ECONOMIC POSSIBILITIES OF PROFIT FROM METAL PCB

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Abstract

The paper is focused on electrical and electronic waste and the associated waste. The generated amount of electronic waste, including mobile phones, supports the search for an efficient way to process this waste. The dominant materials in used mobile phones containing a printed peripheral board are metals, especially copper. It describes the common and less widely used technology for processing electrical and electronic e-waste such as manual dismantling, mechanical, pyro metallurgical, electrochemical, hydrometallurgical methods. Describes various methods of economic evaluation.

Keywords: Economic, recycling, PCB, metals

1. INTRODUCTION

Waste is currently an essential part of our lives. Electrical appliances are used on daily basis in households, at work and also for entertainment. Due to the lower prices of these devices and the frequent arrival of new and more modern models, this type of waste is becoming the fastest growing one. On a global scale, waste electrical and electronical equipment (WEEE) accounts for up to 5 % of the total weight of so-called solid household waste, and therefore it is necessary to focus on its disposal. The importance of using electronic waste for recycling is increasing both from ecological and economic reasons and in connection with the current legislation there is a decreasing amount of unused waste [1,2].

Previous works described national as well as European legislative laws of waste management and related topics of electro waste manufacturing. They contained descriptions of basic laws and notices related to electro waste [3,4]. The other then presented characteristics of electro waste and individual groups of waste types as well. Furthermore, there was a description of average percentage contents of individual devices and a brief overview of a company dealing with electro waste manufacturing. Many publications were devoted to a description of individual methods used for waste manufacturing [5]. The most used manufacturing procedures include mechanical, pyrometallurgical, hydrometallurgical and electrometallurgical methods. Recycling procedures is shown in **Figure 1** [5]**.**

The aim of this publication is an economic-technical evaluation of profitability of individual methods for recycling of electro waste as well as a description of further treatment of material [7-10].

Small electric and electronic devices (MEEZ) most often ends up in mixed municipal waste, which has its environmental and economic impacts. It is estimated that consumers living in the European Union produce about 14-20 kg of electro waste a year. The amount of electro waste increases three times faster than the amount of common municipal waste [11]. In the European Union, this item represents about 5 % of municipal waste, i.e. approximately 6 million tons. There are estimations that in 2020, this amount will be doubled, and it will reach approximately 12 million tons.

An ecological value of materials from MEEZ is significant. Mobile phones are a classic example of MEEZ. On a global level, around a milliard of them was sold in 2016. An estimation of cumulated waste mobile phones in the Czech Republic is 5-8 million, which equals to 500-800 tons of valuable material. On a global level, 250 tons of silver, 24 tons of gold, 9 tons of palladium and 30 000 tons of copper were used for production of mobile phones in 2016.

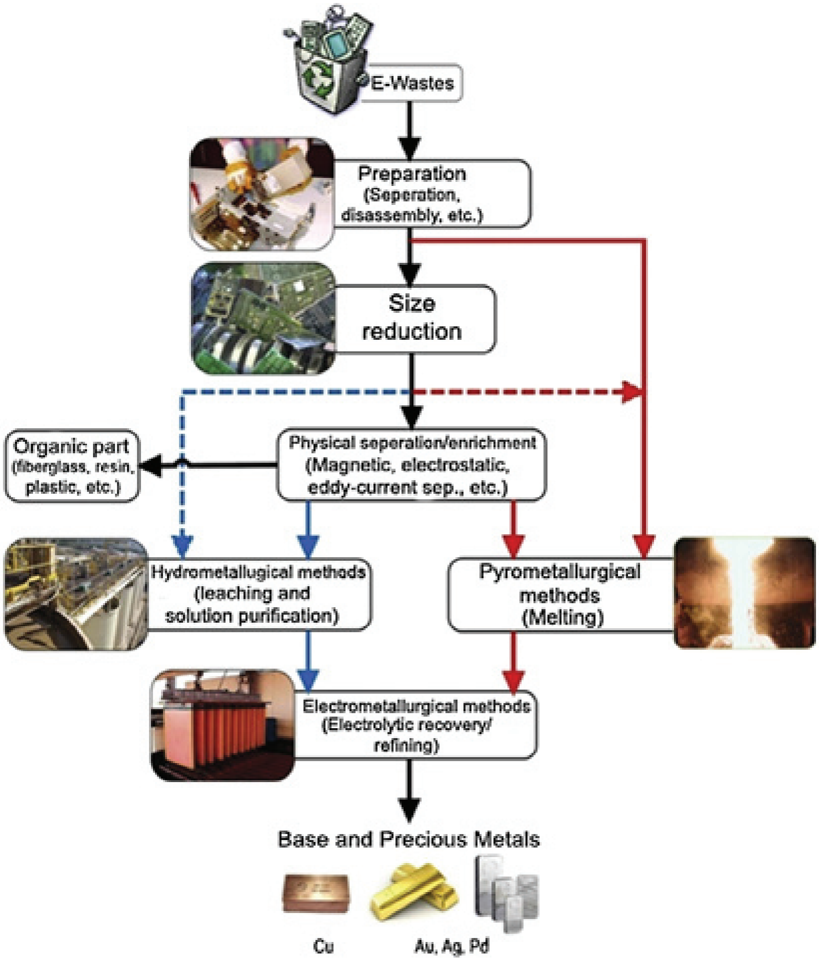

Figure 1 Recycling procedures E waste [5]

Last year, company Apple gained about 28,000 ton of a various materials from equipment that ended their life cycle (old Imacs, iPhones, iPads, other custom electronics). This information is shown in the company's annual environmental report. Part of this weight equal to 27,831 ton belongs to steel, plastic, glass, aluminum and copper [12-14]. Significant part of tnis recovered material is gold, which Apple gained in sum of 999.7 kg. As a result, Apple would recover almost CZK 950 million through reclaimed electronics by recycling of gold. Recycling also gained 3,306 kg of silver, whose value is about CZK 2.5 million. The value of 1.340 tons of copper would then reach a sum about CZK 155 million. Total sum of only three of these materials obtained by recycling would be over CZK 1.1 billion.

2. PREVENTION OF WASTE

A way to reach environmentally thrifty waste management is a clear setup of priorities and a determination of hierarchy of preferred ways of waste management. The highest priority within waste management should be placed on waste prevention itself, either by introduction of non-waste technologies or by a change in consumer behaviour [15]. With decreasing priority, further procedures should follow in the hierarchical list:

- minimization of waste in cases where it is not possible to stop its creation totally (low waste technology),
- recycling of utilisable materials including composting of biowaste,

- energetic utilization of suitable waste by combustion,
- material utilization of solid residues after combustion, e.g. in building industries,
- waste disposal of such waste that is not possible to be used in any way.

Moreover, in the present world of fast-moving consumer goods even higher price automatically does not have to mean for example longer lifetime of a product. Companies do not want to produce products that will last forever. The opposite is truth. Continuous flow of new, innovated or just newly packed products and new fashion trends, price actions and discounts accompanied by huge advertisement lead a consumer to buy “more for less” with no regard to real necessary amount. It forces out also such household products that still reliably serve to its purpose. In such environment, enforcement of preventive attitude in the area of production of consumer waste represents a gradual and long-term process that is closely connected with social, cultural and last but not least economic development of the society [16].

Recycling of waste (from recycling - recirculation, return back to process) represents reusage or further usage of production, manufacturing and consumer waste, materials and energies as sources of secondary raw material with no regard to place or time of waste creation and its usage [17].

It is obvious that recycling is superior to further ways of waste management within the hierarchy of waste management system. Therefore, it is not possible to compare it with any of these directly, even though it influences all of them to a great extent as a level of usage of secondary raw material considerably predetermines the amount of waste that will have to be processed by means of these methods. As such, it should be awarded the highest priority in the waste management system. However, its promotion should always respect economic limits. Expenses for substitution of primary materials with secondary raw materials are strongly variable depending on technological demandingness of the area [10-18].

Electro waste is one of the waste types where one device includes several types of mutually interconnected materials together (**Figure 2**). Thus, technologies for their separation have to be conformed to this aspect together with a certain portion of human work [4].

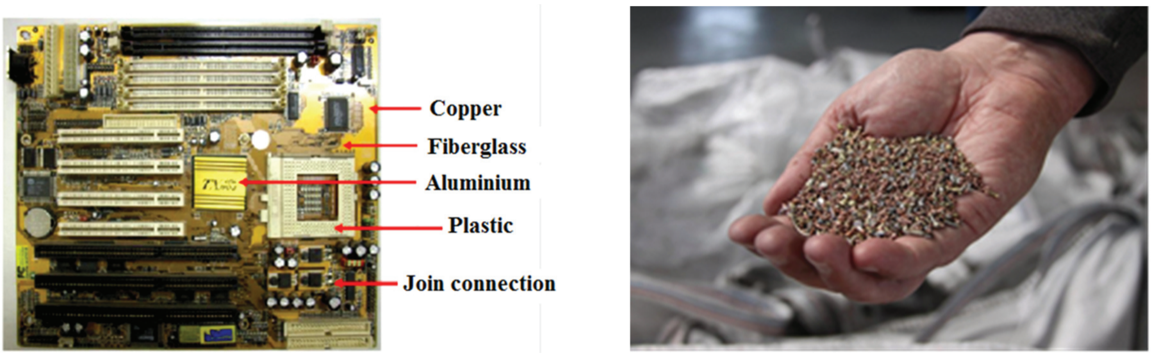

Figure 2 Electro waste - part PCB (polychlorinated biphenyl) [3]

Price of sold waste is a limiting factor for selling economics of individual sorted waste. The price depends on cleanliness of waste. Choice of such devices, which are the most effective with regard to operation expenses, plays a very important role. A presumption for an ideal yield is an application of several levels of crushing and sorting of waste. It is convenient also due to damage protection of further devices. Magnetic piece material and then non-magnetic metals are the most worthwhile materials from the price for sorting point of view with regard to expenses for buying of a separator and expenses for crushing elements. On contrary, technology for precious metals is the most complicated [1-3].

Individual structures of electro waste composition are continuously changing according to various types of production technologies as the market is being continuously entered by new Hi-tech technologies.

3. AN ECONOMIC EVALUATION

Gaining of noble metals from individual electro devices, e.g. from plates with printed connections, is very profitable with regard to their continuously increasing price. However, producers of electronics try to decrease prices, which causes decrease of content amount of noble metals (gold, silver, platinum) in the production process. Thus, the value of recycled electronics decreases and the whole recycling process is less economical. In **Table 1** see SWOT analysis - recycling.

Table 1 SWOT analysis - recycling [own study]

Recycling	
Strengths	**Weaknesses**
• Savings in primary inputs • Savings in energy • Savings in expenses for waste liquidation (waste = material)	• Many limits in a form of economic, ecological, technological and technical obstructions • Limited spectrum of products
Opportunities	**Threats**
• Technological progress • Consumers` interest in ecologically thrifty products from secondary raw materials	• Price decrease of primary materials • Price non-competitiveness towards common products

The value of yielded material is not on such a high level, like for example the value of printed circuit plates of twenty-years-old computers, which contained significantly greater amount of individual noble metals, see **Table 2**.

Table 2 Content of elements in Personal Computer [own study]

Element	Content [%]	Element	Content [%]
plastic	22.99	Au	0.0016
Pb	6.29	Ag	0.0169
Al	14.17	Si	24.88
Fe	20.47	Sn	1.01
Cu	6.93	Zn	2.20
Ni	0.85	other	0.19

3.1. An evaluation of individual processing options

In case of a collective system and consequent demounting, there is an advantage that a customer pays a compulsory recycling fee already during the purchase. The fee serves not only as a support for the collective system but also for delivering the electric device to the collection container. The collection point can also support sheltered workshops for further processors where individual material returns after processing to producers of new components.

There might be a gradual limitation of recycling services provided by the sheltered workshops, which gain waste mainly from collective systems. In a related case, Enviropol company owned by ASEKOL Holding opened the most modern line for electro waste processing in the city of Jihlava not only for the Czech Republic but also for Europe. During its common operation, the line processes 60 tons of electric devices on a daily level. Its capacity is up to 21 000 tons of electric devices. Cleanliness of sorted metals reaches 98-99 % with a minimum of plastic ingredients.

Non-economical aspect of the sheltered workshops plays also the main role. Their processing represents tons a year, not hundreds of tons. The sheltered workshops should by perceived as social projects and they should search for other opportunities how to earn money in case there is a dropout of income from electro waste.

Waste disposal appears to be the worst option.

From the economic point of view, the most advantageous option is demounting into individual parts where there is higher redemption price as we devote time to demounting of parts. When delivering the whole parts, we get lower redemption price, which includes time and expenses for its processing.

4. CONCLUSION

Together with introduction of modern methods of production of surface plates, there is an increase of electro waste. Newer and newer devices with shorter lifetime enter the market. This results in great amount of electro waste. Due to this increasing amount of electro waste, there should be an emphasis on its reuse from legislative as well as moral point of view. These recycled devices contain precious metals, which can be further used in new devices.

Indeed, studies have proven the environmental benefits of the assessed system for the treatment of recovered electrical equipment. It has demonstrated the benefits of recycling WEEE for the environment and thus the efficiency of the system introduced in the Czech Republic. The savings are particularly related to the material utilization of precious metal-rich metals such as silver, gold and palladium. Also, the recycling of copper, iron, aluminum and brass forms has a positive balance. Combustion of the plastics contained in the metal-rich components leads to a reduction in the amount of fuel required for melting metals.

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REFERENCES

[1] BROŽOVÁ, Silvie, INGALDI, Manuela and ŠPERLÍN, Ivan. Economical aspects of high-temperature heating utilization for industrial waste treatment. In *METAL 2013: 22nd International Conference on Metallurgy and Materials*, Ostrava: TANGER, 2013, pp. 1735-1739.

[2] SATERNUS, Mariola, FORNALCZYK Agnieszka, WILLNER Joanna and KANIA Henryk. Methods for silver recovery from by-products and spent materials. Chemical industry. 2016. vol. 95, pp. 78-83.

[3] JONŠTA, Petr, VÁŇOVÁ, Petra, BROŽOVÁ, Silvie and PUSTĚJOVSKÁ, Pavlína. Hydrogen embrittlement of welded joint made of supermartensitic stainless steel in environment containing sulfane. *Archives of Metallurgy and Materials*. 2016. vol. 61, no. 2A, pp. 709-711.

[4] KARDAS, Edyta, BROZOVÁ, Silvie. Situation in waste treatment in Poland. In *METAL 2013 - 22nd International Conference on Metallurgy and Materials*. Ostrava: TANGER, 2013, pp 1773-1778.

[5] CEP, Robert, JANASEK, Adam, SLIVA, Ales, NESLUSAN, Miroslav, BINDER, Martin. Experimental tool life tests of indexable inserts for stainless steel machining. *Tehnicki Vjesnik-Technical Gazette*. 2013. vol 20, no. 6, pp. 933-940.

[6] OUJEZDSKY, Ales, SLIVA, Ales, BRAZDA, Robert. Using ICT in education: measuring systems interfaced to computers. In *9th International technology, education and development conference.* Madrid: INTED Proceedings, 2015, pp. 7509-7512.

[7] DVORSKY, Richard, LUNACEK, Jiri, SLIVA, Ales, SANCER, Jindrich. Preparation of silicon nanoparticular nanocomposite with thin interparticular tin matrix. *Journal of Nanoscience and Nanotechnology.* 2011. vol 11, no. 10, pp. 9065-9071.

[8] SLIVA, Ales, BRAZDA, Robert, ZEGZULKA, Jiri, DVORSKY, Richard, LUNACEK, Jiri. Particle characterization of nanoparticle materials in water jet mill device. *Journal of scientific conference proceedings.* 2010. vol 2, no.1, p. 45.

[9] SLIVA, Ales, SAMOLEJOVA, Andrea, BRAZDA, Robert, ZEGZULKA, Jiri, POLAK, Jaromir. Optical parameter adjustment for silica nano- and micro-particle size distribution measurement using mastersizer 2000. In *9th International symposium on microwave and optical technology (ISMOT 2003).* Ostrava: 2003 INTED Proceedings, 2015, pp. 7509-7512.

[10] JULANDER A., LUNDGREN L., SKARE L., GRANDÉR M., PALM B., VAHTER M., LIDÉN C. Formal recycling of e-waste leads to increased exposure to toxic metals: An occupational exposure study from Sweden. *Environment International*, 2014, vol. 73, pp 243-251.

[11] FRÖHLICHOVÁ, Marie, FINDORÁK, Robert, LEGEMZA, Jaroslav, DŽUPKOVÁ, Martina The fusion characteristics of ashes from lignin and the coke breeze. *Archives of Metallurgy and Materials*. 2018, vol.63, no. 3, pp. 1523-1530.

[12] FRÖHLICHOVÁ, Maria, IVANIŠIN, Dušan, FINDORAK, Robert, DŽUPKOVÁ, Martina, LEGEMZA, Jaroslav. The effect of concentrate iron ore ratio change on agglomerate phase composition. *Metals - Basel, MDPI*. vol. 8, no. 11, pp 1-11, 2018.

[13] BARICOVA, Dana, PRIBULOVA, Alena, ROSOVA, Andrea. Steelmaking slag - waste or valuable secondary raw material. In *13th International Multidisciplinary Scientific Geoconference, SGEM 2013 Albena, BULGARIA, 2013*, Book Series: International Multidisciplinary Scientific GeoConference SGEM, pp 437-442, 2013.

[14] MIHOK, Lubomir, BARICOVÁ, Dana. Recycling of oxygen converter flue dust into oxygen converter chargé. *METALURGIJA*. 2003. vol. 42, no. 4. pp 271-275.

[15] ARI, V. A review of technology of metal recovery from electronic waste, Chapter 6, In: E-Waste in Transition - From Pollution to Resource, pp 121-158, 2016.

[16] CASTRO, L. A., MARTINS, A. H. Recovery of tin and copper by recycling of printed circuit boards from obsolete computers. *Brazilian Journal of Chemical Engineering*. 2009. vol. 26, pp 649-657.

[17] CUI, Hao, ANDERSON, Corby G. Literature Review of Hydrometallurgical Recycling of Printed Circuit Boards (PCBs). *Journal of Advanced Chemical Engineering*. vol. 6, pp 1-11, 2016.

[18] VONTOROVÁ, Jiřina, DOBIÁŠ, Václav, MOHYLA, Petr. Utilization of GDOES for the study of friction layers formed on the surface of brake discs during the friction process. Chemical Papers. 2017. vol. 71, no. 8, 1507-1514.