Plastics in WEEE Screens: Difficulties and Opportunities to Improve the Recycling Rate

Horta Arduin R.[1,*], Grimaud G.[2], Charbuillet C.[3], Laratte B.[1, 4], Perry N.[1]

[1] Arts et Métiers, Université de Bordeaux, CNRS, Bordeaux INP, I2M Bordeaux, Talence, France
[2] MTB Recycling, France
[3] Institut Arts et Métiers Chambéry, I2M, CNRS, Le Bourget du Lac, France
[4] APESA-Innovation, F-40220 Tarnos, France

*corresponding author: e-mail: rachel.horta_arduin@ensam.eu

Abstract
Nowadays the screens collected by the official e-waste schemes in France are mostly comprised of Cathode Ray Tube (CRT). Nevertheless, Flat Panel Display (FPD) collection should increase in the following years. Among other differences in material compositions, FPD screens have higher plastic content. In order to keep complying with the recycling targets for screens, as well as to increase the recycling performance per material, it is necessary to improve plastics recycling. The goal of this study is to quantify the plastic flows in screens generated, collected and recycled in France and to identify the current scenario of plastic recycling. The presence of flame retardants and additives in the plastics, the variety of polymer types, as well as the high volumes of black plastics are among the main challenges in plastics sorting and recycling. From the economic outlook, it is necessary to develop the market that uses secondary raw materials to ensure the profitability of the WEEE chain.
Keywords: E-waste; WEEE; Recycling; Plastics; Flame retardants; Recycling rate

1. Introduction

Annually millions of tons of electric and electronic equipment (EEE) are placed on the market (POM), leading to a massive generation of waste. Waste of electric and electronic equipment (WEEE) is a particularly complex waste stream due to its material composition. While it contains some high-value materials (such as gold and palladium), it also includes some toxic materials (e.g., mercury and brominated flame retardants) (Vadoudi et al., 2015).

In the European Union, WEEE management is regulated by the WEEE Directive (European Commission, 2012). The existing indicators and targets are measured in an overall mass-based approach, and there are no incentives to recover specific materials (e.g., plastics or critical raw materials). Consequently, there is a lack of monitoring of the quantities of materials collected and recycled, as well as of the quality of the materials recycled.

In this context, this study aims to quantify the plastic flows in e-waste in France and identify the current difficulties to improve plastics recycling. The screens (category II of WEEE Directive) is selected as a case study since it represents well how a change in technology influences the volumes and types of material available for collection and recycling.

2. Methods

To quantify plastic flows in waste screens in France, the following data are required: (1) waste generation; (2) share of products in waste screens; (3) plastic content in screens; (4) collection rate ; (5) recycling rate.

In order to estimate the screens generation in France, the WEEE Calculation Tool[1] is used and manually updated with recent POM data in France from the national registers of the French Environment & Energy Management Agency (ADEME) (Deprouw et al., 2018; Fangeat, 2017). The methodology to calculate WEEE generated is based on the amount of EEE POM in the previous years and on the corresponding product lifespan. Regarding the share of different types of screens generated, data from the same tool is used together with data from the Urban Mining Platform[2]. The screens category comprises both cathode-ray tube (CRT) and flat panel display (FPD) screens. It is comprised of the following products: tablets, laptops, TVs, and monitors.

To track target materials in e-waste flows, data about the composition of products and waste flows is essential. Once the compliance schemes do not regularly track the composition of e-waste categories by type of polymers, data from the literature is used (Huisman et al., 2017; Talens Peiró et al., 2016; Tecchio et al., 2018; Wagner et al., 2019) together with characterization assessments performed by the

[1] WEEE Calculation Tool is available in: http://ec.europa.eu/environment/waste/weee/data_en.htm
[2] More details on the Urban Mining Platform is available in: www.urbanmineplatform.eu

compliance schemes. Information regarding screens collected is also annually gathered and reported by ADEME. It is complemented with data from the ProSUM project (Huisman et al., 2017) and Ecologic (one of the compliance schemes in France), to estimate the share of different products collected by the official schemes. Lastly, the recycling rate is quantified based on treatment scenarios defined based on the current practices.

3. Results And Discussions

In 2017, FPD represented 47% of screens generated in France, an increase of 23% in comparison to 2012. The collection of FPD screens by the official schemes has also increased from 5% to 15% in the same period. FPD collection should increase in the following years, and over time CRT amounts will go down to zero.

Changes in the type of screens collected by the official schemes shift the type of materials available for recycling. Besides FPD being richer in terms of precious and critical materials, it also contains more plastics. The amount of plastics in screens generated in France from 2012 to 2017 has doubled. Nevertheless, recycling by the official schemes is still modest. Besides the variety of polymers present in (W)EEE, in this study is considered that only the recycling chain of acrylonitrile butadiene styrene (ABS), polypropylene (PP) and polystyrene (PS) from WEEE are established in France. Figure 1 presents the plastic flows in FPD and CRT screens in 2017. Only 21% of the total plastic generated was potentially recycled, mostly due to the recycling of CRT screens.

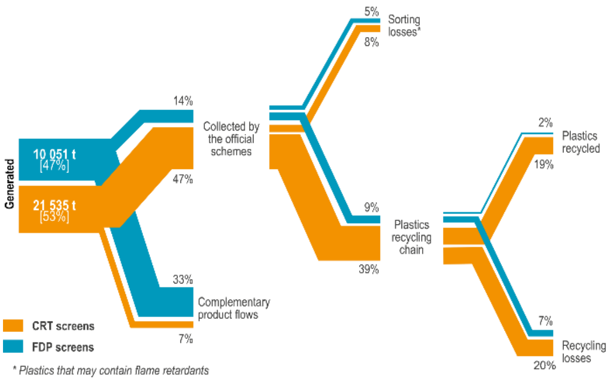

Figure 1. Plastic flows in WEEE screens in France (2017).

According to the WEEE Directive, plastic with brominated flame retardants (BFRs) should be sorted from the other e-waste fractions. In 2017, it represented 13% of the amount of plastics collected by the official schemes. Brominated plastics are usually incinerated with energy recovery or landfilled as hazardous waste.

The quality of the recycled plastic depends both on the product input and on the recycling process (Wagner et al., 2019). The main difficulties identified on e-waste plastics recycling are: (1) presence of brominated flame retardants; (2) sorting limitations due to black plastics; (3) presence of plastic additives; (4) significant range of polymers and limited technologies to sort and recycle them (Buekens and Yang, 2014; Deloitte et al., 2015; Ma et al., 2016; Sahajwalla and Gaikwad, 2018). Therefore, often the recycled material has a lower quality and functionality than the original material (downcycling). Additionally, the polymers recycling processes may be more expensive than the equivalent raw material.

4. Conclusion

Besides the increase of plastics generated in end-of-life screens, its recycling is modest. Aiming to boost recycling of plastics from WEEE and ensure compliance with the European recovery targets, it is crucial to improve materials tracking and support the development of recycling technologies. Moreover, it is necessary to develop the market that uses secondary raw materials to ensure the profitability of the WEEE chain.

Acknowledgements
The authors acknowledge the financial support from ADEME and Ecologic.

References

Buekens, A., Yang, J., 2014. Recycling of WEEE plastics: A review. J. Mater. Cycles Waste Manag. 16, 415–434.

Deloitte, Association Alliance Chimie Recyclage (2ACR), DGE, ADEME, 2015. Analyse de la chaîne de valeur du recyclage des plastiques en France - Trois grands axes d'actions pour développer la filière.

Deprouw, A., Jover, M., Chouvenc, S., Pensec, A., Fangeat, E., 2018. Rapport annuel du registre des déchets d'équipements électriques et électroniques 2017.

Fangeat, E., 2017. Indicateurs de suivi de la filière de Déchets d'Equipements Electriques et Electroniques Ménagers - Rapport interne ADEME.

Huisman, J., Leroy, P., Tertre, F., Söderman, M.L., Chancerel, P., Cassard, D., Amund, N., Wäger, P., Kushnir, D., Rotter, V.S., Mählitz, P., Herreras, L., Emmerich, J., 2017. ProSUM Project Urban mine and Mining wastes - Final report.

Ma, C., Yu, J., Wang, B., Song, Z., Xiang, J., Hu, S., Su, S., Sun, L., 2016. Chemical recycling of brominated flame retarded plastics from e-waste for clean fuels production: A review. Renew. Sustain. Energy Rev. 61, 433–450.

Sahajwalla, V., Gaikwad, V., 2018. The present and future of e-waste plastics recycling. Curr. Opin. Green Sustain. Chem. 13, 102–107.

Talens Peiró, L., Ardente, F., Mathieux, F., 2016. Analysis of material efficiency aspects of Energy related Product for the development of EU Ecolabel criteria - Analysis of product groups: personal computers and electronic displays.

Tecchio, P., Ardente, F., Marwede, M., Clemm, C., Dimitrova, G., Mathieux, F., 2018. Analysis of material efficiency aspects of personal computers product group.

Vadoudi, K., Kim, J., Laratte, B., Lee, S.-J., Troussier, N., 2015. E-waste management and resources recovery in France. Waste Manag. Res. 33, 919–929.

Wagner, F., Peeters, J., Keyzer, J. De, Duflou, J., 2019. Quality Assessment of Plastic Recyclates from Waste Electrical and Electronic Equipment (WEEE): A Case Study for Desktop Computers, Laptops, and Tablets, in: Technologies and Eco-Innovation towards Sustainability II. pp. 139–154.