SUSTAINABLE RECYCLING INDUSTRIES

Recovering Copper from E-waste Cables

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The Issue

Globally, some 44.7 million tons of waste electrical and electronic equipment (commonly referred to as e-waste[1]) is generated annually. This is an equivalent of almost 4,500 Eifel Towers[2]. As the numbers of consumers and new product designs in the consumer electronics segment grow worldwide, the perceived useful lifespan of electronic equipment declines. As a result the quantity and complexity of e-waste increases significantly year on year[3]. E-waste includes such items as mobile phones, laptops and printers as well as cables and wiring, and it is these cables and wiring that contain significant quantities of copper (Cu), an economically valuable metal with rising prices.

Problems arise where safe technologies (such as mechanical cable granulators/shredders) are not applied and cables and might be illegally exported which raises legal as well as ethical questions or end in places with unsafe treatment options. Unsafe processing typically takes place by workers subsisting from recycling using very rudimentary means of copper recovery – typically in the form of uncontrolled open fires. For these workers with few other economic opportunities to earn a living, burning of copper cables and other copper containing fractions of e-waste becomes an important source of income despite the huge cost to their health and the environment.

Understanding, measuring and subsequently monitoring the environmental footprint and impact on human health linked to both safe and unsafe practices can help decision-makers to develop the required legal and policy frameworks for more responsible Copper extraction and e-waste recycling.

The Environmental Footprint of Recovering Copper

The methodology and dataset used to measure the environmental footprint of copper recovery was developed in partnership with World Resources Forum's Sustainable Recycling Industries Programme (www.sustainable-recycling.org) and ecoinvent – the latter an organisation specialising in providing inventory data for life cycle assessments (www.ecoinvent.org).

The dataset was modelled to represent a recovery scenario of copper from cables through an uncontrolled, open-burning process, without any pollution controls in place. This process involves burning off waste cables in open fires that incinerates the outer insulating plastic covering leaving copper as residue which is then collected. Copper is then recovered as the desired product.

The methodology assumed that copper cables contain 62% copper and 38% insulation. The insulation is typically composed of polyvinyl chloride or PVC (66.3%) and polyethylene (31.2%) as well as other materials (2.5%).
A key area of concern is the human exposure to hazardous chemicals and their impact on workers' health.

The uncontrolled open burning process emits to the atmosphere about 1.6 kg of CO2-eq per kg of recovered copper from waste electrical and electronic cables.

Dioxins and mercury (Hg), as well harmful chlorine (Cl) compounds, such as polychlorinated biphenyls (PCBs) are released during the burning of the cable insulation both in form of emissions or as contained in the ash residue. Higher emission levels of these substances are released due to the incomplete burning process as well as the lack of appropriate air pollution controls.

These highly toxic substances have multiple negative impacts on human health and have been proven to cause cancer of the digestive tract, liver and skin. The analysis by ecoinvent also showed a high level of toxicity at the eco-system level. This is mainly due to the toxic substances in the ash and their subsequent absorption into the soil and leaching into waterways. The recovery of copper from cables through environmentally sound processes can almost entirely eliminate these impacts and provide the related health and economic benefits of applying "Good Practice" instead.

What is Good Practice?

There exist three key treatment processes to recover copper from cables: the first uses manual or mechanical processes to strip cables and wiring to recover copper; the second involves heat recovery, and the third uses chemical processing. The type of treatment largely depends on the specifications of the cable (e.g. diameter, copper purity and homogeneity, the cable volumes and the available budget.

Manual or mechanical processing, that is stripping and mechanical granulation of cables, is the most widely used method.

This is due to its simplicity (which allows its application for a wide range of cables) and its relatively low cost. In addition to recovering copper with minimum loss, the cables' plastic insulation can also be recovered safely.

Residues are disposed of safely. This not only avoids the incineration emissions but can also save a considerable amount of raw material to produce new plastic insulation. In addition, using manual and mechanical processing, the copper recovered maintains its physical properties and composition, whereas in open burning, the surface layer of copper oxidizes. As a result, the recovered metal has an inferior quality and subsequently fetches a lower price when sold compared to copper recovered via a manual or mechanical granulation process.

The second process, heat recovery, is where cables are incinerated in high temperature kilns with proper emission controls and the heat is captured for use. Provided optimal operational conditions exist this can largely prevent the formation and release of most hazardous toxins and the calorific value contained within the cable waste can provide a source of heat energy for a variety of purposes.

The third good practice option involves chemical treatment. This option, if properly managed can be an efficient process that is particularly suitable when the composition of waste cables is mixed and contains a range of different metals[4]. Using this process, waste cables are submerged into a series of chemical solutions. Copper is then extracted in a fractionated process using further techniques such as: displacement, crystallization and electrolysis of the leaching solution to isolate the metal. However, this process needs to be carefully managed and monitored to achieve positive net environmental benefits.

Above all, these three processes can only be recommended as good practices if workers and the environment are protected and therefore have to take place in a safe fit-for-purpose work environment with all the activity based required personal protective equipment[5] and safe working precautions[6] for workers.

Measuring and actually reducing the environmental footprint of recovering copper from cables combined with understanding what good practice looks like, provides a number of potential benefits, in particular to reduce significant risks to workers' health by reducing harmful emissions to the atmosphere. However, this will only become a reality if decision-makers act to enable, enforce and improve the legal and policy frameworks to ensure responsible copper recovery from cables and other e-waste fractions. Improvements in the policy and operational spheres are needed and there is a role for all stakeholders in the recycling chain linked to copper recovery. Even a strong regulatory environment can only deliver benefits when there is collaboration between the public sector, private sector and civil society.

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[1] E-waste, refers to all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of re-use1 and include a wide range of products – almost any household or business item with circuitry or electrical components with power or battery supply. In Global E-waste Monitor (2017 figures) https://www.itu.int/en/ITU-D/Climate-Change/Documents/GEM%202017/Global-E-waste%20Monitor%202017%20.pdf

[2] Global E-waste Monitor (2017 figures) https://www.itu.int/en/ITU-D/Climate-Change/Documents/GEM%202017/Global-E-waste%20Monitor%202017%20.pdf

[3] Global E-waste Monitor (2017 figures) https://www.itu.int/en/ITU-D/Climate-Change/Documents/GEM%202017/Global-E-waste%20Monitor%202017%20.pdf

[4] Examples of different types of wires and cables are: Lead VIR, Wire Armour, PVC, Paper and Pyro.

[5] Basic PPE typically includes gloves, protective eye wear, and protective clothing.

[6] A safe working environment must include the provision of both sufficient lighting and ventilation.