



SUSTAINABLE
RECYCLING
INDUSTRIES

2017

Scrap cable processing in Egypt – Challenges & Opportunities



Empa

Materials Science and Technology

Bill, Andreas

Empa

10.12.2017

Introduction

One of the mature issues in the e-waste sector in Egypt is the uncontrolled burning of scrap cables by the informal sector. Burning cables is a fast and easy way to extract copper and aluminum from the scrap cables, the burning plastic releases however toxic fumes including Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans (PCCD/Fs), Polycyclic Aromatic Hydrocarbons (PAHs), and Polybrominated Diphenyl Ethers (PBDEs), all of which are persistent organic pollutants (POPs), harming both human health as well as the environment [1].

As a simple alternative to the hazardous burning of cables, various mechanical processes exist for the separation of plastic and metal parts of cables, resulting in a higher quality end product while avoiding the dangerous emissions from cable burning. The goal of this document is to summarize the most important information about scrap cable processing in Egypt, reviewing different technologies, their advantages and disadvantages and providing a short analysis of the available amount of scrap cables. The provided information should help decision makers develop viable policies and business models to tackle this specific challenge in the field of e-waste management in Egypt.

The remainder of this document is structured as follows: Section 2 contains general information about scrap cables found in e-waste, an estimation of the generated volumes and the possible processing options. Section 3 gives a detailed overview of the various mechanical processing options and specifications for the involved machines. Reflections about important issues specific to the case of Egypt are discussed in section 4, section 5 contains some recommendations from the authors while the conclusions are presented in section 6.

1. General information

Cables and wires are present in every type of electrical and electronical equipment. The majority of cables contain a copper wire as a conductive element while some contain aluminum. Several types of plastics are used as insulators; the most common types are PVC, PE and cross-linked PE (XLPE). The exact composition is variable. As an approximation for cables recovered from e-waste, we use an average composition of 30% metal and 70% plastics.

Availability of cables from e-waste

Using the numbers stated in the UN-University report of 2014 on e-waste generated per capita [2], the actual population of Egypt and the greater Cairo area as well as information about the percentage of cables in e-waste fractions based on data from e-waste recyclers, the following estimations can be made.

	<i>Egypt (96mio inhabitants)</i>	<i>Greater Cairo (20mio inhabitants)</i>
<i>e-waste per capita</i>	4.35 kg/cap	4.35 kg/cap
<i>Total per year</i>	417'600 tons/year	87'000 tons/year
<i>Collection rate</i>	30-50%	30-50%

Cables fraction in e-waste	1.4%	1.4%
Total available cables	1754 – 2923 tons / year	365-609 tons / year

Cable burning

The main advantage and the reason why uncontrolled burning of cables is the dominant process used in the informal sector to extract the valuable copper and aluminum fractions, is that it is fast, cheap and requires no specific infrastructure. Apart from the serious health and environmental impacts of the produced fumes, a fraction of the copper and aluminum are oxidized during the burning process and part of the product is lost while the end-product loses in quality and therefore value.

Mechanical processing

Mechanical processing of cables requires initial investment in the appropriate machinery and, depending on the used technology¹, may be more time-intensive than burning. However, there are two important advantages:

1. No negative impacts on health and the environment
2. Copper and aluminum are obtained at a higher recovery rate and purity, therefore realizing higher market prices

2. Mechanical processing options

Two types of processing are available in the recycling of scrap cables: Cable stripping and cable shredding. In what follows the pros and cons of both technologies are discussed together with the typical machines and their specifications.

Cable stripper

Cable strippers exist in many forms and sizes. They can be manual handhold tools, manually operated machines to be installed on a table or automated machines. Only the latter are of interest for a larger facility since the time requirements for manually operated tools make a large scale application impossible. The principle of a stripper is that the insulator is cut open so that the metal core can be extracted. More expensive models also “peel” the cable, meaning that the plastic insulator is removed in the process making it easier to separate the fractions. If the machine doesn’t provide the peeling, it has to be done manually which increases the processing time.

¹ The different technologies are discussed in details in section 3

Pros

- Low price
- Small size
- No impurities in the recovered fractions
- Suitable for small scale operation
- Low-tech = low maintenance cost

Cons

- Limited range of cable diameters accepted
- Small cables might be problematic
- Cheaper units require further manual dismantling to remove the insulation layer
- Low throughput

When to use

Cable strippers should be used when the processed cables mostly are of diameters larger than 20mm. If the scrap cables come from e-waste, this is generally not the case. However, cable strippers still present the better option when only limited amounts of scrap cables are to be processed and the large investment for a shredder cannot be justified. With a relatively low investment it is possible to process the cables directly inside the workshop and therefore avoid the negative impacts of cable burning while realizing additional revenue and increased margins from the sale of a high value copper and aluminum fractions directly to the end-processor. Cable shredders with a “peeling” function should be favored despite their higher cost since the savings in manpower will most probably justify the higher initial investment after a short amount of time.

Specifications

Sizes and throughput are variable; the general ranges indicated for different machines listed on Alibaba as well as ebay are indicated in the following table. The average machine costs around 1500\$ on both platforms. Some higher priced machines can be found especially from European manufacturers (e.g. Bronneberg, DE). Links to several of the identified options are provided in the reference section at the end of the document. The tradeoff between capacity, investment cost, maintenance cost and functions has to be determined from case to case.

	From	To
Price (USD)	500	3000
Throughput (kg/hour)	25	125
Cable diameters (mm)	1	100
Dimensions LxWxH (mm)	540x410x500	800x650x1450
Weight (kg)	69	250
Power (KW)	1.5	4
Voltage (V)	220	380

Example for small unit (installed on table)**Example for large unit*****Cable shredder /granulator***

Cable shredders use a different approach to separate the plastic from the metal parts. The cables are shredded and milled to small particles called granulate. Then, either gravity separation, electrostatic separation or a combination of both is applied to separate plastic from metal parts. Some residual plastics will remain in the metal fraction, resulting in a slightly lower quality product. The feed has to be sorted according to the core material (aluminum/copper) before processing.

Pros

- Easy to process smaller cables
- High throughput
- Entangled cables accepted
- Manpower requirements minimal

Cons

- High price
- Upper limit for cable diameter
- Purity of product <100%
- Big size
- High power consumption

When to use

Due to the high required investment and the high throughput, cable shredders are more suitable for a facility which mainly specializes in the processing of scrap cables or a workshop with a high enough throughput to justify the investment. These machines are especially useful when important amounts of smaller cables are to be processed. Due to the high running cost it is also important to invest in a machine that can be run at full load as much as possible. The cost of a cable shredder is mainly dependent on the two factors "throughput" and "product purity". As a general rule of thumb one should invest in the machine with the lowest throughput that can process the collected amount of cables with the highest product purity. This will reduce the running cost per volume input while optimize the selling price of the product.

Specifications

The throughput of cable shredders is higher than in the case of cable strippers since the process is more automated and cables don't need to be fed one by one. Different models exist, however, with different throughputs, sizes and other specifications. The following table indicates ranges for machines found on Alibaba and ebay.

	From	To
Price (USD)	5000	30000
Throughput (kg/hour)	80	1000
Upper diameter limit (mm)	20	40
Dimensions LxWxH (meter)	1.5x1.5x1.9	4.5x3.2x3.8
Weight (tons)	0.75	4.5
Power (KW)	12	80
Voltage (V)	220	450
Purity of product	99%	99.99%

Example for small unit



Example for large unit



Decision variables to choose the right technology

The following table gives indication on which technology or combination to use based on three variables: Diameter, Quantity, Investment available. For quantity and investment, if both high and low are marked, it means that the corresponding parameter is of low significance.

	Cable diameter			Quantity		Investment	
	All > 20mm	Mixed	All < 20mm	High	Low	High	Low
Stripping only	x			x	x	x	x
		x			x	x	x
		x		x			x
Shredding & Stripping		x		x		x	
Shredding only			x	x		x	
Sell to the formal sector			x	x	x		x

Stripping only:

- When all collected cables are of large diameter, stripping is the better option regardless of quantity and investment.
- When the collected cables are of mixed diameters but the quantity is low, stripping only is the best option regardless of investment.
- When the collected cables are of mixed diameters, the quantity is high but the available investment low, processing the cables internally leads to higher profit margins but the high investment for a shredder is unavailable, therefore stripping only is the best solution to start.

Shredding & Stripping:

- When mixed cables are collected at high quantities and the available investment is high, a combination of shredding (smaller cables) and stripping (larger cables) is the most efficient solution.

Shredding only:

- When only small cables are collected, the quantities as well as the available investment is high, shredding is the best solution while stripping might not be necessary due to the lack of larger cables.

Sell to the formal sector:

- Assuming a formal downstreaming solution with good practices (shredding and stripping) exists, it can be more viable to sell the collected cables. This is the case when only smaller cables are collected and either the quantity is too low to justify the high investment for a shredder, or the available investment is too low to buy a shredding machine. In these cases it

might be better to sell the cables to a facility that runs a shredding operation thus supporting their higher need for small cables.

Chosing specific machines:

Chosing a specific shredder or stripper has to be done based on the specific requirements and targets of each facility.

Cable strippers:

Concerning cable strippers, the most important differences in available machines are the accepted cable diameters, throughput and the peeling function. Machines for industrial application do not vary that much in size and space requirements, therefore the decision has to be taken based on the type of cables to be processed, initial investment vs. maintenance cost, and based on the ease of operation leading to a more efficient use of manpower.

Cable shredders:

As mentioned before, it is important to chose a shredder based on the targeted collection rate. Running cost can be kept lower when the machine is used at full capacity as much as possible since the running cost in terms of power and manpower is similar regardless of the fact if it is run at full or half capacity. Other important considerations are the running cost (power consumption), maintenance cost and product purity, all of which have an important impact on the long term financial results. These factors should be taken into account in order to chose the right machine with the best long term performance. The possibilities for high quality vs. price are however different for each facility, therefore it is not possible to give a clear recommendation and each facility should do its own research in order to chose well.

Space requirements

The space requirements for a cable processing facility depend on the targeted annual throughput. A higher throughput requires more space for storage, sorting and manuvering the loads. The following numbers can be used to estimate the total space requirements. The total space for two collection targets for the Greater Cairo region are given based on the estimated amount of e-waste cables from section 2.

	Treatment space	Space for storage	Space for operations	Total
Per unit	20m ² /machine	0.7m ² /ton	1m ² /ton	-
30% collection	20m ²	255m ²	365m ²	640m²
50% collection	20m ²	426m ²	609m ²	1055m²

3. Specific considerations for Egypt

In Egypt e-waste, and therefore also the scrap cable fraction, is mainly controlled by a large network of dealers and informal businesses. Only a small percentage of the generated e-waste is collected by the few existing formal recyclers and no down-streaming solutions for scrap cables exist other than selling them to the dealers. Therefore even the cables collected by the emerging formal sector eventually end up being burnt. A safe down streaming solution based on the above discussed technologies is needed.

This solution should not only target the formal sector, since, at least for now, only a small percentage of all scrap cables are collected formally. A strategy should be implemented which targets to channel the highest possible amount of the collected scrap cables from both the formal and informal sector through proper processing.

While proper legislation and controls should be enough to ensure the formal sector uses the provided, correct down streaming option, getting access to the material controlled by the informal sector is much more difficult. Burning the cables has zero processing cost; therefore any mechanical processing will result in higher cost which will need to be recovered elsewhere in order to be competitive. The higher processing cost can be offset by the fact that the quality of aluminum and copper is reduced in the burning process and mechanically recovered materials realize higher selling prices. In 2012 Green Advocacy Ghana (GreenAd) & Blacksmith Institute have studied the performance of cable stripping vs. burning in Ghana [3]. On average, the performance of cable stripping vs. cable burning was as follows:

- **+10%** more copper recovered from the same amount of processed cables
- **+ 8%** higher sales prices due to higher purity
- **+20%** total profit from stripping vs burning

This experiment was carried out with cables of large diameters containing around 75% of copper. Due to the larger diameter, a smaller surface was exposed to the flames and the difference in recovered material and quality would probably be even higher in the case of cables with small diameters.

An additional price advantage can also be achieved by skipping intermediaries and sell directly to the end-consumer.

The market prices of scrap cables in Egypt are indicated around 11EGP/kg for IT-cables by some people active in the trade of this fraction. The current price for higher quality copper is 85EGP/kg. Assuming an average content of 30% copper in scrap cables at this price, the profit margin is estimated at 14.5EGP/kg. Considering the before mentioned 20% higher profit compared to cable burning, a mechanical processing facility would have an economic advantage of 2.5EGP/kg of treated cables which has to cover the higher processing cost.

Access to scrap cables

As discussed above, accessing scrap cables from the informal sector is challenging. The informal sector is purely price-oriented which means that if one wants to access the cables collected through the informal sector, he needs to offer a better price than what they can realize by burning and selling the

copper on their own. Also, the economic advantage needs to be very straight forward in order for the informal sector to go for it. Finally, one has to consider that people working in the informal sector might be reluctant to interact with an official entity. If a policy or business model is to succeed in accessing the scrap cables from the informal sector, it has to take these issues into considerations.

One important information that is somewhat unavailable as of today is the knowledge about where cables are collected and stored, and at which volumes. If a centralized solution is targeted with a high throughput, the knowledge about the accessible quantities and required logistics are of crucial importance.

Considerations for choosing a machine

A facility that specializes in the processing of scrap cables should probably acquire a cable shredder capable of processing cables up to around 20mm alongside a cable stripper which could process the eventual larger cables. In order to minimize the running cost, the throughput of the acquired shredder should match the estimated collection rate while realizing a high quality output. Another consideration should be the necessary maintenance cost. A cheap machine might result in high maintenance cost which can offset the initial savings in the long run.

Based on the numbers presented in section 2, one shredder at the lower end of the throughput range (80-150kg/hour) working 10h/day and 250days per year, could process up to 30% of all scrap cables that could possibly be recovered from all e-waste generated in the greater Cairo region. Once this number is achieved, it is still possible to work in 2 daily shifts and/or add a second machine.

Adding a cable stripper to the facility only adds a fraction of the total investment which is necessary while adding the possibility of processing large cables with high copper content. It should be considered in order to be able to accept all possible inputs and therefore increase the overall collection rate.

4. Recommendations

1. The information about volumes and availability of scrap cables in Egypt given in this document are very limited. An in depth assessment about volumes of cables from e-waste as well as non-e-waste (e.g. power cables, cables from C&D waste etc.) is necessary in order to fix accurate processing targets. This assessment should also attempt to map the geographical material flow of these fractions in order to help plan and optimize the logistics of an eventual cable processing facility.
2. A detailed business case should be developed, looking at the full cost of investment, rate of return, payback period etc. The brief indications given in this document show that mechanical cable processing can lead to economic advantage over burning, due to the higher recovery rate and quality of the end-product. These are preliminary assumptions, however, and a more detailed business plan is required to move forwards.
3. When developing a business model that targets a fraction which is largely controlled by the informal sector, it is crucial to consider the specific challenges this poses. The solutions should incorpo-

rate the strong points of the largely developed informal collection while working to improve the health and environmental impact to the benefit of all the involved parties.

4. It might be beneficial to work with existing formal businesses that require the outputs from cable processing in their manufacturing processes. One possibility could be Elsewedy. The large Egyptian company is active in the manufacturing of cables. In addition to the fact that this company requires big quantities of copper and aluminum as a raw material, they might be open to collaboration in an activity so closely linked to their own business. Also, they sponsor entrepreneurship activities with student groups and might be interested in developing a solution to the cable burning problem as part of their corporate social responsibility activities.
5. The logistics and access to scrap cables is one of the more challenging aspects when developing an efficient solution to the problem. Special thought should be put into developing a good solution. Due to the small size of the involved machines, it might be possible to work with a fleet of mobile units, a large centralized facility or a combination of both.

5. Conclusions

A safe and clean downstreaming solution for scrap cables is needed in Egypt. Since a large part of the scrap cable market in Egypt is controlled by the informal sector, it is important to consider this particular situation and come up with an optimal solution. While the informal sector is highly efficient in collecting e-waste, it processes the recovered cables through uncontrolled burning. A cable shredding facility with the adequate throughput could profit from a formal partnership with a large industrial partner that requires copper and aluminum as raw material, offering the best price for high quality secondary metals recovered from scrap cables. This best price combined with the fact that mechanical processing of cables results in a higher recovery rate and product quality makes it possible to offer better prices and recover scrap cables from the informal sector. A well organized and thought through partnership could result in a high collection rate while avoiding the current problem of cable burning in the informal sector.

Based on some preliminary estimations, a 30% collection target in the Greater Cairo region would require one cable shredder with a moderate throughput of 80-150kg/hour and a cable stripper for larger cable diameters. The required space for this combination and collection target is estimated to be around 640m². It is however recommended to further assess the available quantities, map the current flows of scrap cables and develop a detailed business case before taking a final decision about the needed infrastructure. The feasibility of such a project seems viable when the specific challenges concerning the big informal sector are taken into account. It is therefore highly recommended to implement projects of this type in order to reduce the environmental impact and improve health and life quality of the population.

References

- [1] Y. G. John-Michael Davis*, *A model for partnering with the informal e-waste industry*, 2015.
- [2] UN University, *The global e-waste monitor*, 2014.
- [3] G. & B. Institute, *Feasibility of Copper Recovery through Cable Stripping at Agbogbloshe*, 2012.

Links to cable strippers

Zhengzhou Zhengyang Machinery Equipment Co., Ltd.

https://www.alibaba.com/product-detail/copper-scrap-cable-stripper-electric-wire_60567132910.html?spm=a2700.7724838.2017115.145.62134dc3zMb5Oj

Nantong Suptrue International Trade Co., Ltd.

https://www.alibaba.com/product-detail/copper-cable-wire-stripper-Scrap-Cable_60720876910.html?spm=a2700.7724838.2017115.329.62134dc3zMb5Oj

Steel Dragon Tools

<https://www.ebay.com/itm/Steel-Dragon-Tools-WRA40R-Automatic-Wire-Stripping-Machine-with-Foot-Pedal-/253264507534?trksid=p2349526.m4383.l4275.c10>

Bronneberg

<http://www.bronneberg-recycling.co.uk/en/products/cable-recycling-machines/cable-strippers/cable-stripper-bronneberg-kab-90/>

Links to cable shredders

Zhengzhou Dahlia Commerce Co., Ltd.

https://www.alibaba.com/product-detail/99-99-recovery-rate-copper-wire_60613563623.html?spm=a2700.7724857.main07.99.2bbe0ed6tWLUa1

Xi'an Grand Harvest Equipment Co., Ltd.

https://www.alibaba.com/product-detail/miniBS-400-Waste-Cable-Recycling-Granulator_60592318989.html?spm=a2700.7724838.2017115.24.767bfc9cHAvdMF

Bronneberg

<http://www.bronneberg-recycling.co.uk/en/products/cable-recycling-machines/copper-wire-granulators/>

Guidetti

<http://www.guidettisrl.com/en/products/eko-series/>