RECOVERING VALUE FROM CIRCUIT BOARDS

Outcomes of a CRM Recovery Trial in Manchester, England

The Critical Raw Material (CRM) Closed Loop Recovery Project aims to increase the recovery of target CRMs by 5% by 2020 and by 20% by 2030. To achieve this, the project has invested in trials exploring novel ways to boost the collection and recovery of CRMs from household waste electrical and electronic equipment (WEEE).

One such trial was led by Axion Recycling Ltd ('Axion'), based at Trafford Park, Manchester. Axion are long-established experts in the resource recovery sector. Using this expertise and sector knowledge, they developed and delivered a CRM recovery trial in collaboration with technology and recycling partners.

Trial Context

Current treatment routes for printed circuit boards (PCBs) recover only common and high volume valuable metals. Other rare earth elements, such as tantalum, are lost as they are present in low quantities and recovery is not economically viable.

The objective of this recovery trial was, therefore, to investigate whether different treatment routes could enable economically viable recovery of some of the valuable, but low quantity, elements by isolating the components within which they are contained.

Within the trial, Axion partnered with two organisations; E3 Recycling, based in South Wales, and the Industrial Technology Research Institute (ITRI), the developer of the Itrimex process for chemically treating PCBs to recover all metals, wires and components. E3 Recycling undertook supplementary WEEE dismantling activities and

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then ITRI demonstrated the technical feasibility of their novel process on the PCBs recovered.

The CRMs and other elements specifically targeted in the recovery trials were cobalt, antimony, tantalum, platinum group metals, gold and silver.

Linking WEEE Collection & CRM Recovery

The recovery activities directly followed the successful completion of a retail and charity collection trial[i], which ensured that donated WEEE items that were unsuitable for re-use would remain whole so they could they be manually dismantled and their circuit boards extracted intact. Activities focussed on treating PCBs from data-bearing devices (such as mobile phones, laptops, tablets and computers), which contained components with high levels of CRMs and were therefore ideal for the recovery trial.

Methodology

The trial process consisted of three main elements:

1. **Isolation** – manual dismantling of WEEE items to extract their circuit boards.

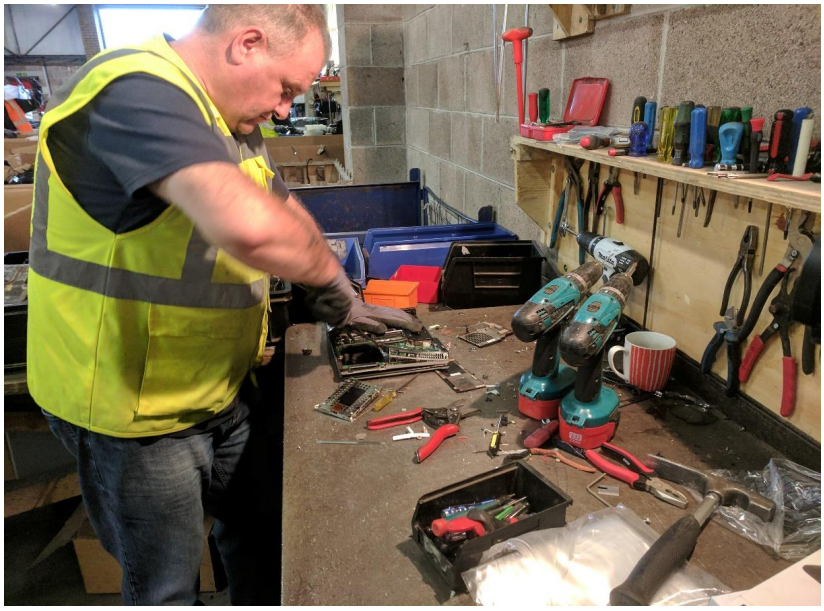


Figure 1 - E3 Recycling operator dismantling items to recover PCBs

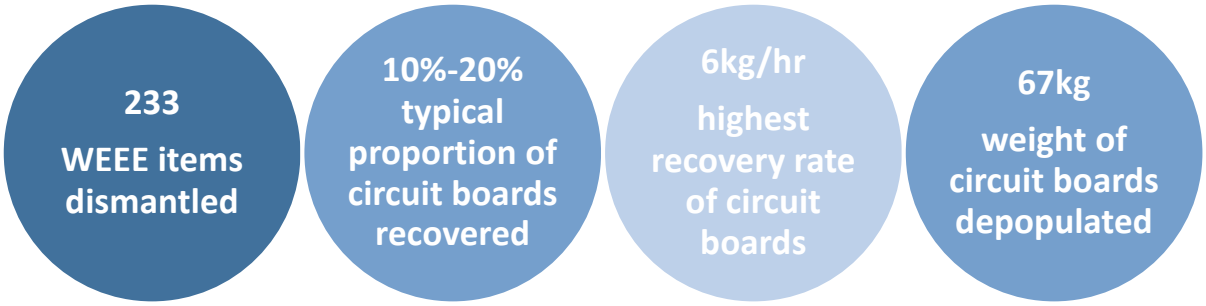
2. **Separation** – using chemical 'depopulation' to remove components from circuit boards. The Itrimex process removed solders at high concentrations and recoveries to maximise the returns achieved from the final refining stage. The process is simple and cost-effective and is normally used for low-grade end of the market products, where profit is hard to achieve by conventional methods. This trial targeted CRM-rich data-bearing devices such as mobile phones, laptops, tablets and computers that were unsuitable for re-use.

Figure 2 - Circuit boards before (left) and after (right) depopulation (6+ year old computer towers)

3. **Segregation** – multi-process separation techniques were employed to segregate and sort components, including size separation (using screening), magnetic separation, density separation and manual hand sorting.

The key stages outlined above enabled the remaining components to be categorised into age groups and faction sizes (from 16mm down to 3.5mm) and then analysed for weight and percentage content of target CRMs.

Trial Outcomes in Numbers



Notes to chart

- *The stated proportion of circuit boards recovered from the items – except mobiles aged 6+ years (34.8%) and routers (~40%).*
- *The stated highest recovery rate of circuit boards was for computer towers. Most other items had recovery rates of less than 3kg/hour, with the exception of routers (4.5-5kg/hour). Laptops were particularly difficult to dismantle, with some taking up to 20 minutes each.*

Trial Learnings

The results from the recovery trials provided both general and process-specific learnings.

General

- The trial demonstrated that dismantling WEEE items can be difficult and time-consuming, especially for smaller items such as laptops and smartphones.
- It is difficult to chemically separate components containing high value elements from circuit boards due to the variety of fixings and issues with large metal pieces such as heat sinks (temperature regulators).
- An alternative option may be to use thermal treatment to melt solder and other adhesives.

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Process-specific

When dismantling items:

- **Use well-lit and ventilated workstations**. This is vital to enable operators to maximise their efforts – i.e. to be able to clearly see the WEEE items and their components in detail.
- **Dismantling is best carried out by experienced operators at an existing WEEE dismantling facility.** Having the skilled operators and suitable facilities and equipment for dismantling was found to be beneficial. Process speeds were heavily dependent upon a specific dismantler's experience, and whether they were familiar with a particular item. Additional training and familiarisation would be needed for operators to build up the skill in dismantling new item types, such as evolving mobile phones.
- **Provide many different tools and attachments**. Many screws and fastenings are unique to individual manufacturers, so a range of drill bits, screwdriver heads and other special tools are necessary.
- **Laptops are difficult to dismantle**. These items took by far the longest to take apart. However, recovery rates for laptops were comparable with many other item types (e.g. tablets / 6+ year old mobile phones) if circuit board recovery numbers are taken into account.

In the depopulation process:

- **Fresh chemical solution works best**. Circuit boards were more efficiently depopulated when the solution was fresh. As the solution goes through a batch process, its efficiency drops.
- **Remove large pieces of metal**. Consideration is needed regarding the large pieces of metal (e.g. aluminium heat sinks) contained in some boards. These would need to be removed in advance if the process was scaled-up to reduce the risk of producing hazardous fumes.
- **Consider alternative removal process**. Many components had to be removed by scraping the boards with a chisel or screwdriver. To economically scale-up this

activity, a tumbling drum or a similar process could be used.

- **Consider an alternative depopulation process**. One option could be to heat and agitate the boards in order to melt the solder. This process is under development by several companies and further work could be carried out to trial this method.

When separating components:

- **The range of separation techniques worked**. They were successful in segregating the components and were able to concentrate the components that had been identified as potentially interesting into smaller size fractions.

Benefits

- This CRM Recovery Project trial has tested and demonstrated a number of repeatable, scalable processes for the recovery of CRMs from WEEE items.
- The trial has also successfully demonstrated the important link between WEEE collection and CRM recovery, which can serve to increase the latter.
- The learning and outcomes of this trial have provided valuable input into the EU-wide policy and infrastructure recommendations that will be published in Winter 2019, which could be applied in a commercial setting to increase the recovery of CRM-rich components from data-bearing devices.
- The WEEE collection method employed in the aforementioned 'retail and charity collection trial' may not be the most appropriate for enabling the recovery of CRMs from components. However, it does ensure that re-usable devices have the best chance of retaining value through resale.
- This trial has shown that a collection network involving a partnership of retailers and charities would best ensure that all items brought in for recycling could be both assessed for re-usability and segregated from non-working WEEE. Re-usable items could be donated to charity partners for resale, offering financial benefits for the charity and corporate social responsibility and environmental performance benefits for retailers.

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[i] Case Study - Axion retail and charity collection trial

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