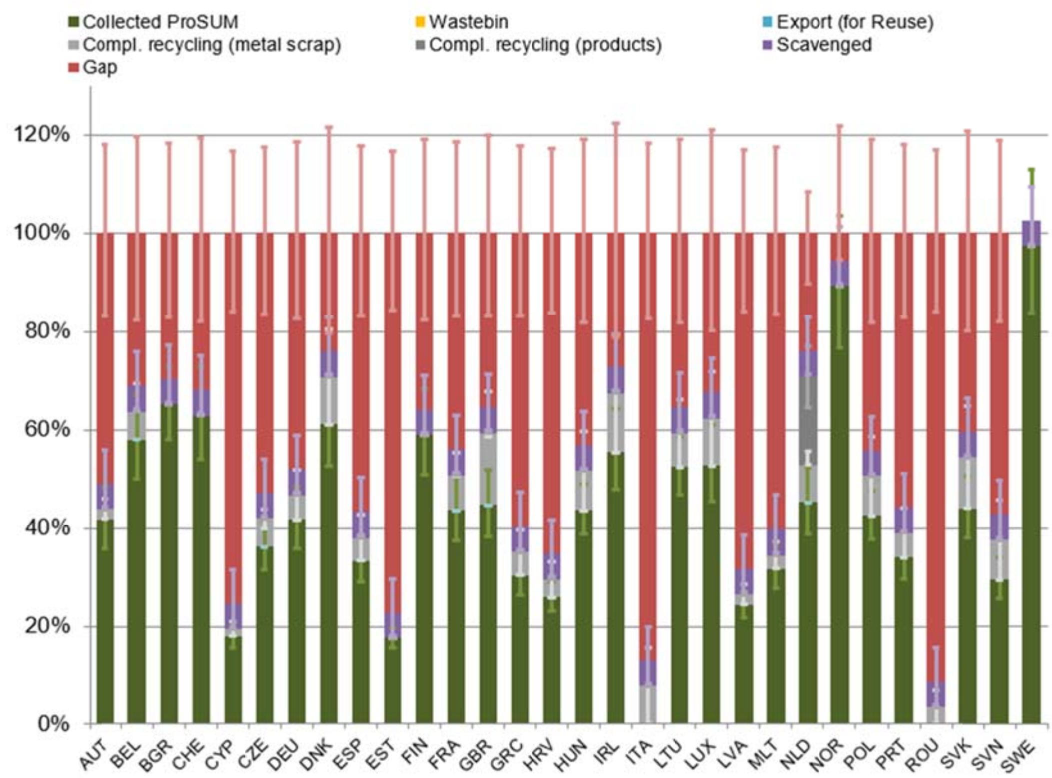
* CHE 2011, Source is WEEE Forum Key Figures. ITA collected is not included. Data is only available in 10 collection cat.

Annex 2.3 Total All Collection Categories, 2013



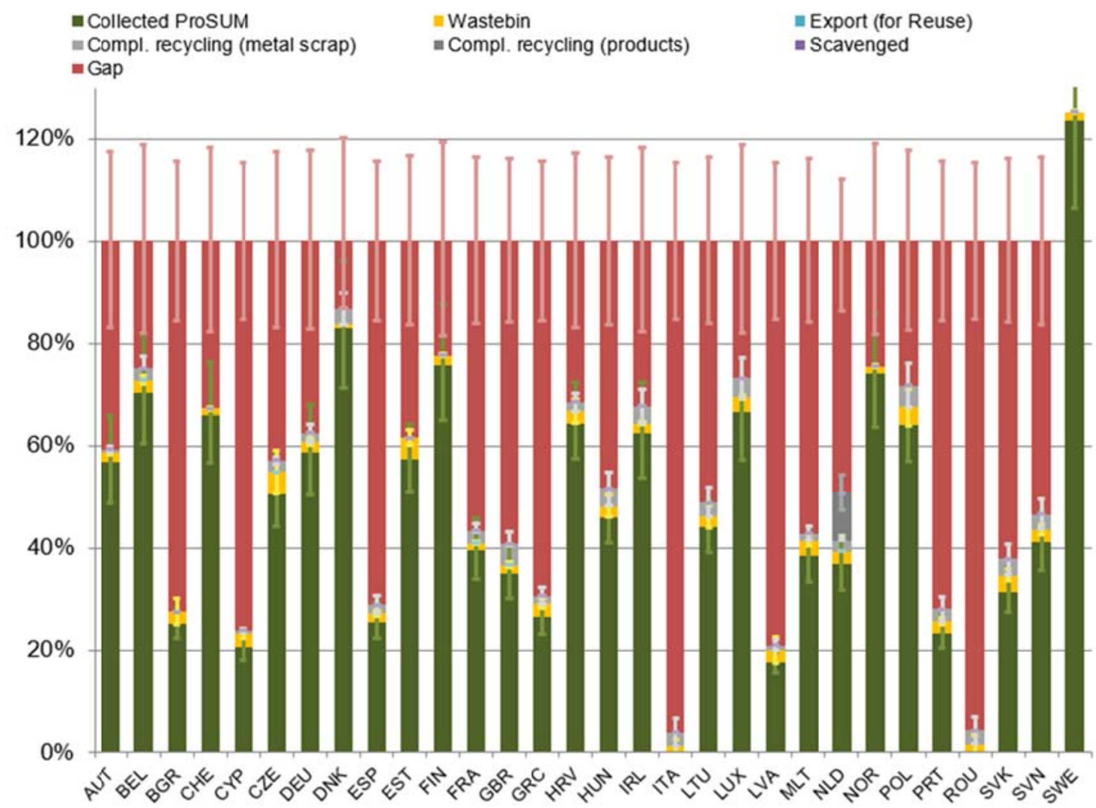
* ITA collected is not included. Data is only available in 10 collection cat.

Cooling and Freezing, 2013



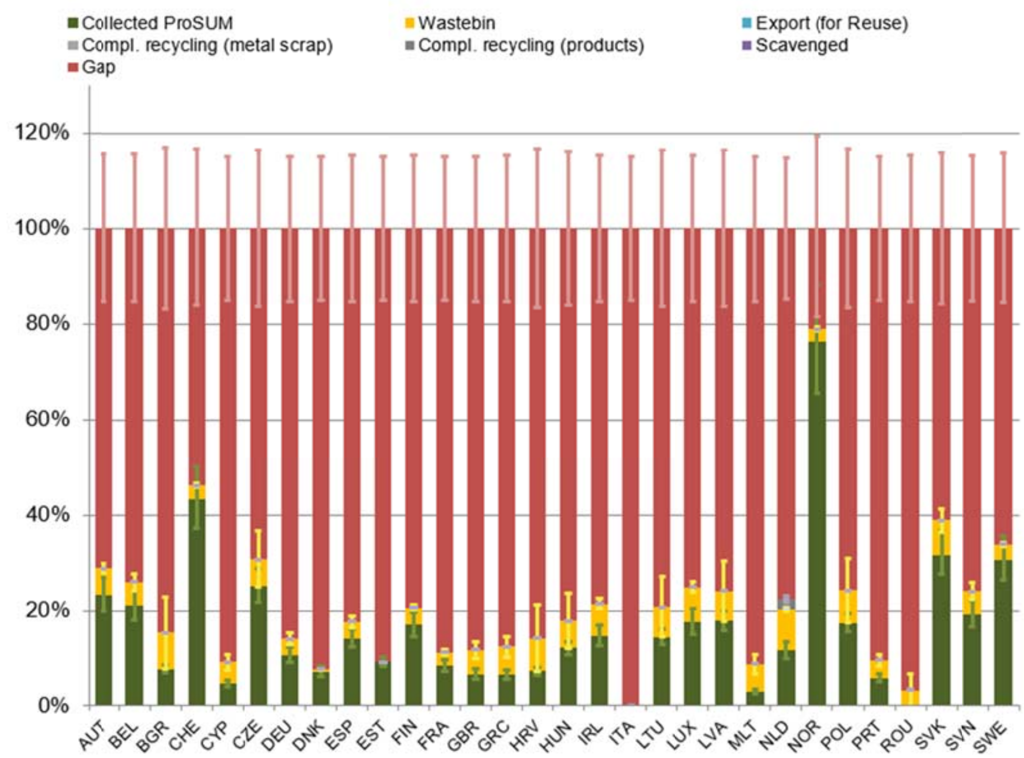
* ITA collected is not included. Data is only available in 10 collection cat.

Screens, 2013



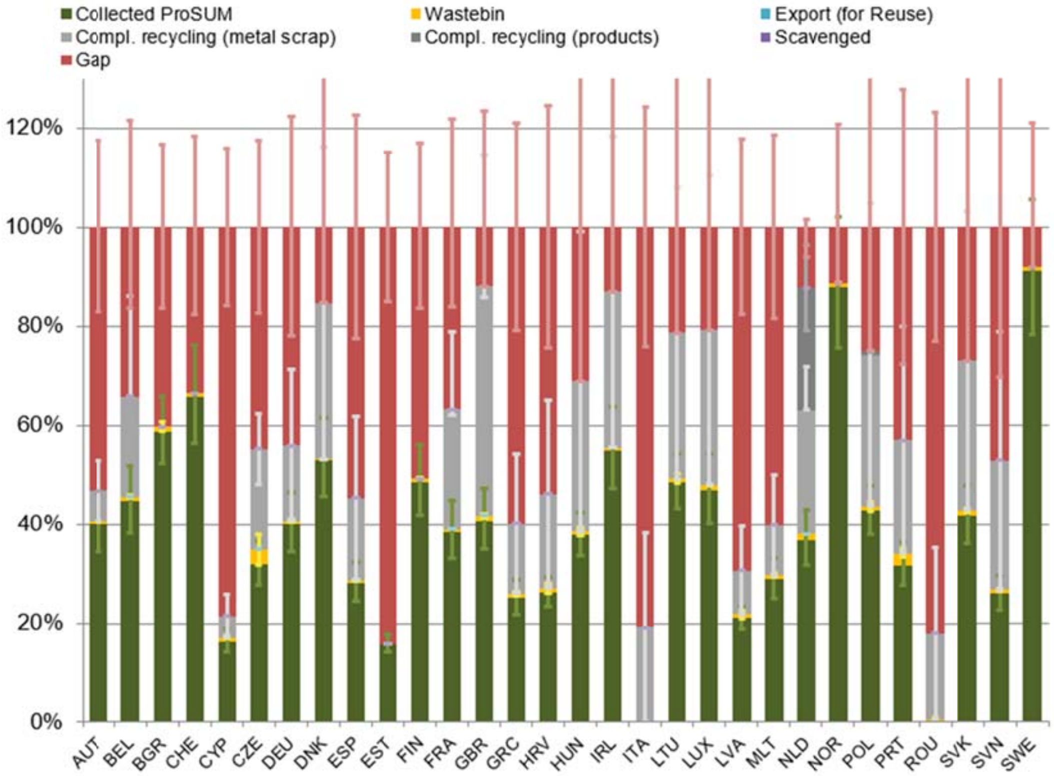
* ITA collected is not included. Data is only available in 10 collection cat.

Lamps, 2013



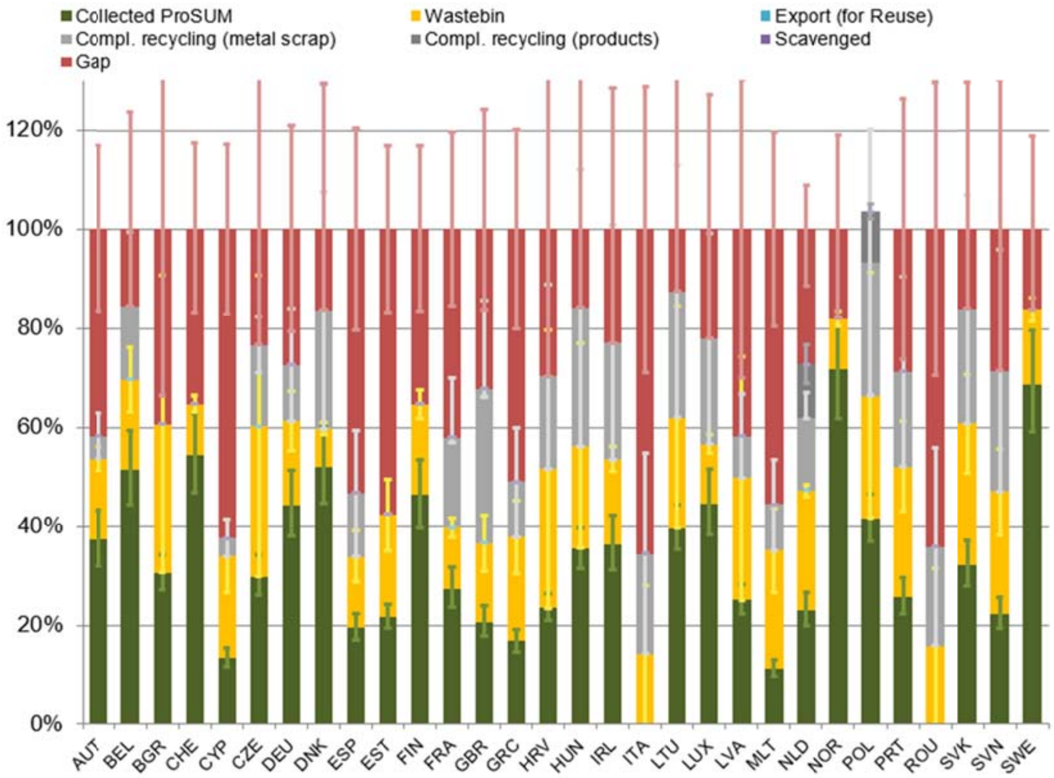
* ITA collected is not included. Data is only available in 10 collection cat.

Large Household, 2013



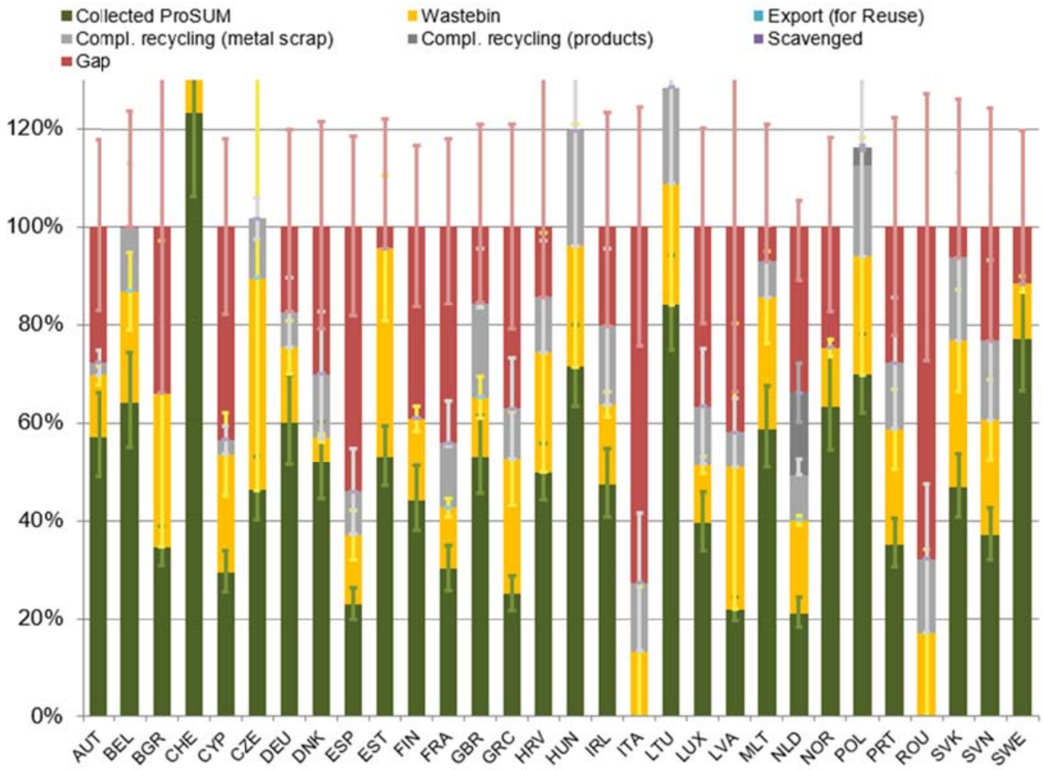
* ITA collected is not included. Data is only available in 10 collection cat.

Small Household, 2013



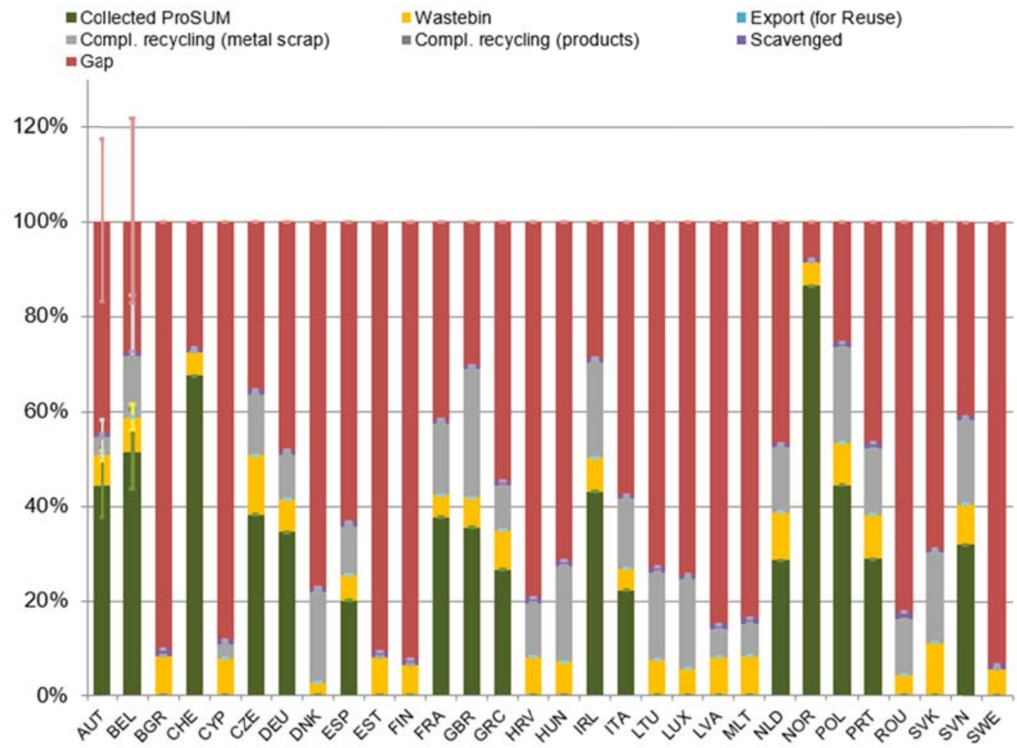
* ITA collected is not included. Data is only available in 10 collection cat.

Small IT, 2013



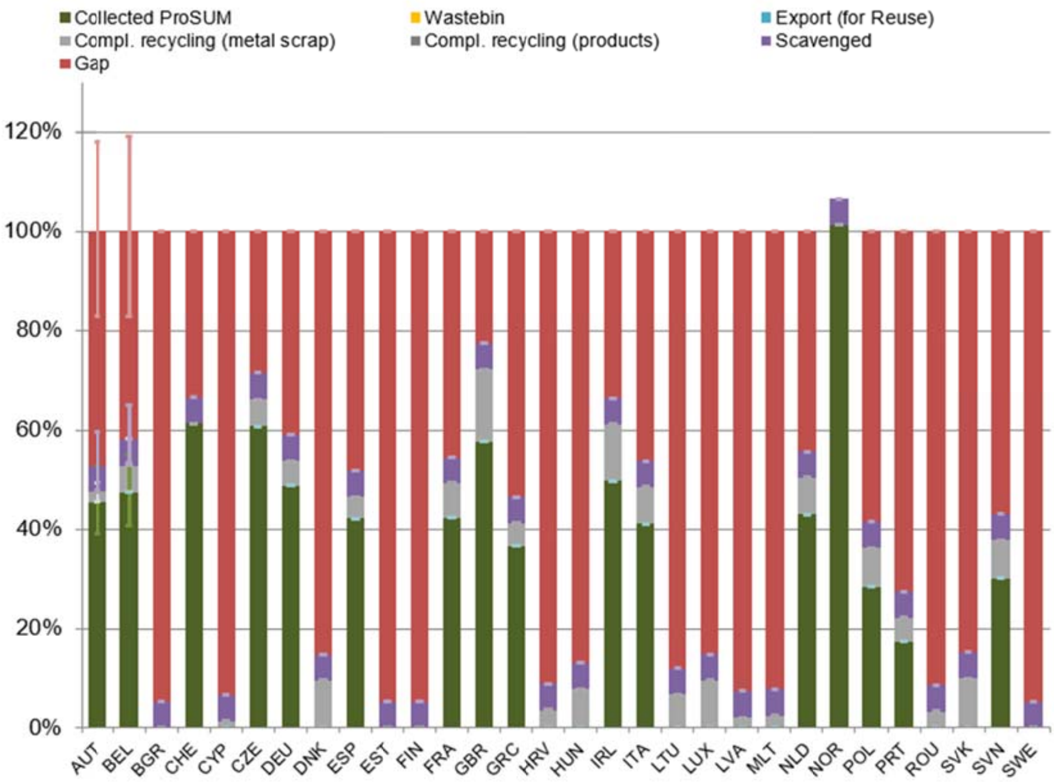
* ITA collected is not included. Data is only available in 10 collection cat.

Annex 2.4 Total All Collection Categories, 2014



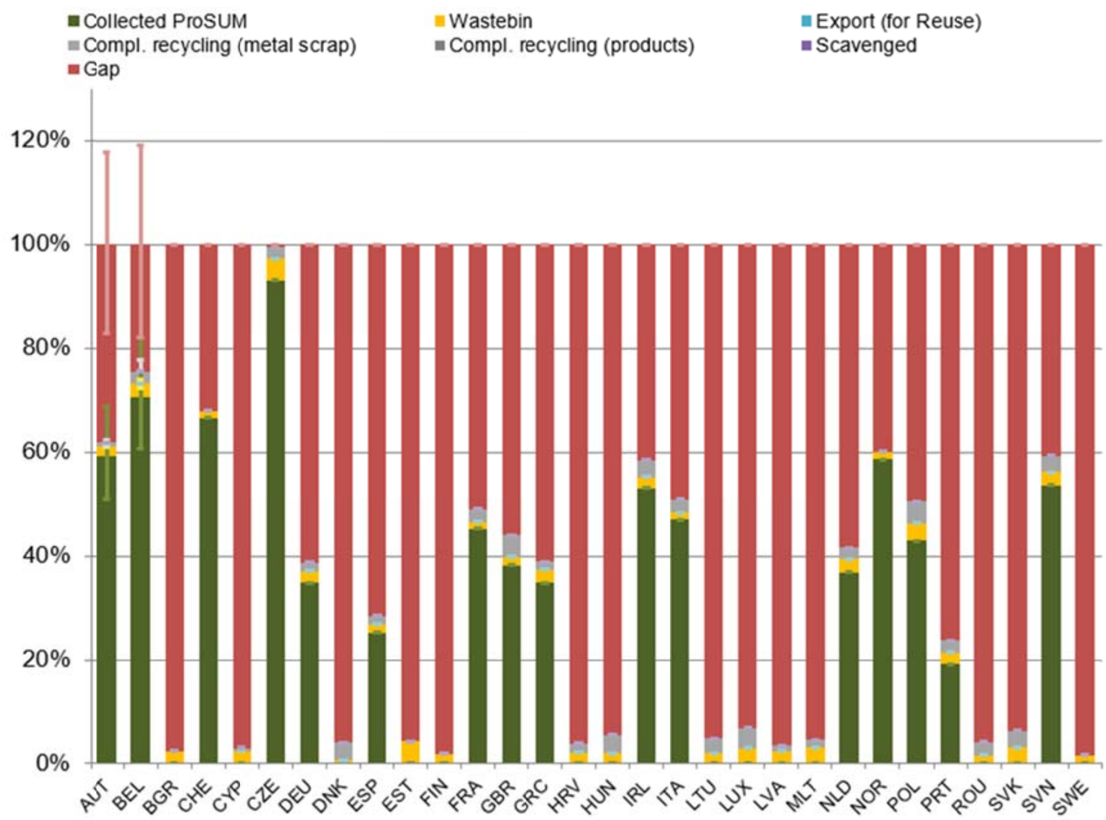
* For 2014, no Eurostat collected data is available yet. WEEE Forum Key Figures 2014 used instead.

Cooling and Freezing, 2014



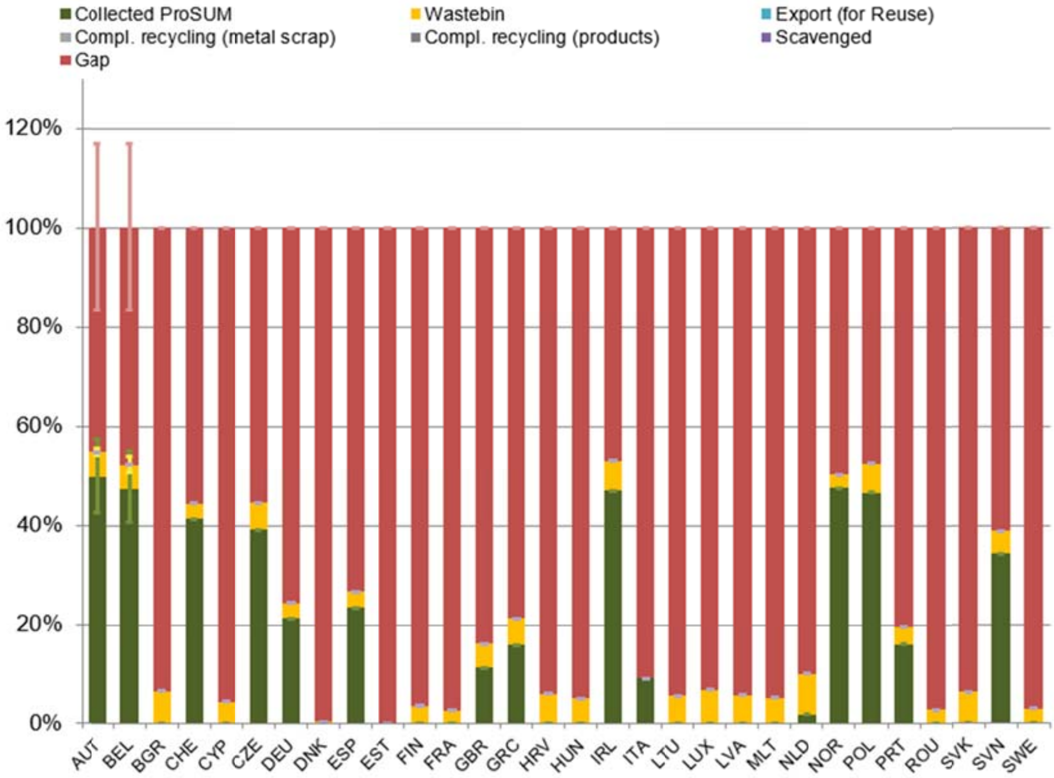
* For 2014, no Eurostat collected data is available yet. WEEE Forum Key Figures 2014 used instead.

Screens, 2014



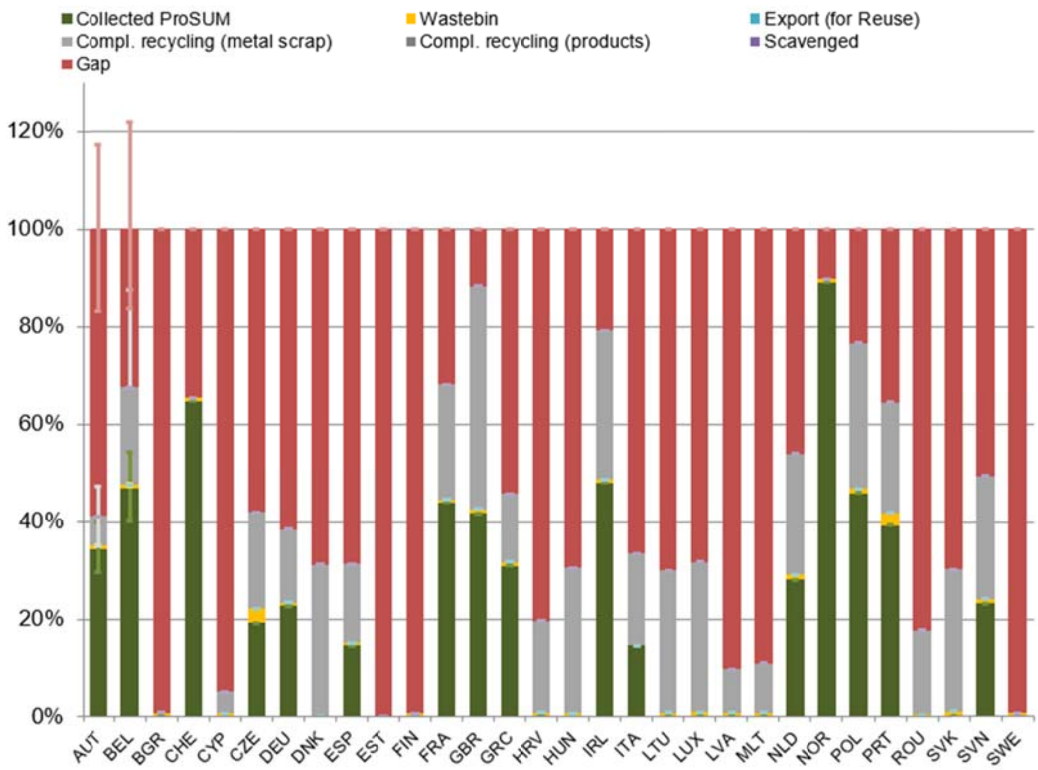
* For 2014, no Eurostat collected data is available yet. WEEE Forum Key Figures 2014 used instead.

Lamps, 2014



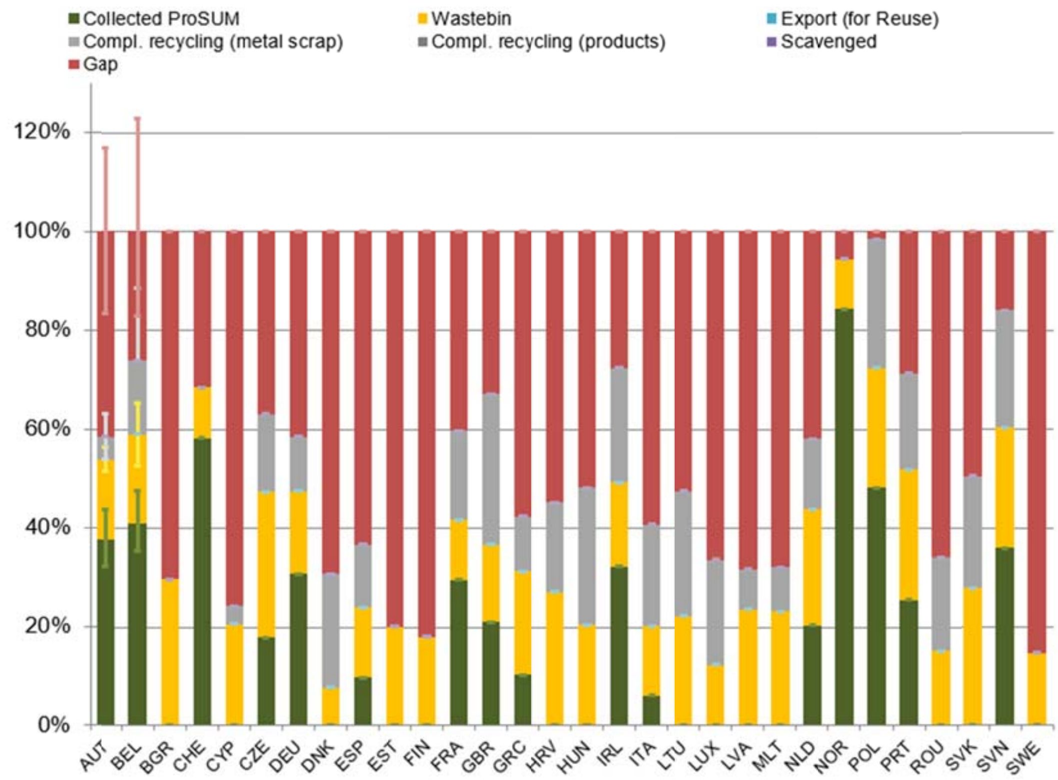
* For 2014, no Eurostat collected data is available yet. WEEE Forum Key Figures 2014 used instead.

Large Household, 2014



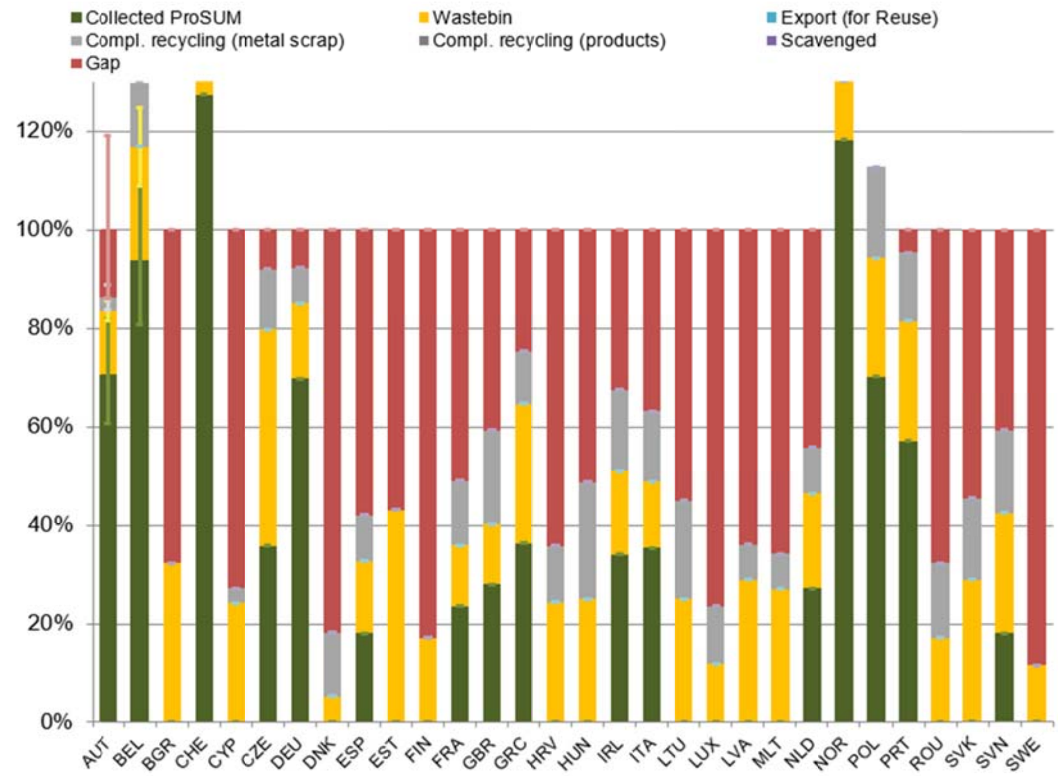
* For 2014, no Eurostat collected data is available yet. WEEE Forum Key Figures 2014 used instead.

Small Household, 2014



* For 2014, no Eurostat collected data is available yet. WEEE Forum Key Figures 2014 used instead.

Small IT, 2014



* For 2014, no Eurostat collected data is available yet. WEEE Forum Key Figures 2014 used instead.