COMMERCIALIZATION OF THE “LEGNICA” COPPER SMELTER - KEY ASPECTS OF CHANGE

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Abstract
This article presents one of the largest smelters in Poland. It employs 1000 employees and turnover locate it among the 100 largest companies in Poland. So far, this smelter is part of the vertical integration of production within a large mining company. The company also has mines the extractive. In accordance with the EU directives and the new concept of the Management Board of the company, smelter has become a player involved in the recovery of raw materials from scrap. As a result, expect major changes in the organizational, economic, technological and environmental issues. The purpose of this article is to analyze these changes. Especially important research problem seems to be the construction supply chain in the reverse logistics. Moreover, an important issue is to define the principles of cooperation with business partners.

Keywords: electronic scrap smelter, copper recovery

1. INTRODUCTION
High prices of copper and its growing consumption at global markets forces smelters to search for this raw material recovery methods, different from those offered by traditional mining. Most frequently it takes the form of copper scrap recycling. So far Polish smelters were obtaining copper from the generated scrap, while competitive companies, at the global markets, have already been recovering copper from electrical and electronic waste, which is economically justified since electrical and electronic waste recycling represents a cheaper form of obtaining this raw material. KGHM [Mining and Metallurgy Company Polish Copper] is planning to open the first, and so far the only, scrap smelter for copper recovery. The process of smelter commercialization mainly refers to:
- changing the business model in terms of international cooperation at the electronic scrap market,
- changing the technology of recycling scrap into raw materials,
- new criteria and rules for the selection of PCB [Printed Circuit Boards] suppliers.

The objective of the hereby paper is to present legal, organizational and technological determinants at the electronic scrap market in Poland. From such perspective the Author discusses the situation of the new market player – “Legnica” Copper Smelter. New markets entrance by the scrap smelter determines its commercialization, since this entity leaves the concern and brings its current knowledge and experience to the free and consolidated market. Additionally the Author presents the review of electro-waste collection and recycling organization in Poland.

2. THE ELECTRONIC SCRAP TRADE MARKET IN POLAND
The term “commercialization” is frequently identified with changes in ownership, which occurred in Poland as the result of economic system transformations. Their scope is regulated by the Act [1] which provides that commercialization refers to a state owned enterprise transformation into a one-person-Treasury-owned enterprise. It can constitute the first stage of indirect (capital) privatization, or be performed for a different than privatization reason, therefore with no intention of making stocks/shares available by the Treasury to the third party. Commercialization [2], [3] is defined as the wide spectrum of activities related to transferring certain technical or organizational knowledge, as well as the related know-how to economic practice.
Therefore commercialization can be defined as the process of providing new technologies at the market. It is usually an invention, an organizational solution or takes the form of developed research results which initiate the process of commercialization. They open new technical and research possibilities, however, prior to commercialization they do not present any market value. This value changes following the implementation of an idea or technology in economic practice.

The electronic scrap trade market in Poland is mainly regulated by the following legal Acts:

- Act dated 29th July 2005 on electrical and electronic waste - WEEE [Waste of Electrical and Electronic Equipment] (Official Gazette No 180, item 1495, with later amendments)
- Act dated 27th April 2001, Environment Protection Law (Official Gazette No 25, item 150)
- Act dated 14th December 2012 on waste materials (Official Gazette of 2013, item 21)

The main Act in force in the European Union, referring to the functioning of WEEE collecting systems, is represented by the Directive 2002/96/EC of the European Parliament and the Council dated 27th January 2003, regarding waste electrical and electronic equipment (WEEE). The Act on WEEE forces entities selling electrical and electronic equipment on the market to establish an adequate system for WEEE collecting and recovering as well as recycling. However, for effective and efficient functioning of such system it is necessary for an adequate level of knowledge and motivation to be represented by all groups participating in the system. The construction of awareness regarding proper WEEE management and disposal is crucial in case of consumers, both individual and institutional, placed at the beginning of the chain where systemic relations are initiated. Consumers have to be aware of their rights and obligations resulting from the Act and be motivated strongly enough not to just throw WEEE to a trash container, but bring it to the designated collection points. It is the responsibility of any municipality to provide such collection centres to local residents. Even the best logistically prepared WEEE management system will not function properly if it is not supported by adequate civic and ecological awareness, as well as the resulting desire for undertaking due actions. The waste of electrical and electronic equipment is passed over for processing and submitted for dismantling, while the obtained materials are subject to recovery and recycling. Selective collecting, dismantling in specialized WEEE recycling plants and the disposal of hazardous substances protects natural environment from contamination. On the other hand, the recovery of raw materials and their usage in new equipment manufacturing extensively reduces the level of natural resources usage and also results in cutting technological costs.

The system of electrical and electronic waste equipment trading (picture 1) identifies groups of entities responsible for meeting due obligations resulting from the legislation in force in Poland:

- entities entering equipment to the market (manufacturers and importers),
- organizations recovering electrical and electronic waste,
- electrical and electronic equipment users,
- entities involved in WEEE selective collection (including retailers and wholesalers of electrical and electronic equipment),
- recycling plants and entities dealing with such waste recovery and recycling,
- entities engaged in buying scrap or equipment repair points,
- institutions responsible for due obligations monitoring and controlling.

In Poland, as of 31st December 2011, the following entities were registered:

- 4597 entrepreneurs running businesses engaged in entering electrical and electronic equipment to the market,
- 10458 entrepreneurs involved in collecting waste equipments,
- 161 entrepreneurs running recycling plants,
- 99 entrepreneurs conducting recycling activities,
- 12 entrepreneurs performing operations different than recovery processes recycling,
- 8 organizations active in electrical and electronic equipment recovery [4].

The model presented in picture 1 illustrates a simplified version of model functioning - information flows are not marked. The Author has assumed, following an extensive simplification, that information flows between
due cells together with the transfer of goods and money. Polish system is still deprived of a computerized strategy for providing information about the subsequent stages responsible for waste equipment life cycle.

The presented system refers to waste equipment recycling, in which the share of copper is the largest and additionally the Recycler recovers copper only. In such situation it is suggested to apply a closed recycling loop. Within the framework of the above recycling type the Author suggests two operating models to be used at the market of copper recycling and recovery:
- integrated activities, the recycler and the processing plant represent the same entity,
- individualized activities where the recycler and the processing plant represent separate entities.

![Diagram of waste equipment recycling system](image)

**Fig. 1** Closed chain of electrical and electronic equipment supply for copper recovery

Source: Author’s compilation

The advantage of the first mentioned form is an opportunity to control an extensive part of logistics feedback chain in the area of information, goods and services flow, but most of all an impact on the quality of the recycled waste. Scrap smelter is most interested in PCB from waste mobile phones, personal computers or, to a lesser extent, programmers. In Poland the following streams of electro-waste are identified, the division of which regarding copper content level and importance for a scrap smelter, is presented in table 1.
Tab. 1 PCB identification in electro-waste

<table>
<thead>
<tr>
<th>Types of PCB from which copper can be recovered according to importance level for the scrap smelter</th>
<th>Name of the introduced equipment group which generated waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Class</td>
<td>IT and telecommunications equipment</td>
</tr>
<tr>
<td>B Class</td>
<td>Large household appliances</td>
</tr>
<tr>
<td></td>
<td>Small household appliances</td>
</tr>
<tr>
<td></td>
<td>Audiovisual equipment</td>
</tr>
<tr>
<td></td>
<td>Toys, leisure and sports equipment</td>
</tr>
<tr>
<td></td>
<td>Automatic dispensers</td>
</tr>
<tr>
<td>C Class</td>
<td>Electronic and electrical tools, excluding bulky, stationary industrial tools</td>
</tr>
<tr>
<td></td>
<td>Monitoring and control instruments</td>
</tr>
</tbody>
</table>

Source: Author’s compilation on the basic of Act dated 14th December 2012 on waste materials (Official Gazette of 2013, item 21)

In order to perform better monitoring of WEEE Act guidelines implementation the division of electrical and electronic equipment into 10 categories was introduced of which some are listed in table 1.

However, the division of each stream into particular types of equipment is still missing. While it is easy to count mobile phones and computers currently launched at the market, it turns out impossible to count waste equipment which entered the market before WEEE Act was passed.

The scrap smelter is mostly interested in mobile phones and personal computers since they provide the largest amount of copper. The underlying data are presented in table 2.

Tab. 2 The composition of raw materials recovered from waste equipment recycling

<table>
<thead>
<tr>
<th>Type and amount of waste equipment</th>
<th>The composition of raw materials recovered from waste equipment recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td>From a computer and monitor weighing 27 kg the following can be recovered:</td>
<td>• 6,8 kg of glass,</td>
</tr>
<tr>
<td></td>
<td>• 6,2 kg of plastic,</td>
</tr>
<tr>
<td></td>
<td>• about 5,6 kg of steel,</td>
</tr>
<tr>
<td>From waste in the form of one million mobile phones the following can be recovered:</td>
<td>• about 3,8 kg of aluminium,</td>
</tr>
<tr>
<td></td>
<td>• about 1,9 kg of copper,</td>
</tr>
<tr>
<td></td>
<td>• 1,7 kg of lead</td>
</tr>
<tr>
<td></td>
<td>• 34 kg of gold,</td>
</tr>
<tr>
<td></td>
<td>• 350 kg of silver,</td>
</tr>
<tr>
<td></td>
<td>• 15 kg of palladium,</td>
</tr>
<tr>
<td></td>
<td>• 15,87 tons of copper</td>
</tr>
</tbody>
</table>


The production of electrical and electronic equipment (EEE) is one of the fastest growing businesses in the world. In the meantime, both technological innovation and market expansion of EEE are accelerating the replacement of outdated EEE, leading to significant increase in waste EEE (WEEE) that induces a new environmental challenge. In Western Europe 6 million tones of WEEE were generated in 1998 and the amount of WEEE was expected to increase by at least 3–5% per annum [5]. In the USA, it was observed that over 315 million computers would reach their date of expiration by 2004 [6]. In Australia there are approximately 9 million computers, 5 million printers and 2 million scanners currently used in households and businesses and all of them will be replaced, most within the next couple of years [7].

Computers and mobile phones represent the devices which contain the largest amounts of copper. Obviously, PCB are delivered to a scrap smelter, but the remaining stuff is left in recycling plants which direct waste streams to other recyclers.

3. CASE STUDY- EXPERIMENTAL PART

“Legnica” Copper Smelter represents the discussed research object which is planning to implement new solutions of technological and organizational nature.
This process can be divided into key areas which require the involvement of top management for the successful implementation of an overall project:

- technology selection is determined by environmental legislation and capital availability,
- market functioning strategy (business model) defining the scope of carried out functions within the framework of a reversed supply chain,
- organization structure transformation and establishment of new organizational units adjusted to the accepted business model,
- changing and adjusting staff competencies to the new functioning conditions.

“Legnica” Copper Smelter, since its establishment, has been implementing changes adjusted to technological advancement and global manufacturing standards, especially in the area of environment protection. The crucial events which occurred in this plant are presented in table 3. “Legnica” Copper Smelter is a self-balancing entity without legal personality and constitutes a part of KGHM group. KGHM Polish Copper Joint Stock Company is a multi-division enterprise consisting of Management Board Office, Accounting Services Centre and 10 divisions: 3 mining plants (MP) (“Lubin” MP, “Rudna” MP, “Polkowice-Sieroszowice” MP), 3 copper smelters (CS) (“Głogów” CS, “Legnica” CS, “Cedynia” CS), Ore Enrichment Plants, Tailings Management Plant, Emergency Rescue Unit, Data Processing Centre.

<table>
<thead>
<tr>
<th>Year</th>
<th>Important events</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>“Legnica” Copper Smelter was founded at the name of Legnica Metallurgical Plant</td>
</tr>
<tr>
<td>1959</td>
<td>Legnica Metallurgical Plant transformation into “Legnica” Copper Smelter</td>
</tr>
<tr>
<td>1970</td>
<td>“Legnica” Copper Smelter was included in the Copper Mining and Metallurgy Company</td>
</tr>
<tr>
<td>1990</td>
<td>Registration of “Legnica” Copper Smelter brand at the London Metal Exchange at the highest quality grade “A”.</td>
</tr>
<tr>
<td>1991</td>
<td>The Company transformation into a joint stock company and new entity registration under the name “KGHM Polish Copper Joint Stock Company”</td>
</tr>
<tr>
<td>1997</td>
<td>Debut on the Warsaw Stock Exchange</td>
</tr>
<tr>
<td>1999</td>
<td>“Legnica” Copper Smelter implements standards confirmed by the certified Quality System issued by the Polish Centre for Testing and Certification and also The International Certification Network</td>
</tr>
</tbody>
</table>

Currently “Legnica” Copper Smelter uses shaft furnace technology and produces annually over 100 thousand tons of high quality electrolytic copper in the form of cathodes weighing 100 kg and 15 – 20 thousand tons in the form of billets. Its production constitutes, on average, 25% of all 3 smelters included in KGHM.

“Legnica” Copper Smelter has the Certificate of Integrated Management System meeting the following standards: PN-EN ISO 9001:2009; PN-EN ISO 14001:2005; PN-N-18001:2004; OHSAS 18001:2007 regarding the production of copper cathodes, round billets of electrolytic refined tough pitch copper, round billets of phosphorous deoxidized copper, sulphuric acid, copper sulphate, nickel sulphate, refined lead as well as monitoring and measurement of natural environment impact and usage.

KGHM is planning to construct a smelter in Legnica specializing in re-melting scrap, also the electronic one. It would be the only smelter of this kind in Poland which could recover copper from scrap. The plant is to be established in Legnica and replace the existing smelter which is already quite obsolete. Old shaft furnaces are planned to be closed. The new scrap smelter is supposed to be opened in 4 years time. Its production powers are to be bigger than those of “Legnica” Copper Smelter which currently produces a little over 100 thousand tons of copper. The new plant would have the capacity for producing about 135-200 thousand tons of this raw material. Production value – at current prices presenting the level of $8260/ton – may increase even by $875 million, up to $1,75 billion.

KGHM owns three smelters – in Legnica, Głogów and Cedyinia. They process 110-140 tons of waste annually which makes up one fifth of the entire copper production in KGHM.
In 2000 “Legnica” Copper Smelter recycled 19.5 thousand tons of copper scrap, while last year it was almost three times more and amounted to 56 thousand tons.

Copper scrap based production constitutes half of the total production and in the period of the recent three years the production from scrap increased in “Legnica” Copper Smelter by over 60%. Additionally, in 2012 the smelter production capacity was enlarged up to 110 thousand tons of cathodes annually. In 2011 61% of input for “Legnica” Copper Smelter was the, so called, concentrate supplied by KGHM. Copper scrap made up 37%. However, the smelter was gradually increasing the share of scrap – in 2000 it recycled 19.5 thousand tons and last year 56 thousand tons. Therefore over half of “Legnica” Copper Smelter production comes from recycling. Experts are absolutely positive that the role of scrap in producing copper will keep growing.

The capacity for copper scrap production is presented in table 4. Following the implementation of new technology and copper scrap recycling, which is generated by waste electronic equipment, this capacity is supposed to increase to the level of 150 thousand tons annually. Such result will place “Legnica” Copper Smelter among the two large players at the Central European market.

**Tab. 4** The capacity for copper scrap production

<table>
<thead>
<tr>
<th>Year</th>
<th>The volume of recycled copper scrap (Mg/year)</th>
<th>Manufacturing capacity (Mg/year)</th>
<th>[%] share of recycled scrap against manufacturing capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>19.5</td>
<td>80</td>
<td>24</td>
</tr>
<tr>
<td>2012</td>
<td>56</td>
<td>110</td>
<td>51</td>
</tr>
<tr>
<td>2016</td>
<td>100 -130</td>
<td>135-200</td>
<td>65-85</td>
</tr>
</tbody>
</table>

Source: Author’s compilation based on data collected during an interview

“Legnica” Copper Smelter is challenged by its business model transformation. The sector is highly consolidated while entities offering similar services in Germany (Aurobis) or Boliden in Sweden have extensive experience in this matter. One of the most important challenges to be faced by “Legnica” Copper Smelter is specifying cooperation rules with scrap suppliers, even more so since the expectations regarding the amount of delivered PCB are high (table 5). Cooperation with just one and owned company will turn out, in a long time perspective, an ineffective activity. The smelter will have no choice, which is against market rules.

**Tab. 5** Averaged copper scrap recycling capacity in 2012

<table>
<thead>
<tr>
<th>Manufacturing capacity of copper scrap recycling plants</th>
<th>“Legnica” Copper Smelter - Poland</th>
<th>Boliden – Sweden</th>
<th>Aurobis – Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>100</td>
<td>250</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author’s compilation based on data collected during an interview

Currently “Legnica” Copper Smelter functions based on concentrate supplies (61%) and copper scrap (39%) carried out by enterprises included in KGHM group. “Metrako” plant meets all needs of the smelter. The share of the second supplier “Centrozłom” is relatively small (3%) which makes it of secondary importance among copper scrap suppliers.

The situation may change drastically when the smelter decides to recycle and/or recover copper from electro-waste. Then, as the major electrical waste market player aiming, on average, at 10 tons monthly of recycled crap, which means 100 thousand ton gross weight of waste computers, programmers, etc., has to be clearly defined regarding functioning rules and cooperation with suppliers. E.g. Boliden segmented its suppliers into these providing only concentrates and recycled materials. Boliden buys metal concentrates from its own mines and cooperates with 20 suppliers who deliver recycled materials. Electrical scrap is supplied by over 100 enterprises.

4. CONCLUSIONS

The analysis of professional literature and secondary materials allowed the Author to present the following conclusions:
Copper scrap market finds itself in the growing phase which means high interest in entities focused on electro-waste collection.

Electrical and electronic waste equipment organizations represent, to an extent, the animators of the entire WEEE cycle. They take over, from entrepreneurs bringing electrical and electronic equipment to the market, all the obligations defined in the WEEE Act. Therefore, on their behalf they organize collecting, processing, recover, recycling and disposal of waste equipment. They are responsible to perform these duties before the Chief Inspectorate of Environment Protection by means of presenting adequate periodical reports.

The Act on electrical and electronic waste equipment does not prohibit entities from combining separate functions in WEEE flows chain (reverse supply chain). In practice it often happens that enterprises join different types of activities, e.g. the function of a processing plant and a recycler. However, once combing the function of a transporting entity, i.e. an entity allowed to transport WEEE, with the function of a collecting, or recycling plant can be justified, combining other functions may become the source of the whole system dysfunctions.

“Legnica” Copper Smelter has a large competitive power, since as a scrap smelter it is attractive for other entities functioning in WEEE cycle. The absence of scrap suppliers to the smelter should not pose any major concern. It seems more important to construct an adequate screening system for suppliers who may deliver an improperly treated scrap.

There is an urgent need for organizing conferences and educational meetings to illustrate the way in which the system of copper recovery from electro-equipment functions, because landfills full of such equipment are extremely hazardous for the environment and at the same time the most expensive to recycle.

“Legnica” Copper Smelter commercialization also means the form of education for people whose awareness of hazards posed by electro-waste is low. The smelter has to ensure permanent and ongoing supply of scrap, which depends on consumers’ involvement.

It is highly necessary to obtain information regarding how much and what amount of equipment is kept in households, companies or all kinds of storages.

REFERENCES
[12] Act dated 14th December 2012 on waste materials (Official Gazette of 2013, item 21