PolyCE

Post-Consumer High-tech Recycled Polymers for a Circular Economy

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Summary

To significantly enhance the use of recycled PCR WEEE plastics in new electronics applications, the first step is redesigning the recycling and recovery chain of WEEE. This deliverable investigates the current WEEE value chain with attention to material flows and mass balances. It provides an overview and identifies the crucial nodes of the WEEE chain. The adopted methodology includes the evaluation of the quantity of plastic put on the market, closely linking it with the amount of EEE POM. The availability of PCR e-plastic is correlated with the WEEE collection quantities. Therefore, WEEE in input and plastic in output from WEEE treatment facilities have been calculated. Qualitative assessment has been performed developing a matrix showing the plastic content of the actual EEE and WEEE flows at polymers level. The specifics of different WEEE streams have been taken into account and the correspondent supply chains compared.

Considering WEEE managed by takeback schemes, it results that more than 717,000 tonnes of WEEE plastics are potentially available in Europe for recycling. However, taking into account that the European collection rate (calculated as the percentage of the e-waste collected over the total e-waste generated) is about 38%, additionally there is a large amount of WEEE plastic that is not yet fully available to plastic recycling operators. Considering the gap between WEEE generated by consumers and WEEE actually collected by take-back schemes, it is possible to estimate that one additional million tons of WEEE plastics would be potentially available in Europe.

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1 Introduction

Task 3.1 of the PolyCE project aims to contribute to the objective of transforming the lifecycle of e-plastic materials into a more sustainable one. To significantly enhance the use of recycled plastics in new electronics applications the first step is redesigning the recycling and recovery chain of WEEE. Therefore, the current WEEE value chain with attention to material flows and mass balances was deemed a fundamental aspect of the PolyCE project. This deliverable provides an organic overview and identifies then the crucial nodes of the WEEE chain.

2 Aim and scope of the deliverable

Several aims are achieved in this task; these are listed here. The quantification of material flows along the entire value chain will allow to stress and highlight the relevance of the PolyCE project itself. According to the latest statistics, the European plastic demand is almost 50 Mt (2016) of which 6.2 % (~3.1 Mt) is in Electrical and Electronics Equipment (EEE) sector [1]. While the plastic recycling rate has increased in recent years, considering that only about 35% of WEEE in Europe is collected through official schemes [2], there is a large amount of WEEE and the related plastic that is treated with non-circular solutions (informal channels). The relevance of the WEEE sector is undeniable: in 2016, the world generated 44.7 million metric tonnes (Mt) of e-waste; by 2021 this figure is expected to increase to 52.2 million metric tonnes [2].

These figures show an emerging and urgent potential for recycling. However, to fully exploit this potential, it is necessary to identify the routes the materials are currently taking through a careful mapping exercise. Such an exercise is presented in this document.

Specifically, the presented deliverable aims to contribute to the achievement of the following objectives:

- identify the nodes of the WEEE value chain;
- evaluate the degree of traceability of plastic;
- perform a quantitative analysis: mass balance at the crucial nodes of WEEE value chain;
- perform a qualitative analysis: evaluation of the polymers availability in WEEE plastic;
- understand the WEEE plastic downstream recycling/value chain.

The outcomes of the deliverable 3.1 will be used as input for the task 3.2 *Product clustering for improved collection, sorting and reprocessing and optimized recycling economics, high purity PCR plastics streams and uptake* and therefore they will be used as the starting point for launching the demonstration trial of task 7.1.

3 The WEEE value chain

The EEE/WEEE value chain is constituted of several steps. However, although there are individual efforts to improve the collection and the recycling of plastics in electronic waste, the e-plastic value chain is still too fragmented.

The EEE/ WEEE value chain is long, complex and often not confined inside national boundaries. Starting from the raw material extraction phase, passing through the production step, and ending with the waste management activities, several subjects are involved along the life cycle of the electronic and electrical devices.

One of the key characteristic of the PolyCE project is its ambition to engage all the actors and stakeholders operating within the EEE/WEEE context (fig.1).

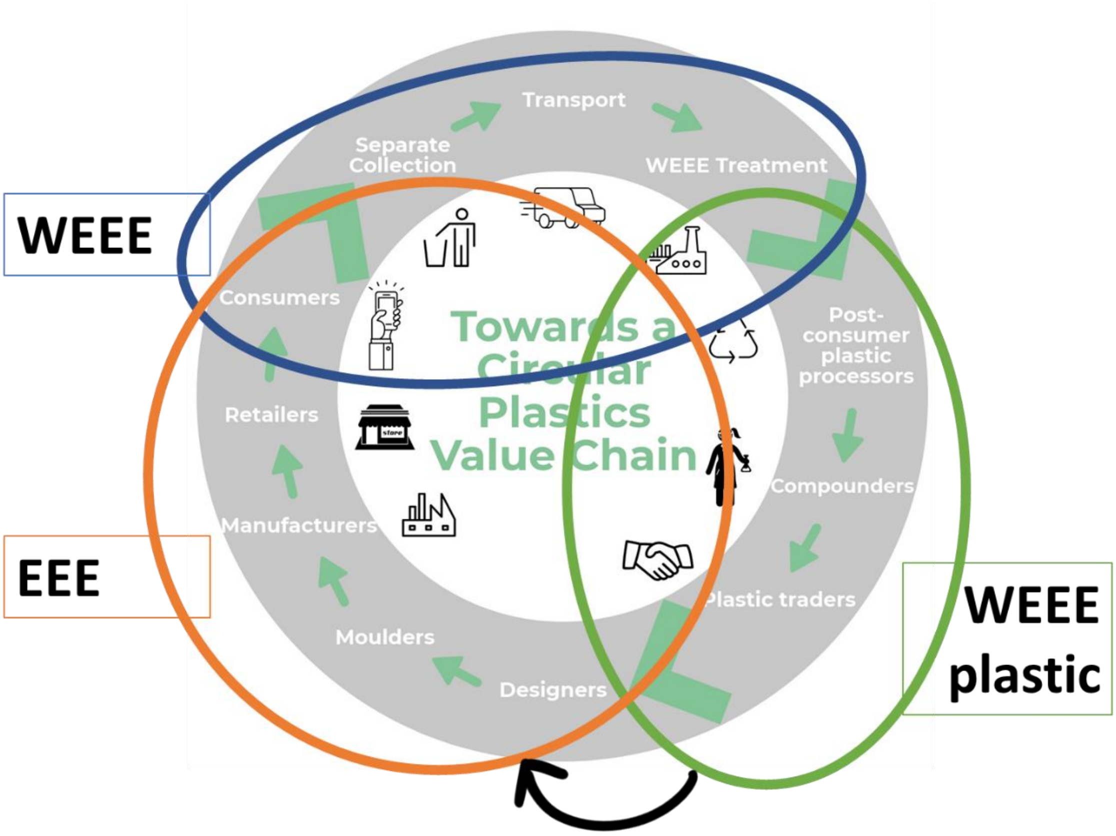

Figure 1. The PolyCE approach: embrace the entire EEE/WEEE value chain

A brief description of the main actors of the EEE/WEEE value chain is proposed below:

OEMs
The Original Equipment Manufacturer (OEMs) have several responsibilities along the studied value chain. For instance, manufacturers have the possibility to decide on the design and materials used in equipment placed on the market (in accordance with technical specifications an functionality requirements of the product).

This means, for example, that manufacturers can adopt *design for recyclin*g principles or can promote the use of recycled instead of virgin material (*design from recycling* approach).

Additionally, when the EEE becomes WEEE, OEMs must adhere WEEE Directive (2012/19/EU) [3]. The directive, based on extended producer responsibility (EPR), states that manufacturers and importers of EEE are responsible for the end of life of their products. In Europe, the WEEE Directive is implemented differently by different national authorities. OEMs may either setup their own system, or assign a third party to execute these regulations. In practice, OEMs often work collectively to exert their responsibility by setting up Producer Responsibility Organisations (PROs). PROs help collectives of manufacturers fulfil their legal requirements with respect to waste management. The organisation on WEEE takeback is organised differently per country.

Consumers
Along the WEEE stream flow there are several other actors involved in the (in)correct waste management. The role of consumers cannot be overlooked. The consumer, who decides to discard its EEE equipment, has the possibility to choose between different options according to the national regulation and city’s waste management system. However, consumers, that generally are not sufficiently aware of their essential role, ignore the available alternatives. The scarcity of information is one of the reasons why consumers too often simply continue to accumulate their WEEE in households or incorrectly dismantle it in municipal undifferentiated waste (this is especially the case for small WEEE). This phenomenon should not be underestimated. Consumer hoarding is a relevant barrier for the efficient management of WEEE. Prior research indicates that the tendency to store WEEE increases with the value of the item itself [4]. Given the outlined abundance of WEEE, it is evident that there is an urgent need to properly communicate how and where WEEE has to be disposed. Moreover entities such as businesses, municipalities, governments are also EEE users, and therefore are involved as well in WEEE production and disposal.

WEEE pre-processors
Moving ahead along the WEEE chain, the activities of the operators that collect, sort (identifying also the equipment that can be refurbished), transport, dismantle and treat WEEE must be taken into account. The role of WEEE pre-processors is particularly crucial and it will be described more in detail afterwards.

Plastic recyclers
Finally, the refining and processing steps for the production of a secondary raw material (in the case of plastic performed by plastic recyclers) also have to be considered, as well as the recovery of spare parts for reuse.
The recycling process of WEEE plastics includes several phases and the involvement of different expertise and technologies. Plastic recyclers put in place several activities (as sorting, washing, compounding and finally extrusion) to transform mixed plastic

flakes in plastic granulates. The plastic granulates are used then by moulders to produce plastic components of new products.

An overview of the plastic recycling steps is provided in figure 2.

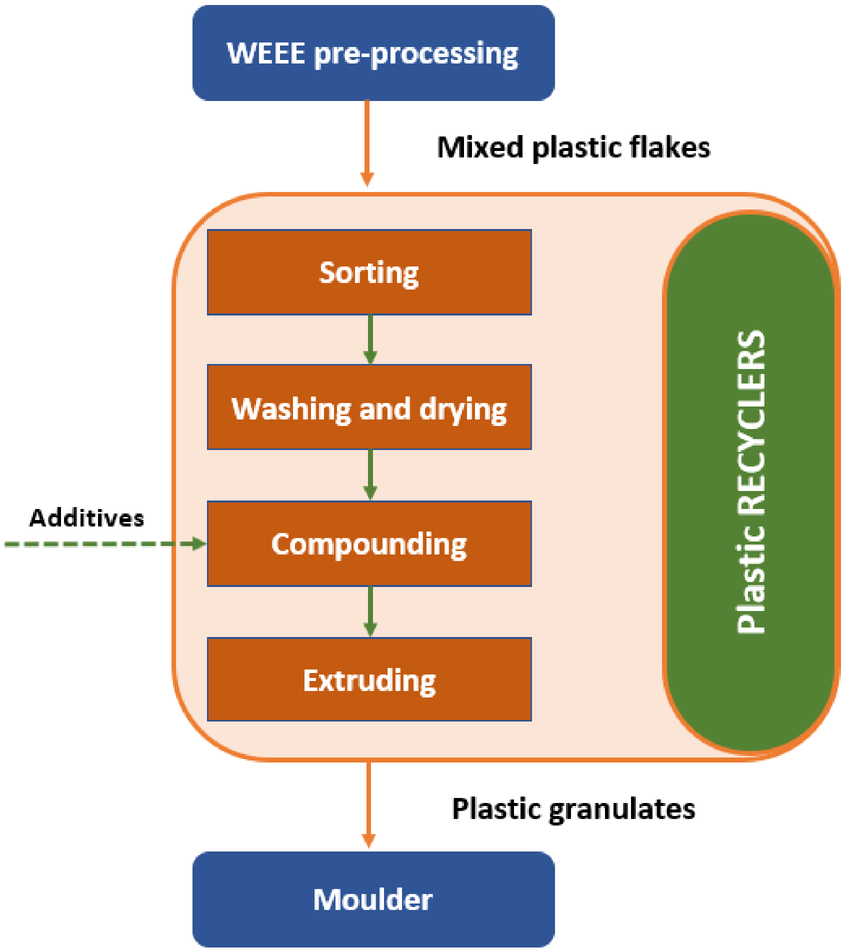

Figure 2. Plastic recycling steps

The performing of each of the listed activities significantly impacts on the functioning of all the chain. Aiming to provide a complete description of the EEE/WEEE value chain, it cannot be denied that in parallel, other actors are operating without respecting the minimum treatment quality standards or illegally operating in the WEEE chain. For example, a considerable amount of WEEE is illegally exported out of EU or irregularly treated. A study realized by the WEEE Forum, a not-for-profit international association of 31 WEEE PROs, informed that in Europe just 35% (3.3 million tonnes of 9.5 million tonnes) of electronics and electrical equipment discarded by companies and consumers in 2012 ended up in official collection and recycling systems [5]. The study estimates 1.3 million tonnes of discarded electronics departed the EU in undocumented mixed exports, of which an estimated 30% (about 400,000 tonnes) was electronic waste; and 70% functioning equipment.

4 Methodology

To follow the plastic route along the EEE/WEEE value chain, a top-down approach was adopted (fig. 3).

The starting point of the analysis was the evaluation of the amount of new EEE put on the market. The adopted methodology includes the evaluation of the quantity of plastic put on the market, closely linking it with the amount of EEE put on the market.

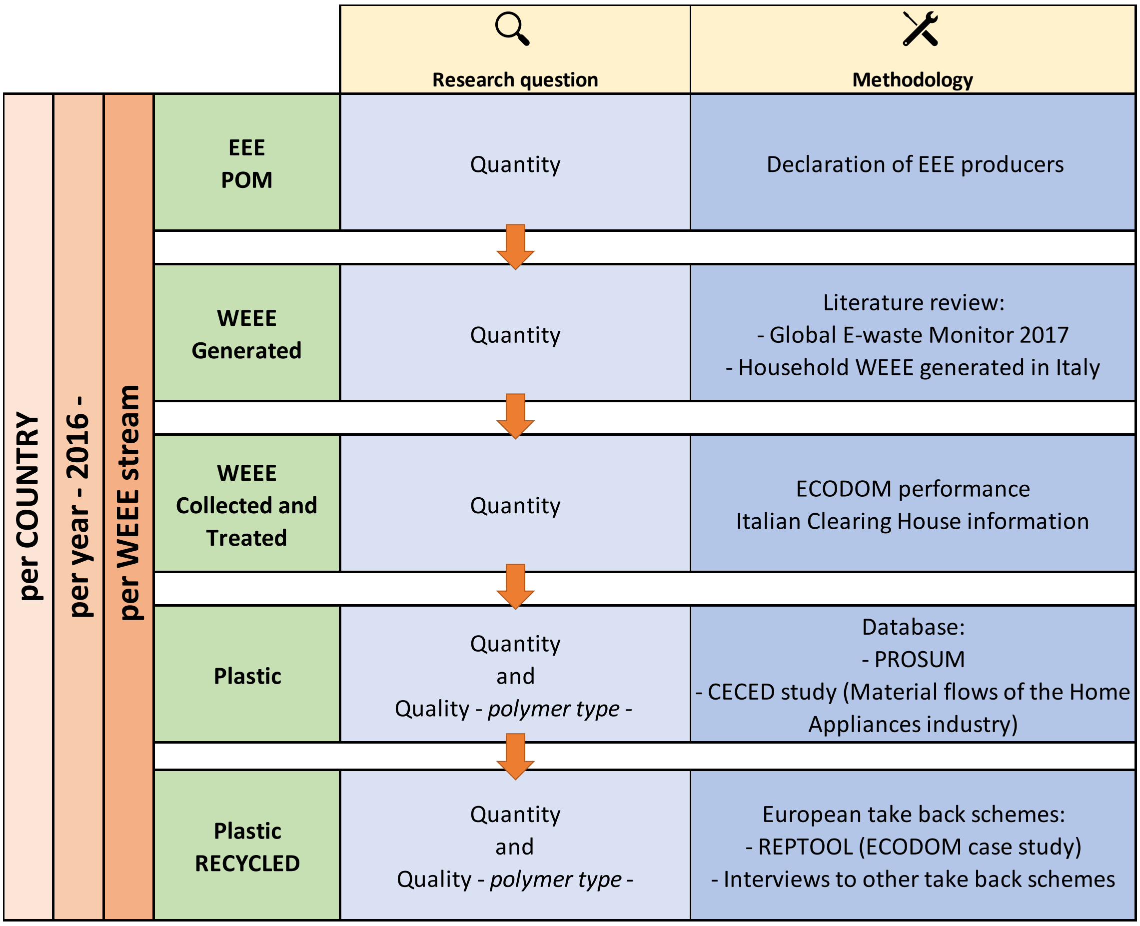

Figure 3. Quantification of material flows along the entire chain: methodology

The research then focused on the other crucial nodes that characterize the EEE/WEEE value chain. In particular, the WEEE generated by households is compared to the WEEE collected by take-back schemes to identify gaps and potential in WEEE collection. Then an in-depth analysis is performed on the WEEE treatment step, investigating the amount of plastic obtained from the shredding and sorting activities performed by the WEEE treatment operators. The plastic obtained is then sent to downstream operators for intermediate sorting and final recovery, recycling or disposal operations.

Considering the ECODOM performance of 2016 (95,890 tonnes of WEEE managed), investigations of plastic amount, recycling share, downstream flows for each WEEE stream, and for each individual product component within WEEE stream, have been carried out. This analysis has been performed through the WF-RepTool tool [8], a database application developed by the WEEE Forum (association of WEEE producer responsibility organisations) to determine treatment results for WEEE in a transparent, traceable manner and to achieve comparable results.

In addition to the quantitative consideration about plastic share/potential PCR availability, a qualitative assessment has been performed resulting in a matrix showing the plastic content of the actual EEE and waste flows at polymers level (see Section 6). The specificity of different EEE products has been taken into account and the correspondent supply chains compared. The results have been validated by means of available literature studies (e.g. Global e-waste monitor 2017), finding of related research project (e.g. PROSUM, CloseWEEE) and performing interviews addressing other European take-back schemes and EEE producers. An overall evaluation of the grade of traceability of the EEE/WEEE plastic is also proposed.

It is highlighted that the following investigation refers to 2016. The decision of analysing this specific year is mainly related to the fact that the proposed methodology aims to use as much as possible realistic and accountable data, e.g. ECODOM's data regarding its WEEE management activity. Considering that task 3.1 started in June 2017, the most recent and complete set of data available was the one referring to 2016. The methodology was applied to 2016 data, but it is repeatable for different years and different national context.

4.1 WEEE streams

The WEEE streams (cooling and freezing appliances, large household appliances, TVs and monitors, small mixed appliances) have been chosen as *minimum research unit*.
The European Directive regarding waste of electronic and electrical equipment (WEEE) was transposed into the Italian law on 13 August 2005 by the Legislative Decree 151 of 25 July 2005 [6]. The WEEE Management system was officially implemented in Italy by the government in November 2007; then the EU Directive was recast and implemented in Italy by the Legislative Decree 49 2014 [7]. According to the legislation, collection must be organized in every collection facility in **5 groups**: cooling and freezing appliances (so called R1); large household appliances (R2); TV and screens (R3); small household appliances (R4); lamps (R5). The 5 groups will be considered as functional unit for the research. However, the mentioned categorization is specific to the Italian WEEE management system. For this reason, a conversion table between the Italian denomination and the UNU Key system is provided (Annex I).

The group R5 (lamps) is not considered in this study. This is due to the fact that ECODOM, whose actual data about WEEE management performance were used in the following calculation, did not manage lamps until 2016.

4.2 WF-Reptool

Plastic is one of the output materials of the WEEE treatment process. To follow the WEEE plastic flow along the different treatment steps and to be able to perform a quantitative and qualitative evaluation of the output PCR WEE plastic, the data provided by the tool WF-RepTool were used [8].

WF-RepTool is a database application developed by WEEE Forum, the association of the European WEEE PROs. The application allows to determine treatment results for WEEE in a transparent, traceable manner and to achieve comparable results between different treatment operators, WEEE systems and countries. WF-RepTool calculates recycling and recovery rates in accordance with what is required in the WeeeLabex standard [9] and monitoring the targets rates given by the legal requirements.

The WF-RepTool is built up on 4 pillars:

- input fractions;
- technologies used;
- output fractions;
- WF-classification.

The WF-RepTool foresees all the steps of different WEEE streams treatment processes including dismantling/de-pollution, shredding and separation, separation of fractions, application of final fractions in final treatment technologies, allowing to collect data regarding each of the mentioned step. Using this tool, all relevant data of the treatment chain will be aggregated. As a consequence, it will be possible to follow whole treatment chain up to the final treatment process (full downstream monitoring, based on the classification of the individual application regarding preparing for re-use, recycling, recovery and disposal).

The WEEE treatment plants that operate as ECODOM’s suppliers are obliged to make detailed information about their treatment performance available through WF-RepTool. The required information consists of the quantitative and qualitative assessment of the input and output fractions of the plants, as well as the further treatment steps of the material

4.3 ECODOM case study

ECODOM is the largest Italian WEEE take-back scheme. Its expertise is therefore incorporated in a case study. The information used for the computation presented below come from ECODOM’s business data-mining operations. The data regarding ECODOM activities are assumed to be representative of the Italian context.

In 2016, 15 take back schemes responsible for the management of household WEEE were operating in Italy. ECODOM is one of the leading WEEE take-back systems in Italy, with a share of 50.3% in R1 market of 65.4% in R2 market [10]. It is a private entity established in 2004 and fully operational since 2008. In 2016, it was formed by 27 producers of electrical and electronic appliances, operating in the Italian market. ECODOM manages WEEE coming from categories R1, R2, R3 and R4. In 2016, ECODOM managed 33.9% of the total amount of WEEE collected in Italy by take back schemes [11]. ECODOM collected WEEE from 4,558 points, in every part of Italy, working with 46 treatment and transport suppliers and 41 different plants, located in several Italian regions. More than 41,000 transports of WEEE have been managed in 2016 by ECODOM's logistic operators [10].

Investigations on plastic amount in WEEE streams, plastic recycling share and downstream flows of plastic, have been carried out starting from ECODOM's performance.

ECODOM seeks to make all its activities' results clear and accessible; this is the reason why every year a Sustainability Report is published, containing all the information on environmental, social and economic performance of the take-back system.

5 From EEE to WEEE

5.1 The EEE POM – Manufacturers

The quantity of plastic put on the market (POM) was first evaluated, closely linked to the amount of EEE put on the market. The quantitative analysis of EEE POM relies on the Key figures made available by the WEEEForum and is built on the European take-back schemes declarations.

The amount of EEE put on the European market in 2016 is reported in the table below (tab. 1).

Table 1. EEE Put on the European Market

	EEE Put on the Market (tons) – 2016
	Europe
C&F	1,448,463
LHA	3,111,004
TV&screens	482,623
SHA	2,873,469
TOT	**7,915,559**

5.2 The WEEE Generated – Consumers

According to the study commissioned by ECODOM to UNU in 2012 to better understand Italian consumer disposal behaviour for WEEE [12], a significant percentage of WEEE is improperly disposed. The likelihood of improper disposal practices appears negatively correlated with the size of the equipment, meaning that smaller products are more likely to be disposed improperly: a large number of citizens affirm that they do not remember the channel used to dispose small household appliances (e.g. ICT). Additionally, it is estimated that about 0.6 kg/inhabitant of small household appliances are left by consumers in old houses. The study was aimed at quantifying the household WEEE generated in Italy and to highlight consumers' WEEE disposal habits and attitudes. Consequently, light was shed on complementary/alternative waste streams, which account for a substantial share of WEEE arising in Italy.

The study provided estimates of the amount of WEEE (kg/inhabitant) generated in Italy per WEEE stream. The estimation was based on a combination of detailed reconstruction of the historical POM data for different types of EEE, the quantification of the accumulated EEE stocks in households, and the creation of life-time profiles for various EEE. The results of the mentioned studies allowed to calculate the figures reported in table 2, referring to year 2016 [12].

Table 2. WEEE generated: Italy

	WEEE generated (tons) – 2016
	Italy
C&F	146,762
LHA	316,762
TV&screens	174,891
SHA	358,344
TOT	**996,761**

The data regarding the WEEE generated in Europe and reported in table 3, were elaborated starting from the information available in The Global E-Waste Monitoring 2017 regarding domestic e-waste generated per country in 2016 [12]. The amount of WEEE generated in Europe is very variable within the different European countries.

Table 3. WEEE generated: Europe

	WEEE generated (tons) – 2016
Germany	1,884,000
UK	1,632,000
France	1,373,000
Italy	996,761
Spain	930,000
Poland	453,000
Netherlands	407,000
Belgium	241,000
Greece	189,000
Switzerland	184,000
Austria	182,000
Portugal	180,000
Norway	150,000
Ireland	93,000
Lithuania	38,000
Slovenia	33,000
Estonia	19,000
Luxembourg	12,000
TOT	**8,996,761**

There are several, and not always predictable, reasons that get people to dispose small electronic equipment. Consumers contribute to the generation of WEEE influenced by different drivers: technological factors, including the need to replace EEE for mechanical or electrical failure, or for reasons of product obsolescence, as well as social factors, such as the desire among consumers to purchase new EEE to replace existing EEE, whether to satisfy new wants or needs, or to attain new functionalities. Therefore, it is difficult to predict the reasons that lead people to hoarding EEE at home, dilating the time between the moment EEE is no longer used and the time it is discarded. To analyse this phenomenon, there are in fact several personal and emotional factors to consider as well as logistical barriers to take into account.

The study of this node of the chain is a fundamental part of the EEE/WEEE value chain analysis. In fact, the bad disposal habits of the citizens, on one hand are responsible for the reduction of the availability of material for recycling, on the other hand provoke environmental damages (e.g. because of improper treatment).

5.3 The WEEE collected – Take back schemes

The availability of PCR e-plastic is correlated with the WEEE collection dimension. The amount of WEEE collected in 2016 by official channels is reported in table 4. Similar to the EEE POM figures, the figures regarding the amount of WEEE collected in 2016 by official channels rely on the key figures made available by the WEEEForum and are built on the WEEE take back schemes declarations. Data referring to Europe regards 17 member states.

The information regarding the Italian context and the ECODOM performance refer to the data made available yearly by the Italian Clearing House. During year 2016 a total amount of 283,075 tonnes of WEEE (including R5) was collected and treated in Italy, with an increase of 13.6% from the previous year, while the national collection average is 4.67 kg of WEEE per capita [11].

Table 4. WEEE collected

	WEEE collected (tons)		
	Europe	**Italy**	**ECODOM**
C&F	662,485	76,159	37,608
LHA	1,158,890	90,147	57,382
TV&screens	539,735	64,183	55
SHA	1,044,472	50,882	845
TOT	**3,405,582**	**281,371**	**95,890**

5.3.1 WEEE generated vs WEEE collected

From the data reported in the tables above (tab 2, tab 4), it is evident that there is a considerable gap between the WEEE generated and the WEEE collected.

The *return rates* (the total amounts of WEEE collected by country or region as percentage of the total EEE put on the market in that country or region) were 43% in Europe and 34% for Italy. It is important to note that these figures are considerably lower for small appliances (36% and 18% for Europe and Italy, respectively). Recall that starting from 2019, the recast Directive (2012/19/EU) sets the minimum rates for separate collection of WEEE to 65% of EEE put on the market or to 85% of WEEE generated on the territory of that Member State.

In 2016, the *collection rates* (the percentage of the WEEE collected over the total WEEE generated) were 38% for Europe and 28% for Italy. Similarly to the specification made for the return rate, the small household appliances represent again the most critical WEEE stream (fig. 4).

The gap between the amount of WEEE generated and the amount of WEEE collected (corresponding to the WEEE collected through official channel, thus traceable and clearly measurable) is due to misbehaviour as for example:

- consumers directly dispose of e-waste through normal dustbins with other types of household waste: the disposed of e-waste is then treated with the regular mixed-waste from households;
- WEEE are disposed outside the official take-back system: it is then difficult to trace them (e.g. not official and standardized statistic available). It is then possible that WEEE are dumped, traded, or recycled with low recycling standards.

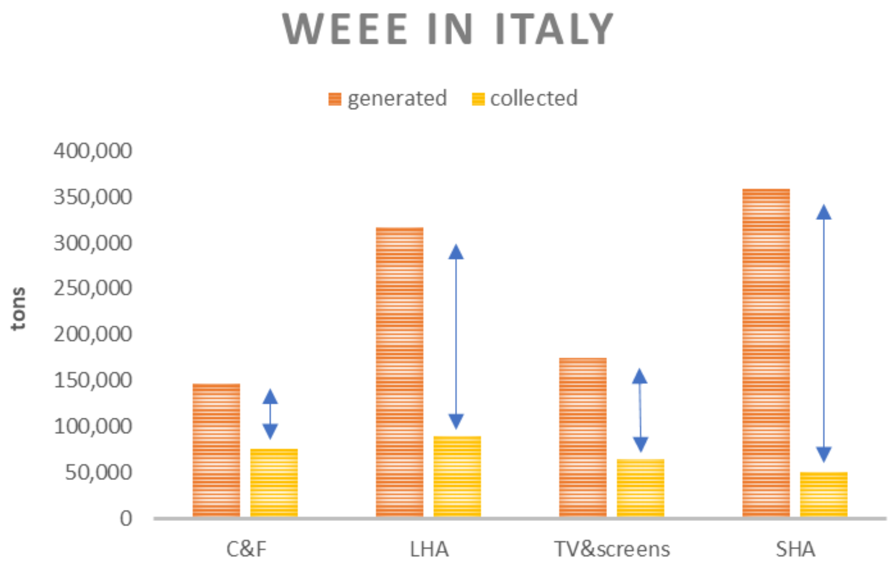

Figure 4. Gap between WEEE generated and WEEE collected in Italy

5.3.2 WEEE collected: composition on WEEE streams

Looking closer to ECODOM's data, it is possible to also provide a more detailed description of the collected WEEE. Specifically, it is possible to provide an estimation of the composition in terms of products of the different WEEE streams. The data reported in table 5 are the results of a sampling campaign performed in 2015 by ECODOM on the collected WEEE.

Table 5. WEEE streams composition: collected product mass per WEEE category

<table>
<tr><th colspan="2">C&F</th><th colspan="2">LHA</th><th colspan="2">TVs&screens</th></tr>
<tr><td rowspan="2">Fridges</td><td rowspan="2">93%</td><td>Dishwasher</td><td>12%</td><td rowspan="3">CRT</td><td rowspan="3">90%</td></tr>
<tr><td>Kitchens</td><td>9%</td></tr>
<tr><td rowspan="2">Freezers</td><td rowspan="2">6%</td><td>Washing Machines</td><td>72%</td></tr>
<tr><td>Dryers</td><td>1%</td><td rowspan="3">FPD</td><td rowspan="3">10%</td></tr>
<tr><td rowspan="2">Air Conditionair</td><td rowspan="2">1%</td><td>Heating&Ventilation</td><td>4%</td></tr>
<tr><td>Microwaves</td><td>1%</td></tr>
</table>

The data regarding the small household appliances stream are not available. This waste stream is extremely heterogeneous and is composed by a very large variety of different products.

6 From WEEE to WEEE plastic

WEEE treatment facilities represent one of the key nodes of the studied chain. Therefore, WEEE in input and plastic in output have been measured and calculated.

After the collection phase, WEEE is transported to dedicated WEEE pre-treatment plans that put in place ad hoc treatment processes according to the specific characteristics of the treated waste stream. The main factors that influence the selection of the appropriate treatment process are the presence of hazardous substances (as in the case of cooling and freezing appliances that contain CFC or HC to be removed before other treatment steps) and the composition of the product belonging to a certain waste flow.

Overall, some main treatment steps can be identified as common for all WEEE streams (fig. 5).

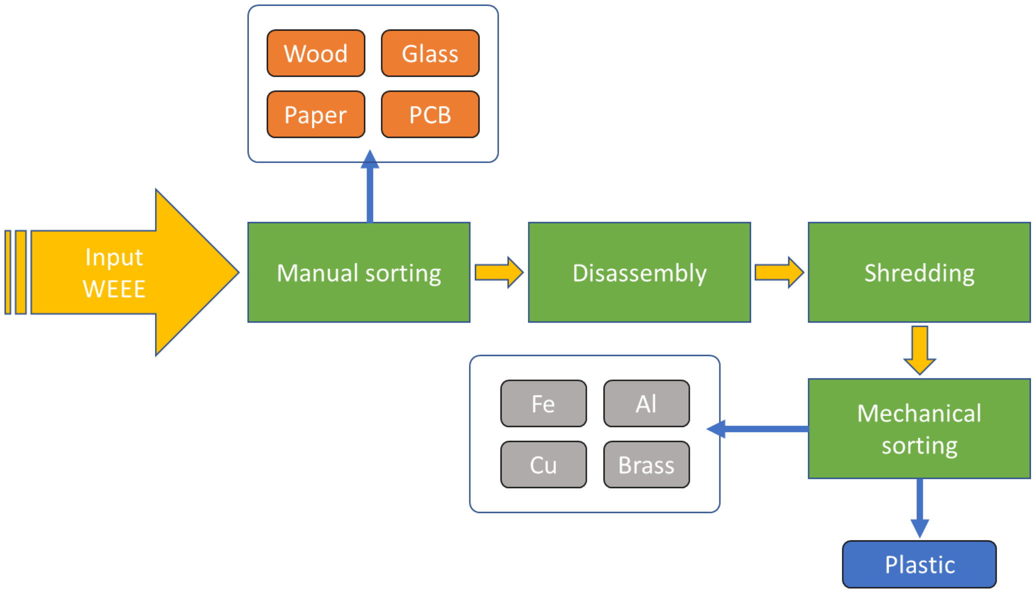

Figure 5. WEEE treatment steps

As shown in the graph, plastic is just one of the several output fractions of the WEEE treatment process. Moreover, often plastic is the outcome of a negative sorting activity, meaning that the target fraction of the sorting is another material (e.g. copper), likely more valuable, and that plastic is a contaminant that needs to be eliminated through the sorting process.

To follow the WEEE plastic flow along the different treatment steps and to be able to perform a quantitative and qualitative evaluation of the output PCR WEE plastic, the data provided by the tool WF-RepTool were used.

6.1 Plastic in WEEE

According to the data collected through WF-RepTool, the plastic content of the different WEEE stream results the one reported in table 6.

Data in table 6 includes the fractions labelled as plastic (e.g. *pieces/parts of plastic, rubber*) as well as the plastic contained in other components (e.g. *plastic from cables, plastic from compressors)* and removed through dedicated treatment steps (e.g. manual dismantling, shredding, mechanical sorting…).

Table 6. Plastic content of different WEEE flows

WEEE flow	C&F	LHA	TV& screens	SHA
Plastic content (%)	**12.98**	**6.82**	**16.42**	**36.40**

WF-RepTool in fact allows to determine results of the whole European WEEE treatment chain linking input fractions of WEEE treatment facilities with output materials. Input and output materials are related through the implemented treatment activities. WF-RepTool database includes about 400 fractions that can be selected as output fractions. Treatment steps are correlated to different treatment technologies, structured to interim technologies (shredding, separation, conditioning) and final technologies (e.g. steel mill, copper smelter, glass smelter etc.). WF-RepTool database includes about 70 headlines for technologies. The fractions and the corresponding composition must be specified before and after each treatment step (except for pure fractions, namely fractions with less than 2% of impurities).

An overview of the WF-Reptool data structure is presented in figure 6.

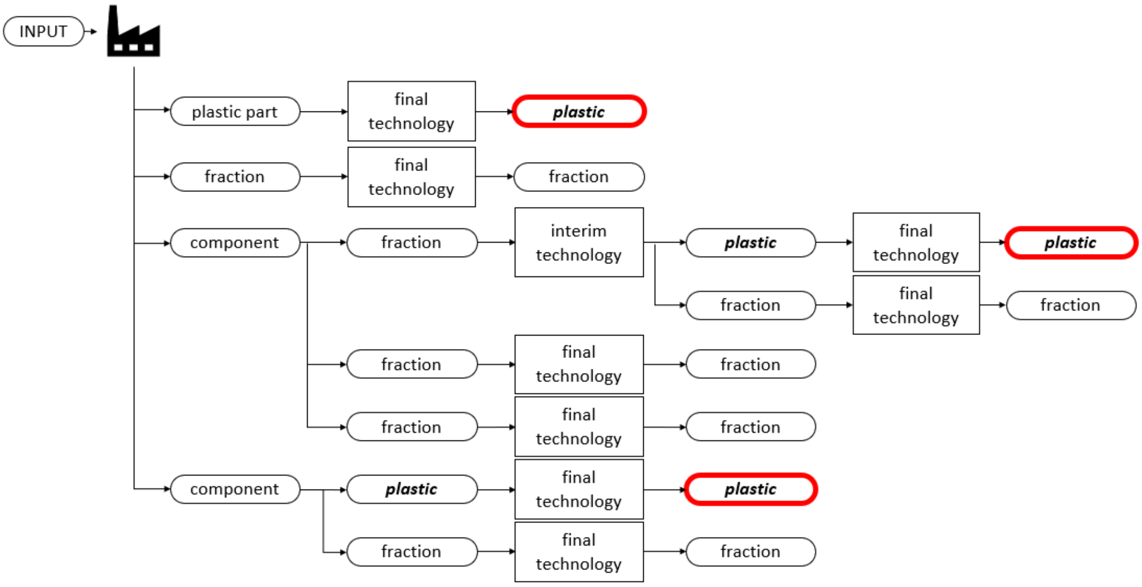

Figure 6. WF-Reptool data structure

More detailed information are reported in the following paragraphs.

6.1.1 Cooling and Freezing Appliances

In 2016, ECODOM managed 37,566.39 tons of WEEE from Cooling and Freezing Appliances. The components containing plastic and the plastic parts or pieces accounted for 10,790 tons. The table below (tab. 7) gives an overview of the plastic content of the C&F Appliances WEEE stream. Specifically, the table reports which component contains plastic and in what amounts.

Table 7. Cooling and Freezing Appliance waste stream: plastic content

Cooling and Freezing Appliances		tons	on the total treated C&F	**Plastic content**		
				tons	on the component	on the total treated C&F
Plastic	Pieces/parts of plastic	147.36	0.39%	138.39	93.91%	0.37%
	Pieces of plastic materials and rubber	4,749.52	12.64%	4,611.49	97.09%	12.28%
	Polyurethane foam	5,203.47	13.85%	5,203.4	100.00%	13.85%
Components containing plastic	Mix of printed circuit boards	0.559	0.00%	0.27	48.30%	0.00%
	Mix of electric motors and transformers	13.56	0.04%	0.97	7.13%	0.00%
	Other components	97.367	0.26%	9.08	9.32%	0.02%
	Compressors	109.27	0.29%	0.22	0.20%	0.00%
	Cables	152.80	0.41%	94.09	61.58%	0.25%
	Mix of metals	316.83	0.84%	21.13	6.67%	0.06%
TOT		10,790.72	28.72%	10,079.11	93.41%	26.83%
TOT without PU foam		5,587.26	14.87%	4,875.65	45.18%	**12.98%**

Overall, without consider the PU foam contribution, 12.98% of the mass of the cooling and freezing appliance waste stream was composed of plastics (4,875.65 tons).

6.1.2 Large Household Appliances

In 2016, ECODOM managed 57,382 tons of WEEE from Large Household Appliances. The component containing plastic and the plastic parts/pieces accounted for 7,269 tons. The table below (tab. 8) gives an overview of the plastic content of the Large Appliances WEEE stream. Specifically, the table reports which components contain plastic and in what amounts.

Table 8. Large Household Appliance waste stream: plastic content

Large Household Appliances		tons	on the total treated C&F	Plastic content		
				tons	in the component	on the total treated C&F
Plastic	Pieces of plastic materials and rubber	1,530.89	2.64%	1,507.28	98.46%	2.60%
	Pieces/parts of plastic	1,889.56	3.26%	1,819.39	96.29%	3.14%
Components containing plastic	Capacitors	11.34	0.02%	1.19	10.51%	0.00%
	Mix of printed circuit boards	55.11	0.10%	35.31	64.08%	0.06%
	Mix of electric motors and transformers	129.19	0.22%	6.28	4.86%	0.01%
	Mix of metal/plastic/organic fractions	405.14	0.70%	118.26	29.19%	0.20%
	Cables	432.12	0.75%	278.36	64.42%	0.48%
	Iron (not pure)	2,816.37	4.86%	182.03	6.46%	0.31%
TOT		7,269.72	12.55%	3,948.11	54.31%	**6.82%**

Overall, 6.82% of the Large Household appliance waste stream was composed of plastic (3,948 tons).

To better characterize the Large Household Appliances waste stream, the results of a sampling campaign performed by ECODOM in 2015 are presented as well (tab. 9). The sampling campaign aimed to understand the composition in terms of plastic content of different products within the Large Household Appliance waste flow.

Table 9. Plastic content of products in Large Household Appliances waste flow

Dishwashers	Kitchen	Washing Machines	Dryers	Household Heating & Ventilation	Microwaves
26%	9%	13%	13%	6%	7%

Using the data provided in table 9, it results that overall the plastic content of the LHA waste flow is 14%. This figure has been used in the subsequent calculation (instead of the one proposed in table 8 resulting from the WF-Reptool analysis).

6.1.3 Televisions and screens

In 2016, ECODOM managed 55 tons of WEEE from TV & screens. The component containing plastic and the plastic parts/pieces accounted for 14 tons. The table below (tab. 10) gives an overview of the plastic content of the TV&screens WEEE stream. Specifically, the table reports which component contains plastic and in what amounts.

Table 10. TV&screens waste stream: plastic content

TVs and screens		Components		Plastic content		
		tons	on the total treated C&F	tons	in the component	on the total treated C&F
Plastic	Pieces/parts of plastic	7.02	12.26%	7.02	100.00%	12.26%
	Pieces of ABS plastic	1.53	2.67%	1.49	98.17%	2.62%
Components containing plastic	Electron gun	0.01	0.02%	0.002	17.15%	0.00%
	Mix of electric motors and transformers	0.02	0.03%	0.001	6.25%	0.00%
	Flat screens	0.02	0.03%	0.004	23.53%	0.01%
	Metals (copper and aluminium)	0.07	0.12%	0.01	15.93%	0.02%
	Cables	1.18	2.06%	0.60	51.06%	1.05%
	Deflectors	1.33	2.33%	0.01	0.98%	0.02%
	Mix of printed circuit boards	3.12	5.46%	0.25	8.01%	0.44%
TOT		14.29	24.97%	9.39	65.77%	**16.42%**

Overall, the TV&screens appliance waste stream was composed of plastics for 16.42% (9 tons).

6.1.4 Small Household Appliances

In 2016, ECODOM managed 845 tons of WEEE from Small Household Appliances. The component containing plastic accounted for 448 tons. The table below (tab. 11) gives an overview of the plastic content of the Small Household Appliances WEEE stream: specifically, it reports which component contains plastic and in what amounts.

Table 11. Small Household Appliances waste stream: plastic content

Small Household Appliances		Components		Plastic content		
		tons	on the total treated C&F	tons	in the component	on the total treated C&F
Plastic	Pieces/parts of plastic	202.81	24.40%	195.20	96.25%	23.49%
	Pieces of plastic materials and rubber	13.92	1.67%	13.92	100.00%	1.67%
Components containing plastic	Processors	0.08	0.01%	0.04	50.00%	0.00%
	Plugs	0.13	0.02%	0.10	79.32%	0.01%
	Batteries	0.39	0.05%	0.03	6.92%	0.00%
	Aluminium	1.19	0.14%	0.01	0.93%	0.00%
	Residues of separations	2.16	0.26%	2.16	100.00%	0.26%
	Power supply	6.70	0.81%	0.46	6.92%	0.06%
	Hard disc, CD-rom-, DVD- floppy unit	8.12	0.98%	0.43	5.30%	0.05%
	Mix of printed circuit boards	10.89	1.31%	5.05	46.33%	0.61%
	Mix of electric motors and transformers	20.33	2.45%	2.95	14.49%	0.35%
	Cables	27.43	3.30%	17.59	64.11%	2.12%
	Mix of plastic/metals/organic fractions	154.39	18.58%	64.55	41.81%	7.77%
	TOT	448.54	53.97%	302.48	67.44%	**36.40%**

Overall, 36.42% of the Small Household Appliance waste stream was composed of plastic (302 tons).

6.2 Plastic downstream chains

As mentioned above, WF-RepTool also allowed to gather information on the output fractions from the WEEE treatment activities, providing details on the PCR WEEE plastic downstream chain.

Therefore, data reported below (tab. 12) are elaborated starting from the declarations made by WEEE pre-treatment operators and collected through WF-RepTool. Table 12 provides an overview of the downstream chain of the different analysed WEEE streams. PUR (polyurethane) is not considered in the analysis.

In table 12, plastics that are reduced in quality and/or functionality with respect to the original material ("downcycled") are included under the heading of "recycled".
Moreover, specifically regarding SHA waste stream, it must be taken into account that the treated material has an average BFRs content of 7% [15] and that currently BFR plastics cannot be recycled.

Table 12. WEEE plastic downstream chain

WEEE flows	Recycled	Energy recovery	Disposed
	% of the total treated WEEE plastic		
C&F	98.45	0.18	1.37
LHA	91.48	1.86	6.66
TV&screens	96.74	0.01	3.25
SHA	84.48	3.25	12.28

The following paragraphs give more details regarding the plastic downstream chain, reporting information for each waste stream and each treated component containing plastics.

The figures reported in this section result from WF-Reptool data elaboration. Therefore, they correspond to the declarations that WEEE pre-treatment operators make yearly to ECODOM, as contractual obligations.

However, it has to be noted that starting from the analysis of different data sources could bring to different results. This discrepancy gives a clear picture of the traceability degree of plastic along the WEEE value chain, that it is very low.

Therefore PolyCE partners consider this information gap as a significant research opportunity: in this regard, all the improvements proposed by the PolyCE project will contribute to make it easier to follow WEEE plastics along the EEE/WEEE value chain and additional effort will be made during the project to validate the presented results.

6.2.1 Cooling and Freezing Appliances

Table 13. Cooling and Freezing Appliances WEEE plastic downstream chain

Cooling and Freezing Appliances		Plastic content (tons)	Downstream chain		
			Recycling	Energy recovery	Disposed
Plastic	Pieces/parts of plastic	138.39	59.61%	6.44%	33.95%
	Pieces of plastic materials and rubber	4,611.49	99.81%	0.00%	0.19%
	Polyurethane foam	5,203.47	0.00%	81.54%	18.46%
Components containing plastic	Mix of printed circuit boards	0.27	0.37%	0.00%	99.63%
	Mix of electric motors and transformers	0.97	100.00%	0.00%	0.00%
	Other components	9.08	69.39%	0.00%	30.61%
	Compressors	0.22	0.00%	0.00%	100.00%
	Cables	94.09	91.75%	0.00%	8.25%
	Mix of metals	21.13	100.00%	0.00%	0.00%
TOT		10,079.11	47.62%	42.19%	10.19%
TOT without PU foam		4,875.65	**98.45%**	**0.18%**	**1.37%**

6.2.2 Large Household Appliances

Table 14. Large Household Appliances WEEE plastic downstream chain

Large Household Appliances		Plastic content (tons)	Downstream chain		
			Recycling	Energy recovery	Disposed
Plastic	Pieces of plastic materials and rubber	1,507.27	97.79%	2.21%	0.00%
	Pieces/parts of plastic	1,819.39	98.58%	1.42%	0.00%
Components containing plastic	Capacitors	1.19	91.69%	0.00%	8.31%
	Mix of printed circuit boards	35.31	81.83%	3.09%	15.08%
	Mix of electric motors and transformers	6.28	57.01%	0.00%	42.99%
	Mix of metal/plastic/organic fractions	118.26	100.00%	0.00%	0.00%

	Cables	278.36	69.16%	4.67%	26.18%
	Iron (not pure)	182.03	0.00%	0.00%	100.00%
TOT		3,948.11	**91.48%**	**1.86%**	**6.66%**

6.2.3 Televisions and screens

Table 15. TV& screens WEEE plastic downstream chain

TVs and screens		**Plastic content (tons)**	**Downstream chain**		
		tons	**Recycling**	**Energy recovery**	**Disposed**
Plastic	Pieces/parts of plastic	7.02	100.00%	0.00%	0.00%
	Pieces of ABS plastic	1.49	99.20%	0.00%	0.80%
Components containing plastic	Electron gun	0.002	50.50%	49.50%	0.00%
	Mix of electric motors and transformers	0.002	100.00%	0.00%	0.00%
	Flat screens	0.004	100.00%	0.00%	0.00%
	Metals (copper and aluminium)	0.01	100.00%	0.00%	0.00%
	Cables	0.60	53.57%	0.00%	46.43%
	Deflectors	0.013	0.00%	0.00%	100.00%
	Mix of printed circuit boards	0.250	100.00%	0.00%	0.00%
TOT		9.399	**96.74%**	**0.01%**	**3.24%**

6.2.4 Small Household Appliances

Table 16. Small Household Appliances WEEE plastic downstream chain

Small Household Appliances		**Plastic content (tons)**	**Downstream chain**		
			Recycling	**Energy recovery**	**Disposed**
Plastic	Pieces/parts of plastic	195.20	93.18%	4.71%	2.10%
	Pieces of plastic materials and rubber	13.92	0.00%	0.00%	100.00%
Components containing plastic	Processors	0.04	100.00%	0.00%	0.00%

	Plugs	0.09	100.00%	0.00%	0.00%
	Batteries	0.03	0.00%	0.00%	100.00%
	Aluminum	0.01	49.57%	0.00%	50.43%
	Residues of separations	2,16	60.93%	0.00%	39.07%
	Power supply	0.46	88.48%	0.00%	11.52%
	Hard disc, CD-rom, DVD-floppy unit	0.43	100.00%	0.00%	0.00%
	Mix of printed circuit boards	5.04	100.00%	0.00%	0.00%
	Mix of electric motors and transformers	2.94	100.00%	0.00%	0.00%
	Cables	17.58	91.68%	0.00%	8.32%
	Mix of plastic/metal/organic fractions	64.55	76.57%	0.00%	23.43%
TOT		302.48	**84.48%**	**3.04%**	**12.48%**

6.3 WEEE plastic polymers

The final goal of the qualitative research was to determine the polymers' share in the recycled WEEE plastics. Furthermore, the aim was to evaluate the amount of available polymers from PCR WEEE plastic that can be potentially reused in new EEE.

The qualitative analysis of the WEEE plastic was performed taking into account different sources of data.

In addition to the quantitative consideration about potential PCR plastic availability, a qualitative assessment has been performed developing a matrix showing the plastic content of the actual waste flows at polymers level. The specificity of different EEE products has been taken into account and the corresponding supply chains were compared. APPLiA study [14], the elaborated data from the H2020 PROSUM project database [13] and interviews with OEMs have been used to perform the qualitative analysis of the PCR WEEE plastic. The mentioned tools allowed to gather information on the amount of polymers totally collected within WEEE streams per year, per European country and per each different disposed product typology.

The research was focused on seven main polymers: ABS, PS, PA, PC, PE, PP and PVC (the polymers containing flame retardants are included in the analysis). The composition in terms of polymers have been combined with the information deriving from the quantitative analysis described above and with the data regarding the actual composition of WEEE flows in terms of products (tab. 5). Specifically, to understand the average composition in terms of polymers of the waste flows in input to the WEEE treatment plant, two additional steps have been performed:

1. the data coming from the WF-Reptool investigation regarding the amount of plastic obtained from the treatment process of different waste flows have been combined with data concerning the polymers share in WEEE plastic. This allowed for the derivation of average material compositions for the products present in WEEE streams;
2. the information regarding the average composition of the products (from step 1), was combined with the data concerning the average composition of the different waste streams in terms of product, as shown in table 5. This enabled the derivation of average material compositions of the waste streams in terms of polymers. The small household appliances waste stream is very heterogeneous (as mentioned in section 5.3.2 data regarding waste composition in terms of products are not available). For this reason, to have an idea of the waste flow composition in terms of polymers, the gathered qualitative information regarding polymeric composition of products was directly combined with the information regarding the amount of plastic available after the WEEE treatment steps (WF-RepTool data).

The qualitative analysis was replicated taking into account the polymeric composition of new EEE (namely not the items that can be find currently in the WEEE streams but the ones that will be disposed in the next years). This approach has been implemented elaborating the data about average material composition of new home appliances (in particular cooling and freezing and large household appliances) [15].

Data regarding polymers share in WEEE plastics have been extrapolated combining information from ECODOM operative information and from literature reviews sources (as PROSUM database and APPLiA study).

However, there are some issues that make it difficult to evaluate the reliability of the presented data (discrepancy with the results of other existing database, lack of details on flame retardants presence, high amount of polymers labelled as *not specified* considering that they do not belong to the main families of polymers addressed in this report).

Therefore, to validate the findings presented in the deliverable, PolyCE project will continue to contribute to the qualitative analysis of WEEE plastics after the submission of this report.

6.3.1 Polymeric composition per appliance

As mentioned, the research was focused on specific polymers: ABS, PS, PA, PC, PE, PP and PVC. In the following paragraphs the amount of the total WEEE plastic collected in Italy is reported and the polymers share is indicated for each WEEE stream and each product within the WEEE stream.

Table 17. Polymeric composition of C&F WEEE plastic collected in Italy, 2016

Cooling and Freezing Appliances	Plastic -tons-	ABS	PS	PA	PC	PE	PP	PUR	PVC	other	Nd.
Fridges	39,748	2.60%	41.74%	0.22%	0.13%	0.36%	12.01%	38.62%	3.30%	0.08%	2.60%
Freezers	4,055	4.79%	57.63%	0.27%	0.09%	1.30%	7.62%	21.28%	5.01%	2.01%	4.79%
Air Conditioners	3,806	0.36%	0.00%	1.15%	0.00%	0.00%	0.00%	0.00%	51.39%	1.19%	0.36%
Other Cooling	5,331	17.19%	2.61%	0.00%	1.88%	0.06%	42.53%	0.00%	0.01%	35.72%	17.19%
TOT	**52,940**	**2,158**	**19,065**	**143**	**155**	**198**	**7,350**	**16,215**	**3,469**	**2,038**	**2,148**

Table 18. Polymeric composition of LHA WEEE plastic collected in Italy, 2016

Large Household Appliances	Plastic tons	ABS	PS	PA	PC	PE	PP	PUR	PVC	other	Nd.
Dishwasher	5,051	10.77%	3.37%	0.20%	1.60%	1.45%	60.69%	0.01%	0.67%	21.18%	0.06%
Kitchen	916	2.43%	1.17%	1.55%	3.56%	0.73%	5.48%	6.25%	21.15%	35.57%	22.11%
Washing Machines	21,049	16.65%	2.66%	0.08%	0.48%	0.73%	60.46%	0.00%	2.59%	16.29%	0.06%
Dryers	1,535	20.74%	4.44%	0.56%	1.40%	2.40%	53.03%	0.00%	0.26%	17.12%	0.05%
Household Heating & Ventilation	1,906	19.01%	6.81%	0.89%	1.50%	1.15%	16.88%	0.06%	0.53%	42.07%	11.08%
Microwaves	1,434	32.15%	1.72%	0.07%	2.77%	0.55%	25.61%	0.03%	2.44%	34.60%	0.05%
TOT	**31,891**	**5,213**	**963**	**68**	**305**	**301**	**17,344**	**60**	**822**	**6,385**	**431**

Table 19. Polymeric composition of TV&screens WEEE plastic collected in Italy, 2016

TVs and screens	Plastic tons	ABS	PS	PA	PC	PE	PP	PUR	PVC	other	Nd.
CTR Monitors	447	5.38%	13.28%	0.00%	0.39%	0.00%	3.19%	0.00%	6.64%	10.06%	61.05%
FDP Monitors	3,402	20.25%	3.41%	0.01%	3.23%	0.08%	0.11%	0.02%	0.03%	72.51%	0.36%
CRT Tube TVs	154	22.62%	0.00%	0.00%	2.31%	0.00%	13.41%	0.00%	0.00%	15.60%	46.06%
FDP	7,610	15.29%	8.65%	0.02%	5.82%	0.23%	1.24%	0.04%	0.06%	68.64%	0.00%
TOT	**11,612**	**1,912**	**834**	**2**	**558**	**20**	**133**	**3**	**35**	**7,804**	**344**

Table 20. Polymeric composition of Small Household Appliances WEEE plastic collected in Italy, 2016

Small Household Appliances	Plastic tons	ABS	PS	PA	PC	PE	PP	PUR	PVC	other	Nd.
Laptops	1,753	12.81%	2.50%	0.00%	4.69%	0.04%	0.58%	0.00%	1.10%	63.52%	14.76%
Tablets	99	9.86%	0.00%	0.00%	3.22%	0.00%	0.00%	0.00%	1.64%	85.28%	0.00%
Other Small Household	14,624	22.18%	5.04%	0.09%	6.19%	1.86%	30.89%	0.05%	0.17%	33.37%	0.17%
Food	11,983	16.91%	2.61%	1.34%	5.91%	1.17%	41.89%	0.00%	0.15%	29.97%	0.04%
Hot Water	6,340	25.42%	0.98%	3.80%	1.49%	0.42%	49.52%	0.00%	0.90%	13.30%	4.16%
Vacuum Cleaners	12,843	24.86%	3.67%	0.01%	2.08%	1.53%	12.72%	0.02%	0.33%	14.84%	39.93%
Personal Care	2,743	34.63%	3.89%	0.42%	6.19%	0.64%	30.46%	0.00%	0.44%	23.24%	0.08%
Small Consumer Electronics	2,863	66.85%	18.35%	0.10%	5.09%	0.01%	0.98%	0.00%	0.20%	8.37%	0.06%
Portable Audio & Video	1,055	65.87%	8.56%	0.00%	7.20%	0.01%	0.03%	0.00%	0.01%	17.99%	0.34%
Music Instruments. Radio. Hi-Fi	6,094	53.64%	15.10%	0.09%	3.06%	0.44%	2.26%	0.00%	0.51%	24.70%	0.20%
Video	4,673	51.18%	9.81%	0.10%	6.58%	0.17%	3.22%	0.04%	0.54%	28.15%	0.22%
Speakers	1,406	49.34%	24.67%	2.18%	2.80%	0.92%	2.55%	0.01%	0.16%	17.31%	0.07%
Cameras	373	40.75%	11.07%	0.00%	8.15%	0.02%	0.90%	0.00%	0.70%	37.61%	0.80%
Household Tools	4,233	19.01%	5.75%	0.81%	1.47%	7.23%	30.81%	0.02%	0.18%	34.71%	0.00%
Toys	2,469	61.60%	7.34%	0.00%	8.26%	1.82%	0.76%	0.11%	0.10%	20.01%	0.00%
Household Medical	50	7.86%	0.04%	0.00%	0.00%	0.00%	78.21%	0.00%	0.00%	13.89%	0.00%
Household Monitoring & Control	16,042	38.43%	60.19%	0.00%	0.00%	0.00%	1.38%	0.00%	0.00%	0.00%	0.00%
Small IT	2,718	43.09%	9.05%	0.07%	11.64%	0.01%	0.12%	0.00%	0.53%	27.51%	7.97%
Desktop PCs	2,385	34.36%	5.48%	0.00%	5.12%	0.14%	0.83%	0.00%	4.09%	26.90%	23.07%
Printers	15,836	38.25%	23.06%	0.14%	6.41%	0.63%	1.04%	0.22%	0.21%	28.01%	2.03%
Telecom	6,753	71.86%	7.86%	0.24%	2.11%	0.36%	1.52%	0.00%	0.22%	15.67%	0.15%
Mobile Phones	928	16.42%	4.71%	0.57%	8.93%	0.00%	1.01%	0.00%	0.00%	40.13%	28.22%
Game Consoles	1,877	46.56%	16.64%	1.22%	2.47%	0.78%	4.49%	0.04%	0.59%	23.06%	4.14%
TOT	**120,139**	**42,796**	**19,112**	**574**	**5,009**	**1,196**	**17,479**	**52**	**423**	**26,347**	**7,152**
% on the entire waste stream	**100%**	**35.62%**	**15.91%**	**0.48%**	**4.17%**	**1.00%**	**14.55%**	**0.04%**	**0.35%**	**21.93%**	**5.95%**

Analysing the data reported in the tables above, it must be taken into account that for some specific products the share of polymers indicated as unspecified (labelled as Nd. in the tables) was significant (e.g. 46% for CRT in TV&screens stream, 42% for vacuum cleaners, 28% for mobile phones, 23% for desktop PC in SHA stream and 22% for kitchen in LHA stream). This should be taken into consideration when the mentioned data are compared with other researches and studies investigating WEEE flow and EEE products composition.

6.3.2 The average composition of waste streams in terms of polymers

6.3.2.1 Cooling and Freezing Appliances

As far as it concerns the Cooling and Freezing Appliances waste flow, it is assumed that the plastic content of the products in the waste stream is the same for all the different products. Specifically 12.98% in weigh of the item was considered as plastic (following the results of the WF-RepTool investigation presented in table 7) (fig. 5). PUR (polyurethane) was not considered in this analysis.

The average plastic composition of the products within the Cooling and Freezing Appliances waste flow is presented and the average composition of the considered waste flow in terms of polymers is presented below (fig. 7 and fig. 8; detailed figures in Annex II).

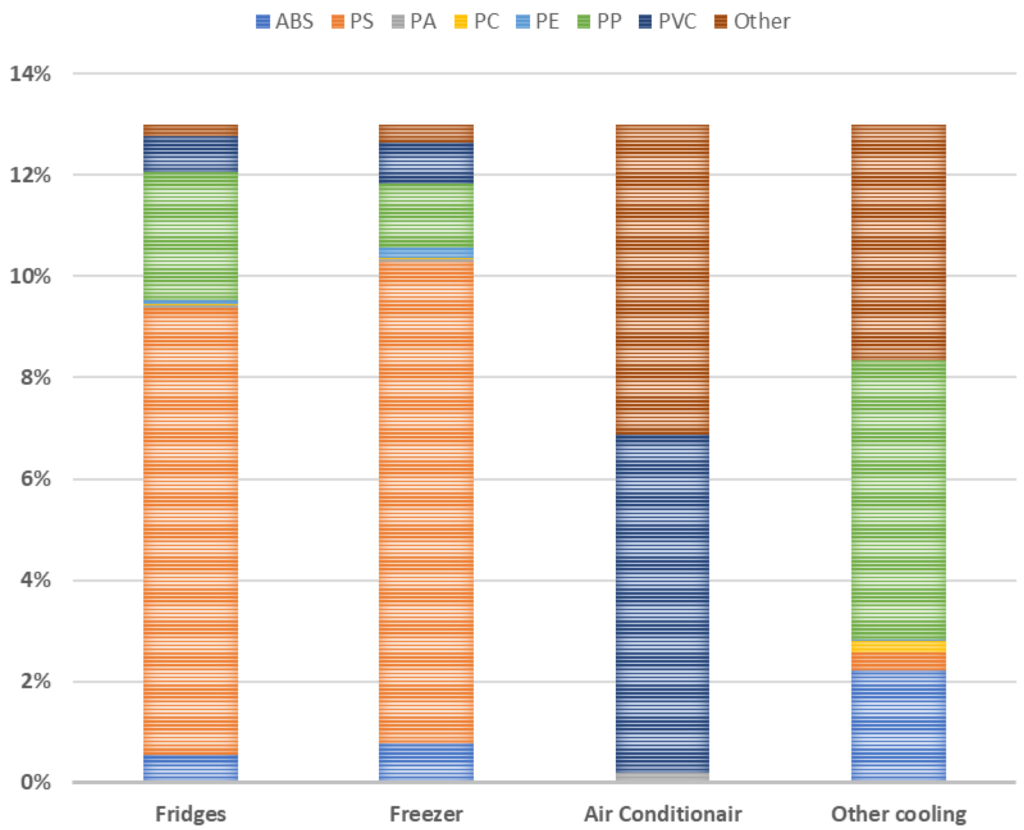

Figure 7. Cooling and Freezing Appliances waste stream: polymers per products composition

Figure 8 reports the composition in terms of polymers of the plastic content of the Cooling and Freezing waste stream (plastic content of Cooling and Freezing Appliance waste stream resulted 12.98%). This waste stream contains mainly PS (8.78%) and PP (2.44%). Data reported in figure 8 has been elaborated considering the actual presence of products in the current waste flow.

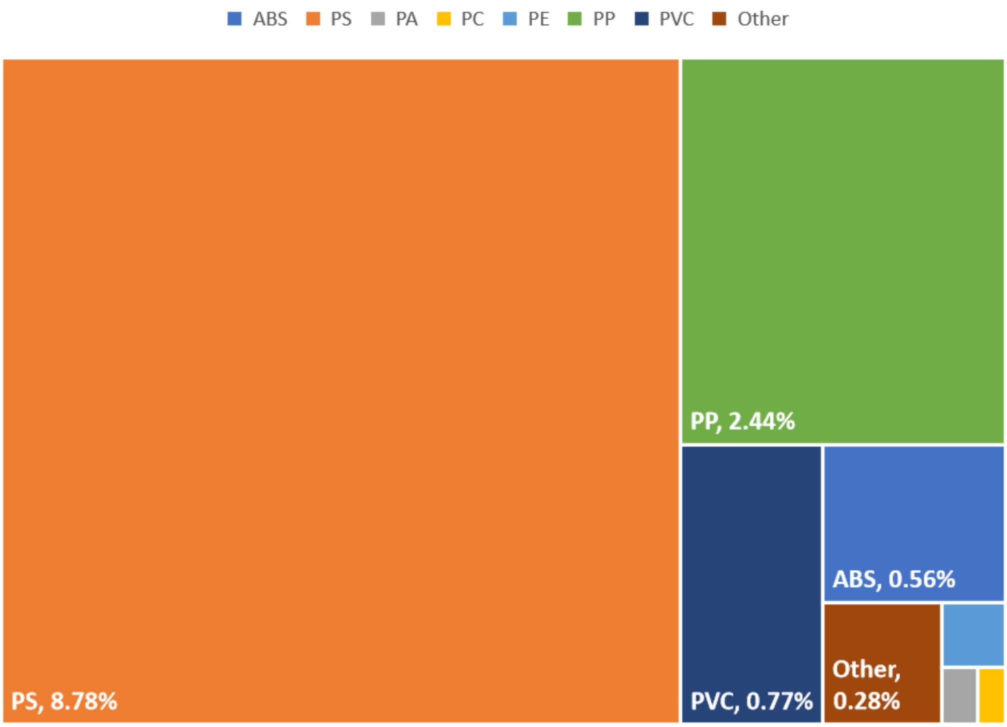

Figure 8. Cooling and Freezing Appliances waste stream: composition in terms of polymers (Total 12.98%)

The discrepancy between EEE composition and WEEE stream composition can be explained considering temporal difference in construction and disposal. Namely, in the waste flow very different products in terms of year of production can be identified. This corresponds to a considerably high variety of products composition. Moreover, there are *losses* of plastic in the waste flow considering that it is not always easy to isolate the plastic parts of the products during the treatment steps.

These considerations apply also to the other waste streams analysed.

6.3.2.2 Large Household Appliances

As far as it concerns the Large Household Appliances waste flow, it is assumed that the plastic content of the products in the waste stream is the one proposed in tab. 9, resulting from the sampling campaign performed by ECODOM. The results of plastic composition study is presented below (fig. 9 and fig. 10; detailed figures in Annex III).

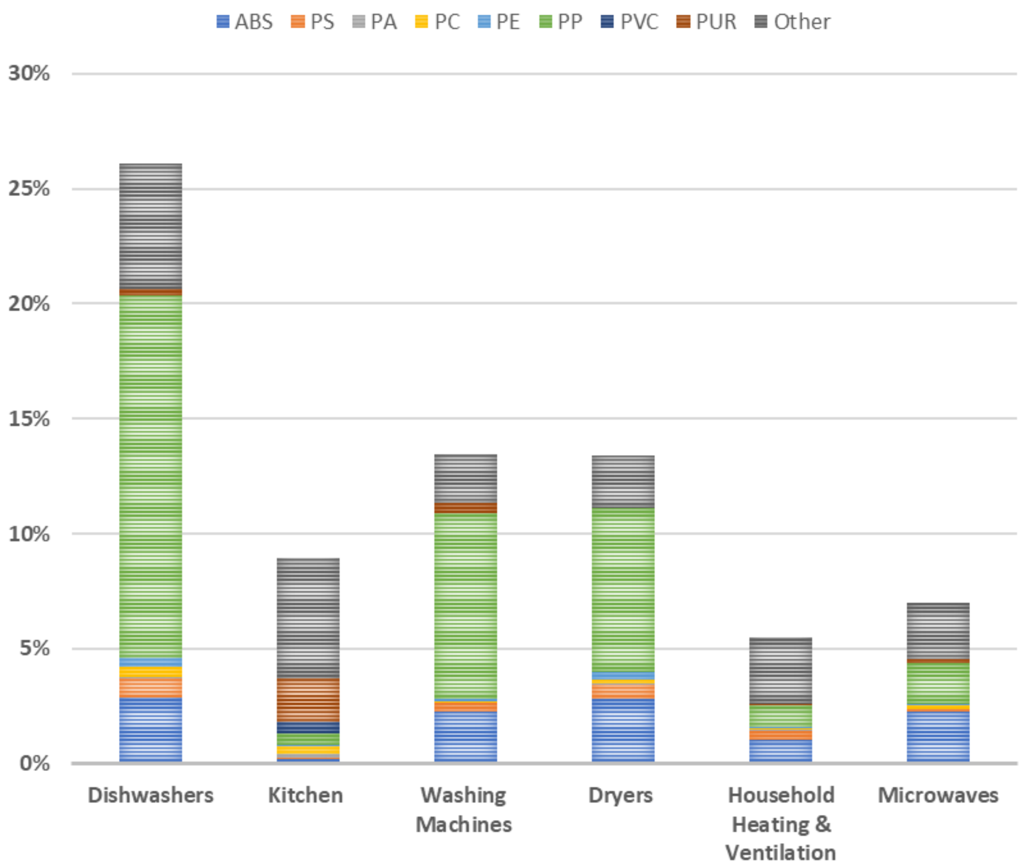

Figure 9. Large Household Appliances waste stream: polymers per products composition

Figure 10 shows the composition in terms of polymers of the plastic content of the Large Household Appliances waste stream (plastic content of Large Household Appliances waste stream resulted 14.05%). This waste stream contains mainly PP (7.89 %) and ABS (2.09%). Data reported in figure 10 has been elaborated considering the actual presence of products in the current waste flow.

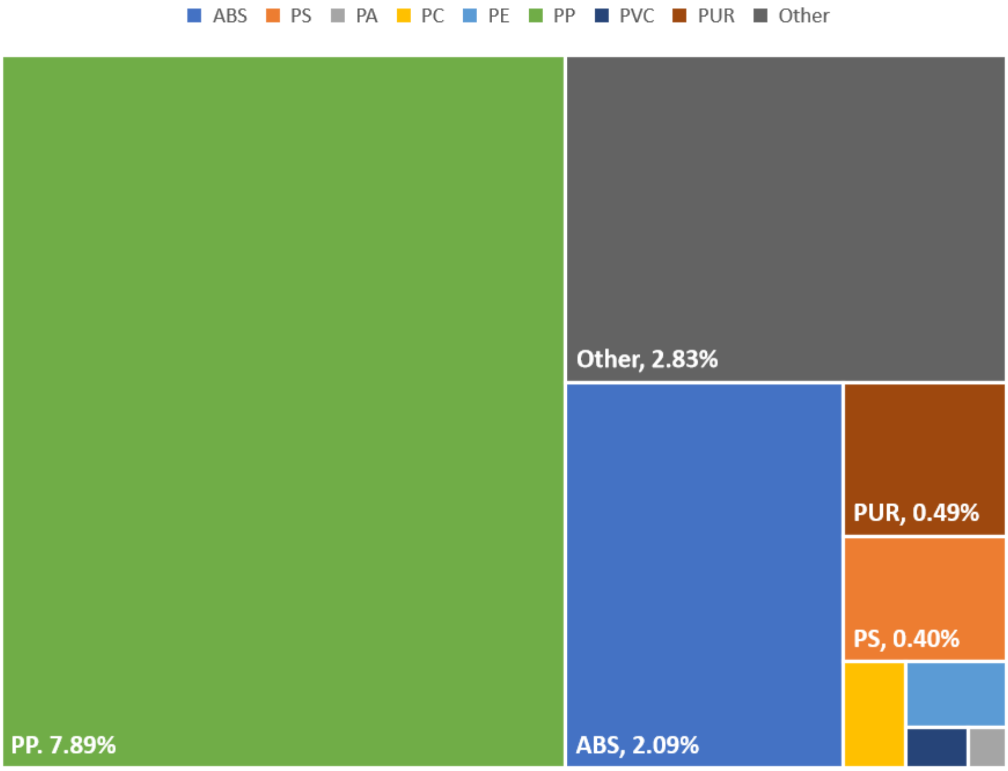

Figure 10. Large Household Appliances waste stream: composition in terms of polymers [Total 14.05%]

6.3.2.3 Televisions and screens

As far the TV&screens waste flow is concerned, it is assumed that the plastic content of the products in the waste stream is the same for all the different products. Specifically 16.42% in weigh of the item was considered as plastic (following the results of the WF-RepTool investigation presented in table 10) (fig.11, fig. 12, detailed figures in Annex IV).

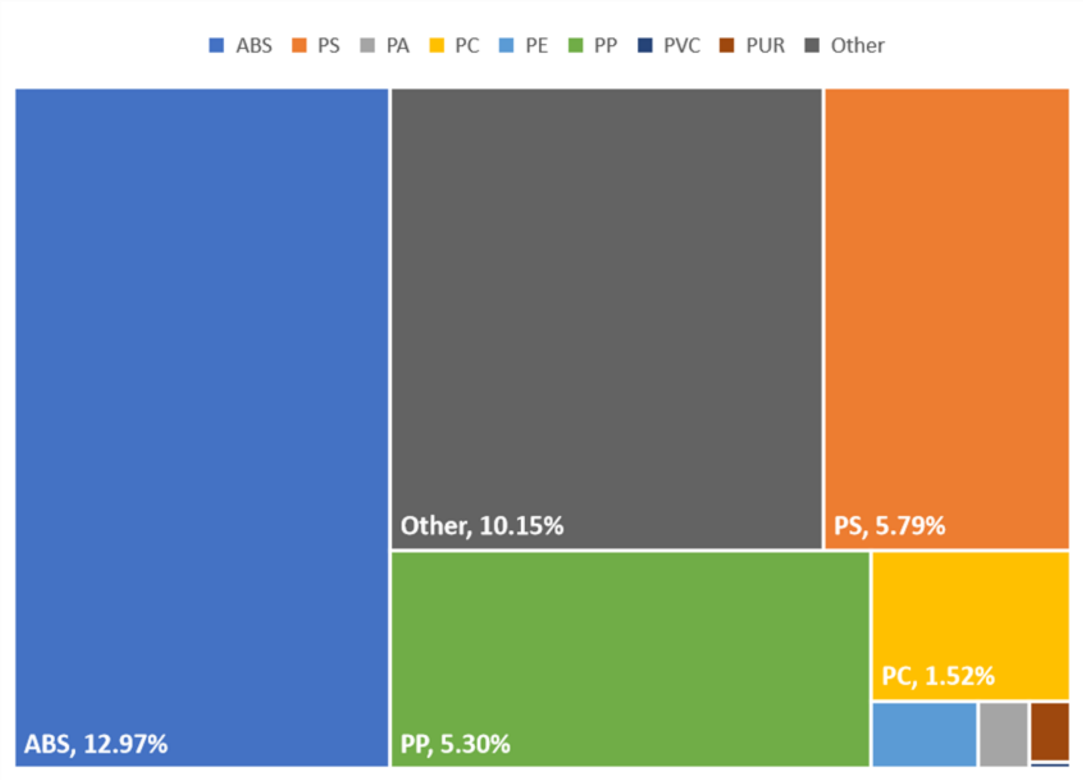

Figure 11: TVs and screens waste stream: polymers per products composition

Figure 12 reports the composition in terms of polymers of the plastic content of the TV&screens waste stream (plastic content of TV&screen waste stream resulted 16.42%). This waste stream contains mainly ABS (3.59 %) and PP (2.00%). Data reported in figure 12 has been elaborated considering the actual presence of products in the current waste flow.

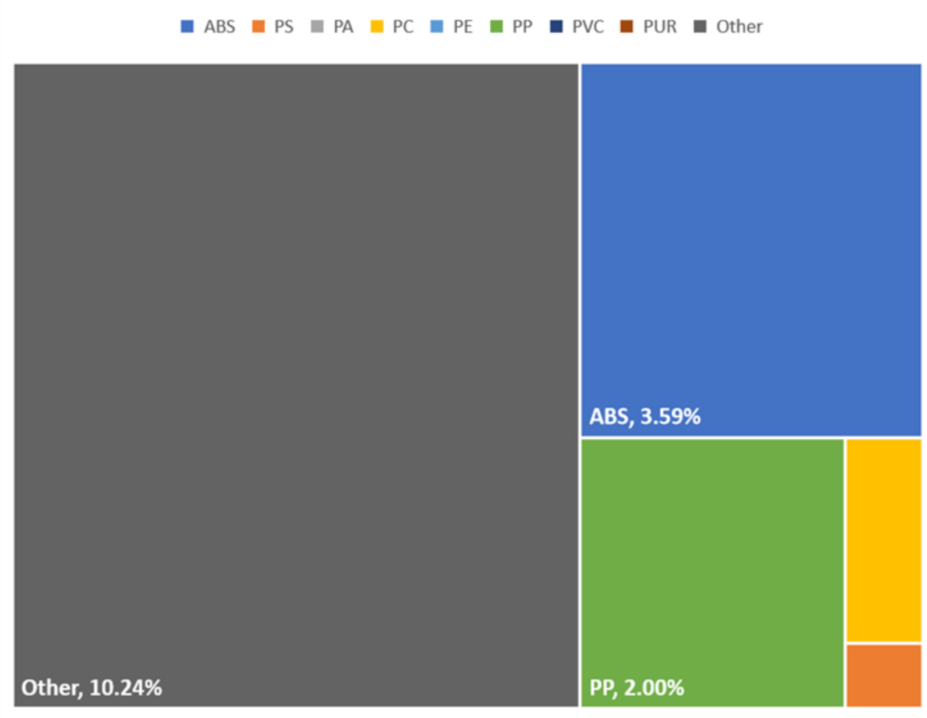

Figure 12: TV&screens waste stream: composition in terms of polymers [Total 16.42%]

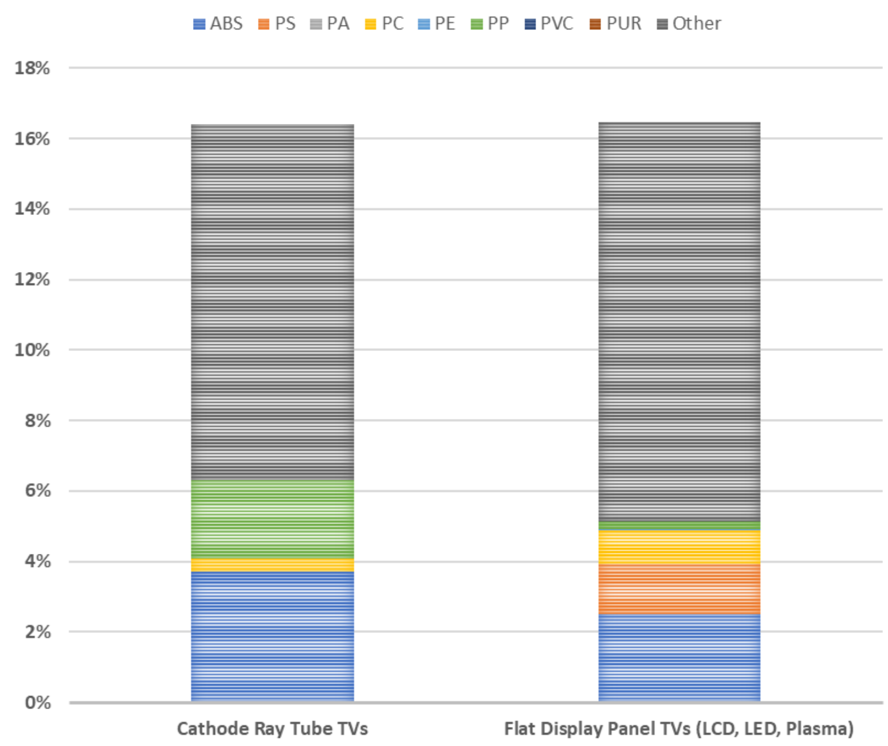

Figure 13. TVs and screens waste stream: polymers per products composition

6.3.2.4 Small Household Appliances

Considering the very high heterogeneity of the Small Household Appliances category, to have an idea of the waste flow composition in terms of polymers, the percentage of the different polymers shown in table 20 were applied to the amount of plastic available after the treatment (WF-RepTool data presented in table 11).

Figure 13 shows the composition in terms of polymers of the plastic content of the Small Household Appliances waste stream (plastic content of Small Household Appliances waste stream resulted 36.40%). This waste stream contains mainly ABS (12.97%), PS (5.79%) and PP (5.50%). Detailed data are reported in Annex V.

6.3.3 Polymers in waste streams

The analysis reported above allows for the definition of the polymers' availabilities in collected WEEE in Italy.

An overview of the composition of the different waste stream composition is presented (tab. 21; fig. 14).

Table 21. Plastic composition of the different WEEE streams

WEEE streams	ABS	PS	PA	PC	PE	PP	PVC	Other	TOT
C&F	4.31%	67.63%	0.37%	0.20%	0.64%	18.78%	5.89%	2.18%	100%
LHA	14.89%	2.80%	0.21%	0.94%	0.91%	56.22%	3.52%	20.16%	100%
TVs&screens	21.88%	0.87%	0.00%	2.66%	0.02%	12.19%	0.01%	62.37%	100%
SHA	35.62%	15.91%	0.48%	4.17%	1.00%	14.55%	0.36%	27.91%	100%

In the graphs in the remainder, the heading "other" refers to plastics not studied in this document as well as unidentified plastics. It must be noted that for some specific product the share of polymers indicated as unspecified was significant (e.g. 46% for CRT in TV&screens stream, 42% for vacuum cleaners, 28% for mobile phones, 23% for desktop PC in SHA stream and 22% for kitchen in LHA stream), as reported in section 6.3.2.

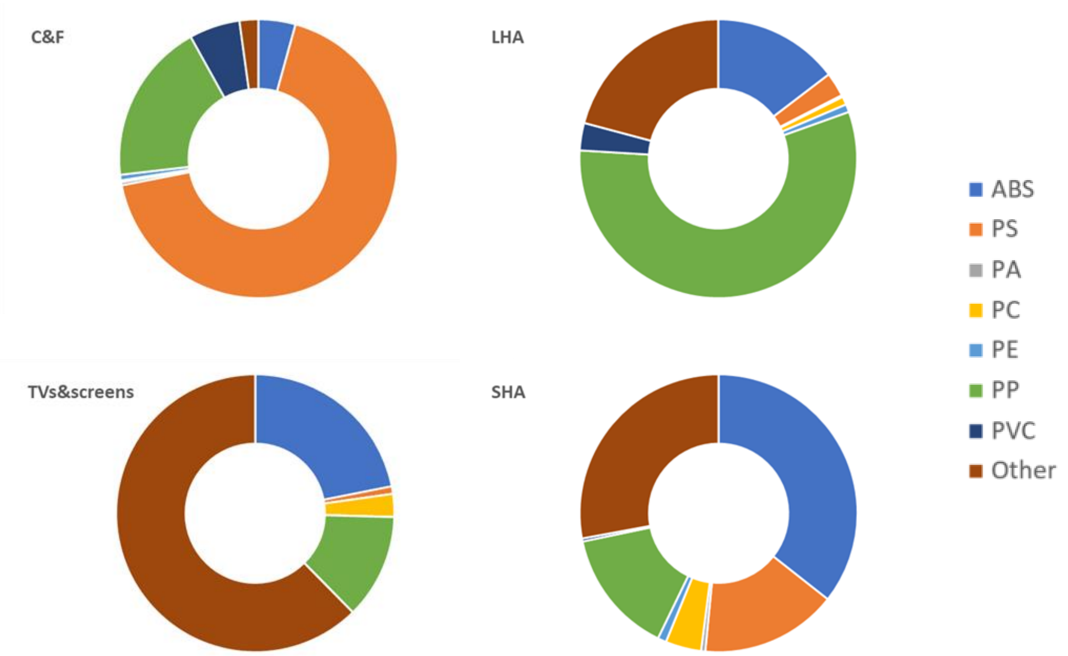

Figure 14. Plastic composition of the different waste stream

Overall, the performed analysis shows that in Italy, in 2016, 51,609 tons of WEEE plastics were obtained from the WEEE treatment (SHA accounted for 36% of the total; LHA, TV&screens and C&F accounted respectively for 25%, 20% and 19% of the total). The share of each polymer is presented below (fig. 15).

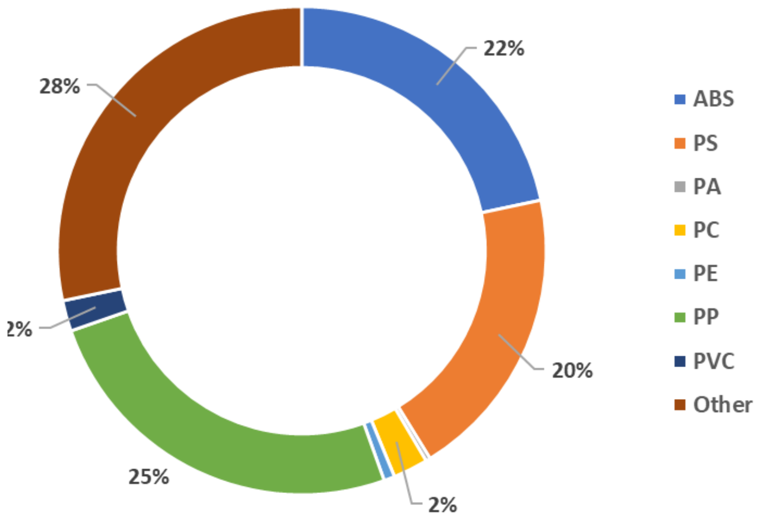

Figure 15. The Italian WEEE plastic mix collected

The contribution of each waste flow to the total amount of polymers collected is reported in the graph below (fig. 14, tab. 22).

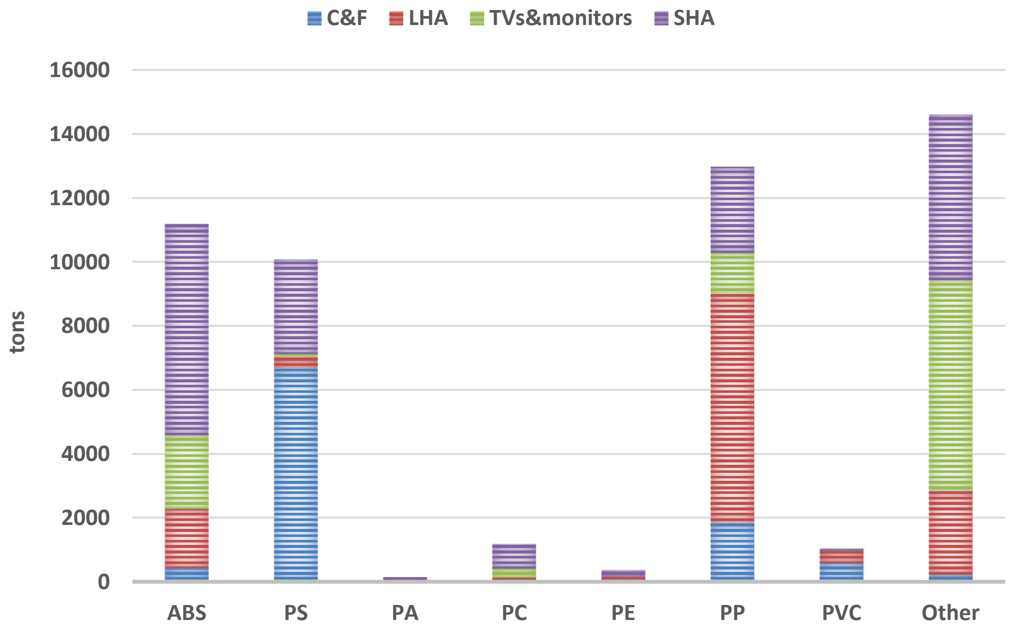

Figure 16. Available WEEE plastic in Italy

Table 22. Available WEEE plastic in Italy

WEEE streams (Italy)	ABS	PS	PA	PC	PE	PP	PVC	Other	TOT
				tons					
C&F	426	6,686	37	20	63	1,856	582	216	9,885
LHA	1,858	356	27	120	117	7,142	403	2,643	12,665
TVs&screens	2,307	92	0	280	2	1,284	1	6,572	10,539
SHA	6,597	2,947	89	772	185	2,695	65	5,169	18,520
TOT	**11,188**	**10,080**	**153**	**1,193**	**367**	**12,978**	**1,050**	**14,600**	**51,609**

The calculated amount of collected ABS was 11,118 tons in Italy, mainly from SHA plastic (59%). The amount of collected PP was 12,978 tons in Italy, mainly from LHA plastic (55%). The amount of collected PS was 10,080 tons in Italy, mainly from C&F plastic (66%).

6.3.3.1 From WEEE generated Italy

As evaluated before, there is a significant gap between WEEE generated by consumers and WEEE actually collected by take-back schemes. Taking into account this difference, it is possible to estimate the amount of plastic that would be potentially available if all the generated WEEE would be collected. Figures 17 through 18 and table 23 depict the potential distribution and total masses of collected WEEE polymers if the collection gap were bridged.

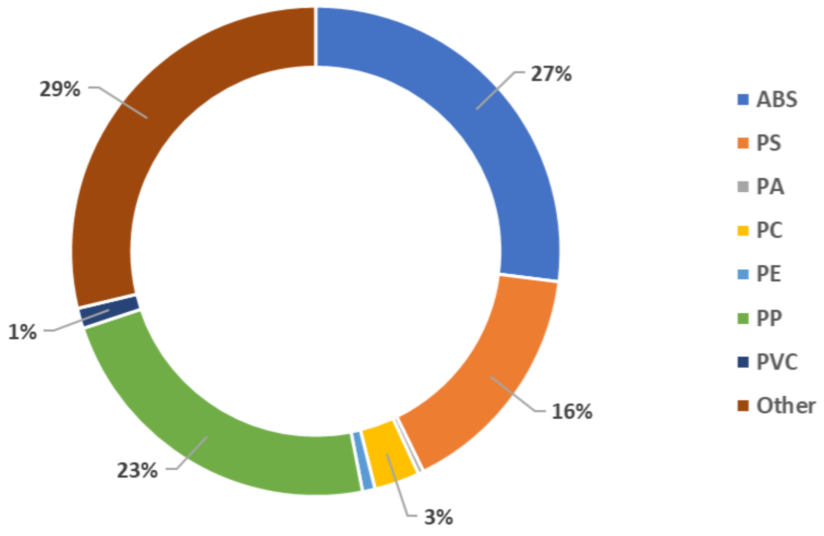

Figure 17. Potential plastic mix from WEEE generated in Italy

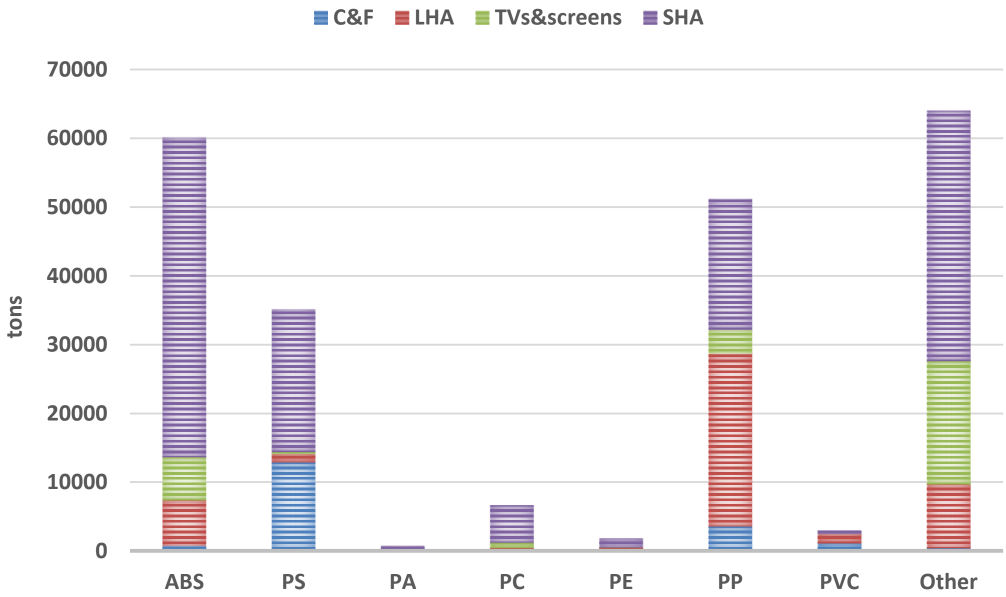

Figure 18. Potentially available WEEE plastic from WEEE generated in Italy

Table 23. Potentially available WEEE plastic from WEEE generated in Italy

WEEE streams	ABS	PS	PA	PC	PE	PP	PVC	Other	TOT
tons									
C&F	821	12,884	71	38	122	3,577	1,122	416	19,050
LHA	6,528	1,250	93	423	409	25,097	1,415	9,287	44,502
TVs&screens	6,286	250	1	764	7	3,500	2	17,908	28,717
SHA	46,462	20,753	630	5,439	1,304	18,979	457	36,405	130,429
TOT	60,097	35,137	795	6,664	1,842	51,152	2,995	64,015	222,697

Looking at the WEEE plastic generated, the figures for Italy rises from 51,000 to more than 222,000 tons (SHA represents 59% of the total amount).

6.3.3.1.1 From WEEE collected in EU

The same approach presented in section 6.3.3 is applied to the European context, studied considering the amount of WEEE collected in Europe in 2016 by take back schemes, as reported in table 4.

Overall, in Europe a total of more than 717,000 tons of WEEE plastics were obtained from the treatment. SHA accounted for 53% of the total; LHA, TV&screens and C&F accounted respectively for 23%, 12% and 12% of the total.

The amount of collected ABS was 182,410 tons in Europe (74% related to SHA plastic). The amount of collected PP was 174,081 tons in Europe (53% related to LHA plastic). While the amount of collected PS was 123,991 tons in Europe (47% related to C&F plastic and 49% related to SHA plastic). This is depicted in figures 19 and 20, as well as table 24.

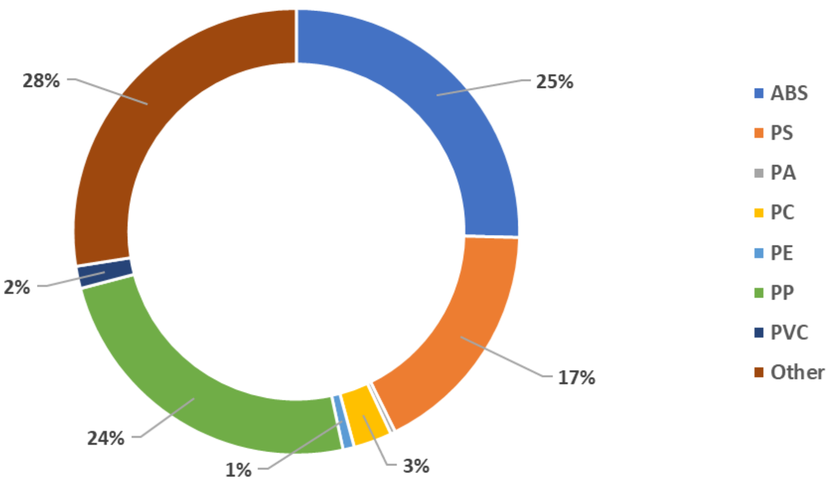

Figure 19. Polymer mix in WEEE plastics: Europe

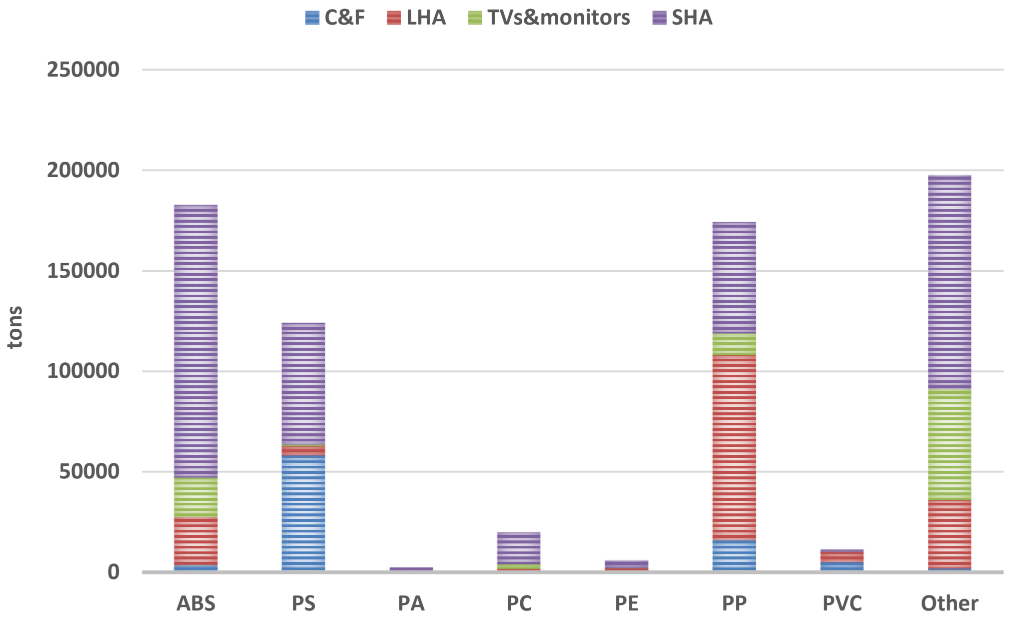

Figure 20. Available WEEE plastic in Europe

Table 24. Available WEEE plastic in Europe

WEEE streams	ABS	PS	PA	PC	PE	PP	PVC	Other	TOT
tons									
C&F	3,705	58,157	318	173	550	16,147	5,064	1,876	85,991
LHA	23,882	4,575	342	1,547	1,498	91,817	5,177	33,976	162,813
TVs&screens	19,400	771	2	2,357	21	10,800	5	55,266	88,623
SHA	135,423	60,488	1,837	15,854	3,802	55,317	1,331	106,110	380,162
TOT	182,410	123,991	2,499	19,931	5,871	174,081	11,577	197,228	717,588

6.3.3.1.2 From WEEE generated in EU

In the same way as in section 6.3.3.1, also the analysis concerning the European context should take into account the gap between WEEE generated by consumers and WEEE actually collected by take-back schemes. Considering this difference, it is possible to estimate the amount of plastic that would be potentially available after the treatment of all the WEEE generated in Europe. As reported in table 3, in 2016, 8,996,761 tons of WEEE have been generated in Europe. Assuming that the contribution of each waste flow to the total amount of WEEE generated is the same of the one of the Italian case study, it results that in Europe would be potentially available more than 2 million tons of WEEE plastics (tab. 25, tab. 26).

Table 25. Potentially available WEEE plastic from WEEE generated in Europe

WEEE streams	WEEE collected (tons)	WEEE generated (tons)	Plastic potentially available (tons)
C&F	662,485	1,324,676	171,943
LHA	1,158,890	2,859,093	401,674
TVs&screens	539,735	1,578,573	259,196
SHA	1,044,472	3,234,418	1,177,248
TOT	**3,405,582**	**8,996,761**	**2,010,061**

Table 26. Potentially available WEEE plastic from WEEE generated in Europe: polymers

WEEE streams	ABS	PS	PA	PC	PE	PP	PVC	Other	TOT
tons									
C&F	7,409	116,289	636	346	1,101	32,286	10,126	3,751	171,943
LHA	58,920	11,286	843	3,816	3,695	226,522	12,772	83,821	401,674
TVs&screens	56,739	2,255	6	6,895	60	31,587	16	161,638	259,196
SHA	419,364	187,313	5,688	49,095	11,773	171,301	4,121	328,592	1,177,248
TOT	542,432	317,143	7,174	60,150	16,629	461,696	27,034	577,803	2,010,061

Considering that the European collection rate (calculated as the percentage of the e-waste collected over the total e-waste generated) is about 38%, there is a large amount of WEEE plastic that is not managed by documented operators [2]. The remaining 62% of WEEE is exported, recycled under non-compliant conditions in Europe, scavenged for valuable parts or simply thrown in waste bins by citizens. Operators not working within the official system are likely not interested in WEEE plastic recovery. This is due to the fact that WEEE contains materials currently much more valuable on the market, such as iron, aluminium, gold, copper and palladium, which makes WEEE attractive for illegal single operators as well as for established criminal networks [5]. Therefore, there are more than 1 million tons of WEEE plastics that currently it is not fully available to plastic recycling.

6.3.3.1.3 From WEEE collected in EU in the future

Analysing the projection for the future waste streams elaborating the data reported in the APPLIA study [14], it is noted that the total amount of WEEE plastic from C&F is expected to increase by 75% compared to the current value, reported in table 24; while the total amount of WEEE plastic from LHA is expected to decrease by 14% compared to the actual value, reported in table 26. Some variation in the polymeric composition of the different WEEE flows is also expected (tab.27, fig.21, fig.22, fig.23).

Table 27. Available WEEE plastic in the future

WEEE streams	ABS	PS	PA	PC	PE	PP	PVC	Other	TOT
				tons					
C&F	9,719	87,607	62	185	1,039	16,476	9,003	26,586	150,676
LHA	15,738	395	2,618	2,343	1,088	70,958	3,434	42,763	139,337
TOT	25,456	88,002	2,680	2,528	2,128	87,434	12,437	69,349	290,013

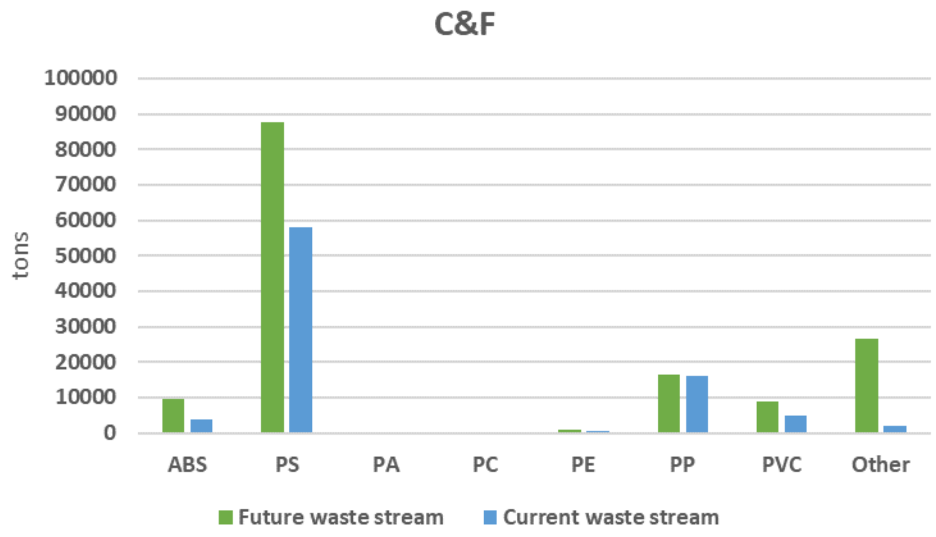

Figure 21. Available WEEE plastic in the future WEEE stream (C&F Appliances)

The data regarding the projection for the future has been elaborated starting from the information contained in the report issued by CECED, European Committee for Home Appliances [14]. From this study the composition of new equipment, that will be part of the WEEE flow in the future, has been extrapolated (detailed figures in Annex V). The other assumptions applied along this study remains consistent.

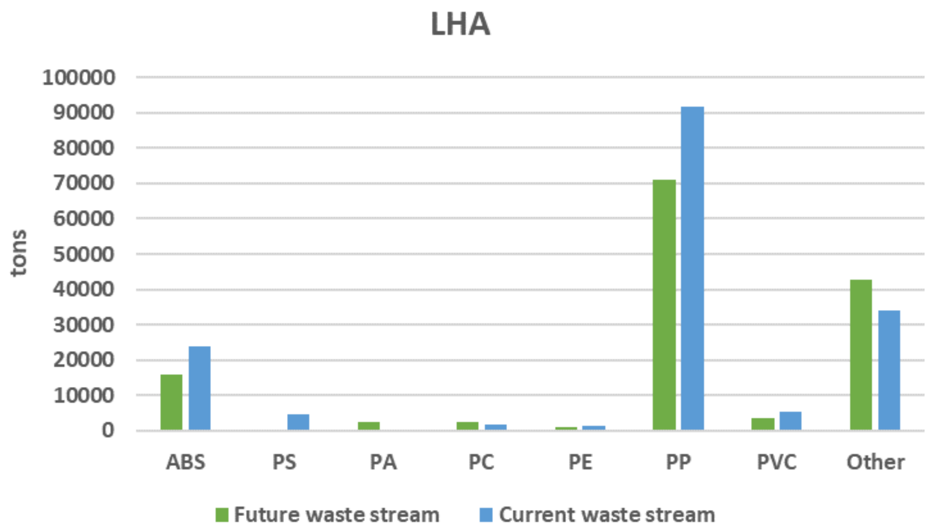

Figure 22. Available WEEE plastic in the future WEEE stream (LHA)

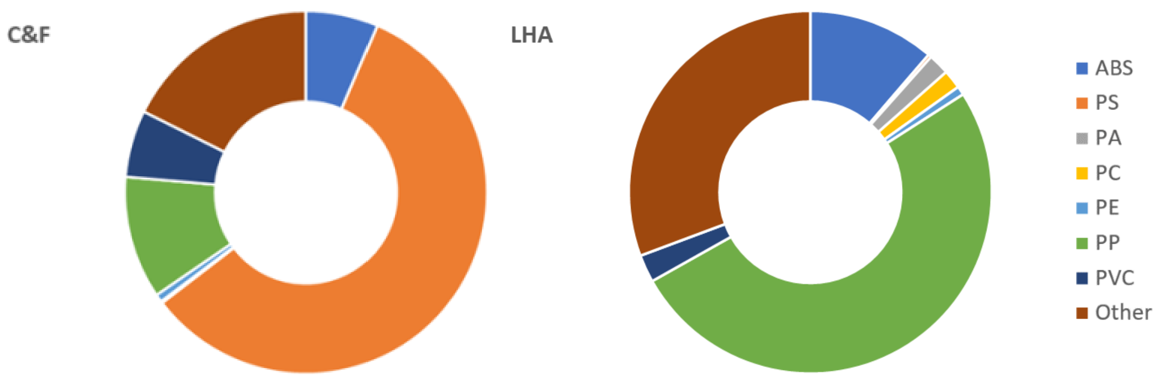

Figure 23. Polymeric composition of future WEEE flows

6.4 The WEEE plastic – plastic recyclers

Currently, WEEE plastic recycling processes have an average yield of 60%. Today, the main challenges that the plastic recyclers have to face are technical and legislative [16]. The technical issues are:

- difficult separation of polymers due to their similarity in terms of density;
- high variety of colours in PCR WEEE plastic flows.

While the legislative constrains are:

- WEEE plastic treatment outside European boundaries (WEEE plastic materials disappear from Europe);
- flame retardant issues (legal complexity);
- competing price outside Europe.

7 From WEEE plastic to EEE

According to the Plastic Europe research [1], the European plastics converter demand accounts totally for 49.9 mt. The electric and electronic sector demand accounts for 6.2% of the total plastic demand, namely 3.1 mt of plastic.

The research presented in this deliverable shows that about 717,000 tons of WEEE plastic are obtained annually from the WEEE treatment in Europe. This is roughly 23% of the actual EEE plastic demand (figure 24). Currently, the reintroduction of recycled WEEE plastics into the EEE value chain is obstructed by losses and difficulties in the recycling process (see section 5.2). The gap between disposed WEEE and WEEE actually collected further reduces the amount of available WEEE plastics. The collection of WEEE from SHA should be promoted, as this WEEE category has the largest plastic content (36.4%) and at the same time the lowest return and collection rate. Looking at the applications, from the OEMs point of view, there are still several challenges that must to be faced to effectively use PCR plastic in new application. Some of them are related to the complexity of the PCR plastic value chain [16]. Specifically:

- PCR plastic market is characterized by many suppliers on the market with huge quality variation;
- there is a low level of technical support regarding PCR plastic;
- the high quality recycled grades have lower price than virgin material, however, PCR plastic quality is not clearly defined and quantities are not stable.

The application of PCR WEEE plastic in new product is impeded also by other factors as:

- the quality of PCR plastic varies according to the used source;
- transparent natural colour and food contact grades are scarcely available (mainly black and grey colour currently available);
- using PCR plastic is difficult to obtain high gloss surfaces.

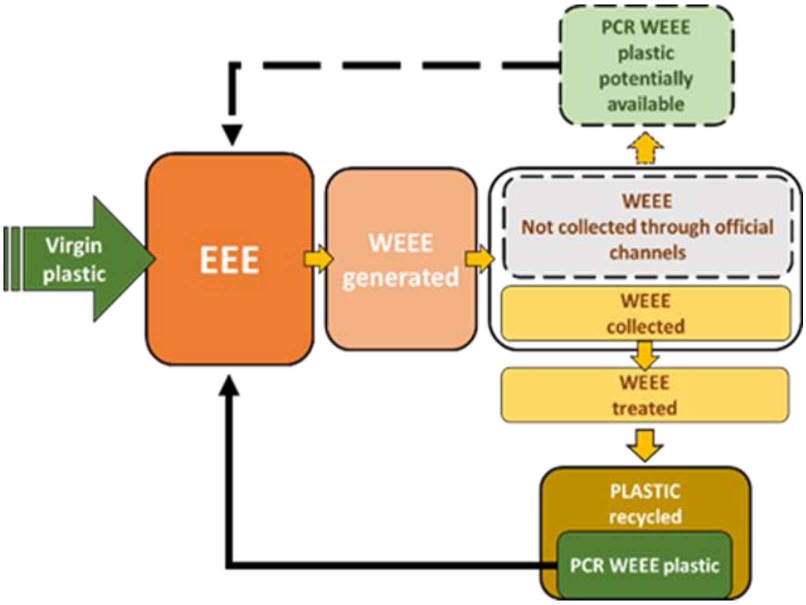

Figure 24. PCR WEEE plastic value chain

8 Future developments

Additional research effort will be devoted to validate the obtained results. For this purpose, an extensive sampling campaign has been conducted and plastic analysis (e.g. FTIR analysis) will be performed to determine the plastic composition of different WEEE products (allowing to create a detailed and complete database) (task 3.2 *Product clustering for improved collection, sorting and reprocessing and optimized recycling economics, high purity PCR plastics streams and uptake*).

KU Leuven – University of Leuven will analyze the plastic type and presence of phosphor (P FR) or bromine (Br FR) based flame retardants by XRF and FTIR analysis. The number of samples to be analyzed depends on the one hand on the desired accuracy of the plastic composition and on the other hand on the complexity of the mixture of plastics found in a specific product category.

The sampling campaign has been performed in a WEEE pre-treatment plant on different occasions. The sampling activity has been structured following the detailed instruction prepared by KULeuven for a prior research [17]. The KU Leuven – University of Leuven has developed a procedure to analyze the plastic composition of WEEE and to forecast how the material composition of specific product categories and/or jointly treated clusters of product categories will evolve over time.

The procedure to gather the required data has the following steps:

1. register the date of the experiment, as the material composition is known to evolve in time;
2. register the origin of the data to assure easy retrieval of the samples;
3. give every collected sample a sample number;
4. give every data record a unique number starting;

5. register to which product category the product belongs by filing in the UNU Key and the HS-Code;
6. register the brand of the product, as the type of plastics adopted has been proven to be brand dependent and clustering could also be performed based on brand names;
7. register which component that was sampled. If more than one component is sampled per product, for example when it is expected that multiple plastics are used in a product, it is important to add another row and duplicate all other data.
8. register the model number to allow verification;
9. register the product weight to determine the average weight per product;
10. dismantle the plastic component and register the weight of the sampled component to allow to determine the wt% of (different) plastics in a specific waste steam;
11. look inside the plastic component for in mold markings indicating the plastic type, year of production, location of production and flame retardancy according to UL 94. This to allow, when possible, a quick verification of the plastic analysis and to analyze the correctness of in mould markings;
12. register the size of the monitor or TV, as a relation is expected between the size and the adopted plastic type;
13. register the color of the plastic, as it can be valuable to cluster products based on their color, as white and light grey plastic recyclates are of higher value than dark colored recylates;
14. drill out a sample from the plastic housing and write the sample number on the plastics.

The table below (tab. 28) shows the plastic samples taken so far. Figure 25 gives an overview of the plastic samples collected.

Table 28. Plastic samples collected during the sampling campaign

Cooling and Freezing Appliances	Fridge boxes/drawers	40
	Fridge interior/door	41
	Freezer	49
Large Household Appliances	Dishwasher	13
	Dryer	1
	Washing Machine drums	17
	Washing Machine front/dispenser	22
Small Household Appliances	Expresso machine	5
	Iron	7
	Keyboard	5
	Radio	6
	Printer	4
	Vacuum cleaner	3
	Laptop	2
	Mixer	2
	Lamp	1
	Modem	1
	Paper shredder	1

	Portable electric heater	1
	Remote control	1
	Router	1
	Scale	1
	Speaker	1
	Telephone	1
	Wireless phone	1
	Game console	1

Figure 25. Plastic samples collected during the sampling campaign

The graph below (fig. 26) shows the results of the analysis performed so far by KULeuven on part of the plastic samples listed in table 26. The graph includes also results of analysis performed on samples collected outside the PolyCE project. The numbers in the figure refer to the amount of samples analysed.

Figure 26. Results of the analysis performed by KULeuven: product composition

The data regarding plastic compositions of relevant WEEE streams and waste flows in Europe will be used together with data on the plastic sorting and recycling efficiency in an optimization tool that will be developed to determine which product categories should be jointly or separately treated. Therefore, the next steps will be to derive a method to compute promising clustering policies and to incorporate properties of product streams (including the degree and type of possible contaminants as well as the colour and its effect on the value of the material).

To assure that new and valuable insights will be obtained from this optimization tool, it is crucial to collect the right data with sufficient detail. Therefore, the sampling campaign will be replicated and additional analysis will be performed.

The sampling campaign described above aims to validate the results presented in this deliverable and to establish a comprehensive reliable database containing information on plastic composition of different WEEE products.

For this purpose, more experimental data are needed. Therefore, ECODOM will collect and provide additional plastic samples to KU Leuven, in charge of performing the required additional material characterization analysis. The additional samples will be provided in form of plastic disks (collected from WEEE products according to the experimental set up reported above) or in form of plastic flakes of shredded product families (e.g. shredded material from *coffee machines cluster*).

9 Conclusion

The present document aims to provide a comprehensive overview of the current WEEE value chain and to quantify the plastics flows and the mass balance between the crucial nodes of the WEEE value chain.

The research shows that overall in Italy more than 51,000 tons of WEEE plastics are currently made available by the treatment of about 281,000 tons of WEEE. This figure, considering the significant gap existing between the amount of WEEE generated and WEEE collected, results considerably higher when also WEEE not documented are included in the calculation. Specifically, the treatment of the entire amount of WEEE estimated to be generated in Italy (more than 996,000 tons) can make potentially available more than 222,000 tons of WEEE plastics.

At the European level, the treatment of more than 3 mt of WEEE by takeback schemes could make available more than 717,000 tons of WEEE plastic. Additionally, considering that around 9 million tons of WEEE are generated in Europe, more than 2 million tons of WEEE plastic would be potentially available for recycling.

The analysis of the polymeric composition of the current WEEE plastic mix reveals that ABS and PS are the polymers mostly present in the Italian WEEE flow (accounting respectively for 22% and 20% of total collected WEEE plastics); while ABS and PP are the polymers mostly present in the European WEEE flow (accounting respectively for 22% and 20% of total collected WEEE plastics; while PS accounts for 17% of total collected WEEE plastics). In terms of polymers, also the compositions of the different waste streams, used as *research units* for this investigation, show some differences: PS represents 67% of the total plastics contained in Cooling and Freezing Appliances; PP represents 56% of the total plastics contained in Large Household Appliances; ABS represents 35% of the total plastics contained in Small Household Appliances. Furthermore, regarding the Televisions and Screens waste flow, the share of polymers indicated as unspecified was significant (62% of the total collected plastics).

Despite the material availability proved by the figures presented above, the reintroduction of recycled WEEE plastics into the EEE value chain is obstructed by losses and difficulties in different steps of the studied WEEE value chain. One of the main technical issues to be faced regards the high variety of plastic types (in terms of polymers and colours) currently present in WEEE flows. Plastic sorting is in fact a complex process due to the density similarity of polymers and the high variety of colours in WEEE plastic flows. Adopting a systemic approach, as the one proposed in the PolyCE project, improvements can be introduced at different crucial nodes of the value chain:

- at the waste collection level, WEEE collection should be promoted and the gap between WEEE generated and WEEE collected should be reduced (especially concerning Small Household Appliances). Moreover, organizing the collection in *clusters* (e.g. products families defined taking into account the plastic content of the products) can increase the efficiency of the subsequent treatment steps;
- at the WEEE treatment level, new treatment technologies (e.g. innovative sorting equipment) or treatment procedures (e.g. manual dismantling additional steps) should be introduced to reduce plastics mix and to implement the treatment of batch of products collected according to certain clusters;

- at the plastic recycling level, innovative recycling solutions should facilitate the separation of mixed plastics.

This deliverable will support all the activities of task 3.2, responsible for the identification of appropriated clusters of products to optimize collection, sorting and recycling of WEEE plastics. Moreover, it will be used as the starting point for launching the demonstration trial of task 7.1. Activities of task 7.1 will operatively test the effectiveness of the proposed improvements.

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ANNEX I

Table 29. Conversion between the Italian denomination and the UNU Key system

Italian categorization		UNU-Key	
Cooling&Freezing Appliances	R1	0108	Fridges (incl. combi-fridges)
		0109	Freezers
		0111	Air Conditioners (household installed and portable)
		0112	Other Cooling
Large Household Appliances	R2	0001	Central Heating (household installed)
		0102	Dishwashers
		0103	Kitchen (e.g. large furnaces, ovens, cooking equipment)
		0104	Washing Machines (incl. combined dryers)
		0105	Dryers (wash dryers, centrifuges)
		0106	Household Heating & Ventilation (e.g. hoods, ventilators)
		0114	Microwaves (incl. combined, excl. grills)
TV&screens	R3	0308	Cathode Ray Tube Monitors
		0309	Flat Display Panel Monitors (LCD, LED)
		0407	Cathode Ray Tube TVs
		0408	Flat Display Panel TVs (LCD, LED, Plasma)
Small Household Appliances	R4	0303	Laptops
		0303	Tablets
		0201	Other Small Household (e.g. small ventilators, irons, clocks, adapters)
		0202	Food (e.g. toaster, grills, food processing, frying pans)
		0203	Hot Water (e.g. coffee, tea, water cookers)
		0204	Vacuum Cleaners (excl. professional)
		0205	Personal Care (e.g. tooth brushes, hair dryers, razors)
		0401	Small Consumer Electronics (e.g. headphones)
		0402	Portable Audio & Video (e.g. MP3, e-readers)
		0403	Music Instruments, Radio, Hi-Fi (incl. audio sets)
		0404	Video (e.g. Video recorders, DVD, Blue Ray)
		0405	Speakers
		0406	Cameras (e.g. camcorders, photo & digital still cameras)
		0601	Household Tools (e.g. drills, saws,mowers)
		0701	Toys (e.g. car racing sets, electric trains, music toys)
		0801	Household Medical (e.g. thermometers)
		0901	Household Monitoring & Control (alarm, excl. screens)
		0301	Small IT (e.g. keyboards, external drives & accessories)
		0302	Desktop PCs (excl. monitors, accessoires)
		0304	Printers (e.g. scanners, multi functionals, faxes)
		0305	Telecom (e.g. (cordless) phones, answering machines)
		0306	Mobile Phones (incl. smartphones, pagers)
		0702	Game Consoles
		0002	Photovoltaic Panels (incl. inverters)
Lamps	R5	0502	Compact Fluorescent Lamps (incl. retrofit & non-retrofit)
		0503	Straight Tube Fluorescent Lamps
		0505	LED Lamps (incl. retrofit LED lamps & household LED luminaires)
		0506	Household Luminaires (incl. household incandescent fittings)
		0501	Lamps (e.g. pocket, Christmas, excl. LED & incandescent)

ANNEX II

Table 30. Cooling and Freezing Appliance: product composition

Cooling and Freezing Appliances	Fridges	Freezer	Air Conditionair	Other cooling
ABS	0.55%	0.79%	0.05%	2.23%
PS	8.83%	9.50%	0.00%	0.34%
PA	0.05%	0.04%	0.15%	0.00%
PC	0.03%	0.01%	0.00%	0.24%
PE	0.08%	0.21%	0.00%	0.01%
PP	2.54%	1.26%	0.00%	5.52%
PVC	0.70%	0.83%	6.67%	0.00%
Other	0.22%	0.33%	6.11%	4.64%
TOT	12.98%	12.98%	12.98%	12.98%

Table 31. Cooling and Freezing Appliances: waste stream composition

Cooling and Freezing Appliances	Fridges	Freezer	Air Conditionair	Other cooling	TOT
ABS	0.51%	0.05%	0.00%	0.00%	0.56%
PS	8.21%	0.57%	0.00%	0.00%	8.78%
PA	0.04%	0.00%	0.00%	0.00%	0.05%
PC	0.03%	0.00%	0.00%	0.00%	0.03%
PE	0.07%	0.01%	0.00%	0.00%	0.08%
PP	2.36%	0.08%	0.00%	0.00%	2.44%
PVC	0.65%	0.05%	0.07%	0.00%	0.76%
Other	0.20%	0.02%	0.06%	0.00%	0.28%
TOT	12.07%	0.78%	0.13%	0.00%	12.98%

ANNEX III

Table 32. Large Household Appliance: product composition

Large Household Appliances	Dishwasher	Kitchen	Washing Machines	Dryers	Household Heating & Ventilation	Microwaves
ABS	2.86%	0.18%	2.28%	2.81%	1.05%	2.25%
PS	0.88%	0.10%	0.36%	0.59%	0.37%	0.12%
PA	0.05%	0.14%	0.01%	0.08%	0.05%	0.00%
PC	0.42%	0.32%	0.06%	0.19%	0.08%	0.19%
PE	0.38%	0.07%	0.10%	0.32%	0.06%	0.04%
PP	15.78%	0.49%	8.10%	7.11%	0.93%	1.79%
PVC	0.00%	0.54%	0.00%	0.00%	0.00%	0.00%
PUR	0.26%	1.89%	0.40%	0.00%	0.06%	0.17%
Other	5.46%	5.22%	2.14%	2.28%	2.92%	2.43%
TOT	26%	9%	13%	13%	6%	7%

Table 33. Large Household Appliances: waste stream composition

Large Household Appliances	Dishwasher	Kitchen	Washing Machines	Dryers	Household Heating & Ventilation	Microwaves	TOT
ABS	0.34%	0.02%	1.64%	0.03%	0.04%	0.02%	2.09%
PS	0.11%	0.01%	0.26%	0.01%	0.01%	0.00%	0.39%
PA	0.01%	0.01%	0.01%	0.00%	0.00%	0.00%	0.03%
PC	0.05%	0.03%	0.05%	0.00%	0.00%	0.00%	0.13%
PE	0.05%	0.01%	0.07%	0.00%	0.00%	0.00%	0.13%
PP	1.89%	0.04%	5.83%	0.07%	0.04%	0.02%	7.90%
PVC	0.00%	0.05%	0.00%	0.00%	0.00%	0.00%	0.05%
PUR	0.03%	0.17%	0.29%	0.00%	0.00%	0.00%	0.49%
Other	0.66%	0.47%	1.54%	0.02%	0.12%	0.02%	2.83%

ANNEX IV

Table 34. TV&screens: product composition

TV&screens	Cathode Ray Tube TVs	Flat Display Panel TVs (LCD, LED, Plasma)
ABS	3.71%	2.51%
PS	0.00%	1.42%
PA	0.00%	0.00%
PC	0.38%	0.95%
PE	0.00%	0.04%
PP	2.20%	0.20%
PVC	0.00%	0.01%
PUR	0.00%	0.01%
Other	10.12%	11.31%
tot	16.4%	16.5%

Table 35. TV&screens: waste stream composition

TV&screens	Cathode Ray Tube TVs	Flat Display Panel TVs (LCD, LED, Plasma)	TOT
ABS	3.34%	0.25%	3.59%
PS	0.00%	0.14%	0.14%
PA	0.00%	0.00%	0.00%
PC	0.34%	0.10%	0.44%
PE	0.00%	0.00%	0.00%
PP	1.98%	0.02%	2.00%
PVC	0.00%	0.00%	0.00%
PUR	0.00%	0.00%	0.00%
Other	9.11%	1.13%	10.24%

ANNEX IV

Table 36. Small Household Appliances: waste stream composition

Small Household Appliances	
ABS	12.97%
PS	5.79%
PA	0.17%
PC	1.52%
PE	0.36%
PP	5.30%
PVC	0.01%
PUR	0.13%
Other	10.15%
TOT	36.40%

ANNEX V

Table 37. Future products composition: Cooling and Freezing Appliances

Cooling and Freezing Appliances	Fridges	Freezer	Air conditioners	Other cooling
ABS	1.50%	1.20%	0.00%	0.00%
PS	13.40%	12.70%	0.00%	0.00%
PA	0.01%	0.00%	0.00%	0.00%
PC	0.03%	0.00%	0.00%	0.00%
PE	0.13%	0.60%	0.00%	0.00%
PP	2.50%	2.70%	0.00%	0.00%
PUR	1.30%	2.50%	0.00%	9.80%
Other	4.00%	1.50%	20.30%	20.00%
TOT	22.87%	21.20%	20.30%	29.80%

Table 38. Future products composition: Large Household Appliances

Large Household Appliances	Dishwashers	Kitchen	Washing Machines	Dryers	Household Heating & Ventilation	Microwaves
ABS	1.20%	0.00%	1.60%	4.70%	0.00%	1.50%
PS	0.22%	0.00%	0.00%	0.68%	0.00%	0.09%
PA	0.25%	0.00%	0.27%	0.15%	0.00%	0.00%
PC	0.23%	0.00%	0.24%	0.13%	0.00%	0.05%
PE	0.36%	0.00%	0.07%	0.00%	0.00%	0.03%
PP	10.20%	0.00%	6.60%	14.10%	0.00%	0.59%
PVC	0.35%	0.00%	0.00%	0.00%	0.00%	0.00%
PUR	0.82%	0.19%	0.24%	0.17%	0.00%	0.63%
Other	5.80%	1.70%	3.50%	7.00%	5.50%	3.10%
TOT	19.43%	1.89%	12.52%	26.93%	5.50%	5.99%