

# Critical Raw Materials: Closed Loop Recovery

**SCREEN**  
**Cluster Workshop**

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A large teal circle is centered on the page. It has a dark blue outer ring and a lighter teal inner circle. The text is centered within the inner circle.

WRAP's  
vision is a  
world in which  
resources  
are used  
sustainably



**CRITICAL  
RAW  
MATERIAL**

# The CRM Project Partners



**Wuppertal  
Institut**



**CRITICAL  
RAW  
MATERIAL**

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# The CRM Project

Huge quantities of waste electronic and electrical equipment (WEEE) are disposed of each year in the European Union. Although certain valuable materials are recovered in the recycling of waste electronic equipment (e.g. aluminium, copper), many “critical raw materials” (CRM) are not, and are lost from the system forever...



Collection of WEEE  
and recovery / recycling of  
the CRMs in four countries  
via tender



Aim of the combined trials is  
to collect a large amount of  
WEEE and to increase  
recovery of target CRMs by  
5% by 2020



The project will focus on  
developing policy  
recommendations  
using trials and trial  
evaluation data

# WEEE CATEGORIES



Displays  
(typically LCD screens)



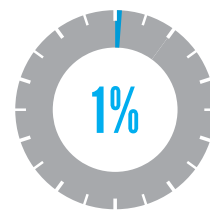
ICT



Consumer  
electronics



Small mixed WEEE  
(including batteries)



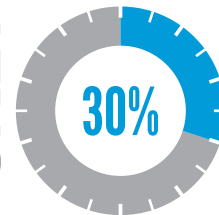
estimated  
**CRM**  
recovery from  
**WEEE**



9.9m tonnes of waste  
electronic and  
electrical equipment

is generated each year in the EU

**BUT ONLY**



is properly  
collected  
and recycled

**CRM**  
RECOVERY

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# WHAT ARE CRMs?



Raw Materials classified by the European Commission as “Critical” due to their high economic importance to the EU combined with a high risk associated with their supply.

Periodic table showing 17 Critical Raw Materials (CRMs) highlighted in blue:

- Scandium (Sc)
- Yttrium (Y)
- Lanthanum (La)
- Cerium (Ce)
- Praseodymium (Pr)
- Neodymium (Nd)
- Promethium (Pm)
- Samarium (Sm)
- Europium (Eu)
- Gadolinium (Gd)
- Terbium (Tb)
- Dysprosium (Dy)
- Holmium (Ho)
- Erbium (Er)
- Thulium (Tm)
- Ytterbium (Yb)
- Lutetium (Lu)
- Carbon (C)
- Cobalt (Co)
- Ruthenium (Ru)
- Rhodium (Rh)
- Palladium (Pd)
- Silver (Ag)
- Antimony (Sb)
- Tantalum (Ta)
- Niobium (Nb)
- Molybdenum (Mo)
- Rhenium (Re)
- Iridium (Ir)
- Platinum (Pt)
- Gold (Au)
- Bismuth (Bi)



## 2017 CRMs

Antimony, Fluorspar, LREEs, Phosphorus, Baryte, Gallium, Magnesium, Scandium, Beryllium, Germanium, Natural graphite, Silicon metal, Bismuth, Hafnium, Natural rubber, Tantalum, Borate, Helium, Niobium, Tungsten, Cobalt, HREEs, PGMs, Vanadium, Coking coal, Indium, Phosphate rock

\* HREEs=heavy rare earth elements,

LREEs=light rare earth elements,

PGMs=platinum group metals

[http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical\\_es](http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_es)



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**PHASE 1:**

**Collection Trials**

**PHASE 2:**

**Treatment Trials**





# Target materials

- **High value** IT equipment and consumer electronics
- Typically **hoarded** by consumers due to security concerns
- Not recovered via usual WEEE recovery channels
- Likely to contain **high levels of CRMs** on the PCBs

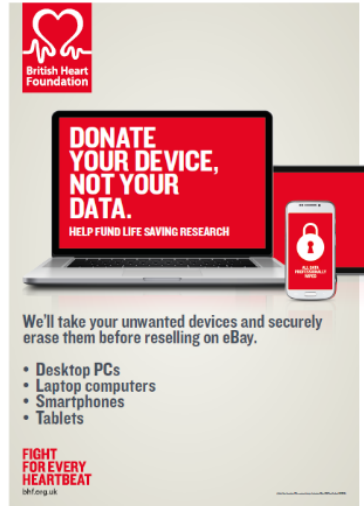
## Target items

- Games Consoles
- Cameras
- Laptops
- PCs
- Tablets & Mobile Phones
- External Hard Drives
- Modems / Routers
- DVD/ Blu-ray Players

# Axion Consulting

## Phase 1 Collection Trials:

With Dixons Carphone, The British Heart Foundation, John Lewis and E3 Recycling



- **Retailer take-back** building on existing take-back schemes
- **Charity** store take-back scheme
- Retailer **incentivised** return scheme

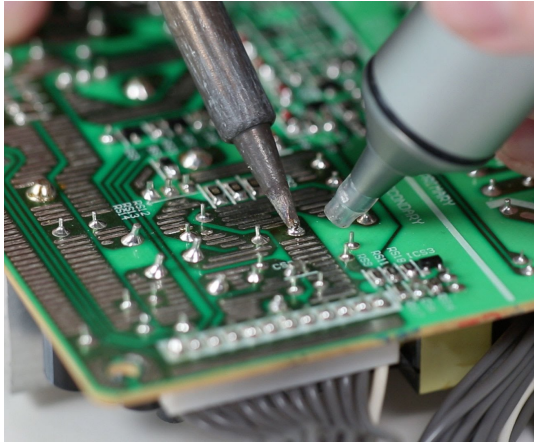
### Benefits:

- Trusted brands offset security concerns
- WEEE is more likely to be collected whole and less damaged
  - condition is more suitable for re-use and manual disassembly
- Whole PCBs more suitable for the processing phase of the trial

# Axion Consulting

## Phase 2 Treatment Trial:

Component extraction from printed circuit boards



- **Proof of concept**, laboratory scale trial.
- De-soldering of PCBs to remove **whole components** and harvest the tin from the solder.
- The individual components are then sorted into different groups based on a range of scenarios (e.g. rich in particular CRMs, maximising material purity or recovery).
- The sorting takes place at the TOMRA test facility in Germany.
- The fractions will then be chemical analysed for CRM content.

# Re-tek

## Phase 1 Collection Trials:

- **Employee Amnesty**

Unwanted household electricals collected from 8 organisations

- **Household Waste and Recycling Centres**

Secure containers for housing re-usable WEEE are placed next to the existing containers for standard WEEE collections

- **University Halls of Residence Hubs**

Concierge at the Unite Halls of Residence acted as a collection point for any waste electricals from students at the end of the winter term and the start of the spring term.

# Re-tek

## Phase 2 Treatment Trial:

Electrochemical CRM extraction from solution



- **Proof of concept**, laboratory scale trial.
- The PCBs extracted from the non-reusable electricals are crushed and then put into solution with either acid or different microbes to release the CRMs into solution. These solutions undergo further separation chemistry techniques before passing through an electrochemical cell to extract **cobalt**, **silver** and **gold** from solution.

# Ecodom

## Phase 1 Collection Trials:



- **Public Square in Italy**  
Large blue collection container is sited in a series of public squares across Milan on 4 consecutive Sundays in each square.
- **Two School and Community Collection Days**  
The first is for students and includes engagement sessions, the second day is open to the local community to donate electricals too.
- **Grocery Stores**  
In-store bring banks.

# Ecodom

## Phase 2 Treatment Trials:

Maximising recovery from existing processes and recovery of CRMs from rechargeable batteries

- **Angiari (Italy)**

The collected WEEE will be sorted, separated and pre-processed into CRM-rich and non-CRM-rich fractions. These fractions will be passed through STENA's existing precious metal recovery process and the CRM levels assessed to determine if the method of collection and levels of sorting lead to an overall increase in CRM capture and recovery.

- **Colico (Italy)**

Laboratory scale process to extract **graphite** and **cobalt** from rechargeable batteries. Anodic and cathodic parts are separated and thermally treated to form a solution from which CRMs are extracted.



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# RecyclingBörse

## Phase 1 Collection Trials:

- **Re-use Olympics in Schools**

Competition days in schools to encourage competition to collect the most items for re-use.

- **Kerbside Collection from Households**

Each household is provided with a sack to fill with WEEE to be collected monthly

- **Re-use Boxes for Households and Businesses**

Householders and businesses can request a box for collection of WEEE.

These boxes are returned to the RecyclingBörse depot, shops or collection points.



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# RecyclingBörse

## Phase 2 Treatment Trials:

- **Biological Extraction of Tantalum**

Printed circuit boards are to be broken up by electrohydraulic fragmentation.

Use of bio-leaching and biosorption to extract elemental tantalum located within the tantalum capacitors which are extracted from the circuit boards after fragmentation.

- **Extraction of Neodymium From Magnets**

Neodymium-containing Magnets will be extracted from hard disk drives. These magnets follow a multi-step process to remove the protective coating and are then homogenized to produce new materials that can be used to create sintered magnets.



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# Asekol

## Phase 1 Collection Trials:



- **Mobile Collection Units in Areas Not Suited to Permanent Collection Containers**

Mobile collection units that accept textiles and WEEE are placed in specific areas of Prague for a 24 hour period.

They are located in areas of Prague that are unable to site permanent, stationary collection units due to the historic beauty and importance of the surroundings. The locations of these collections are advertised via posters, social media and news reports.



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# Asekol

## Phase 2 Treatment Trials:

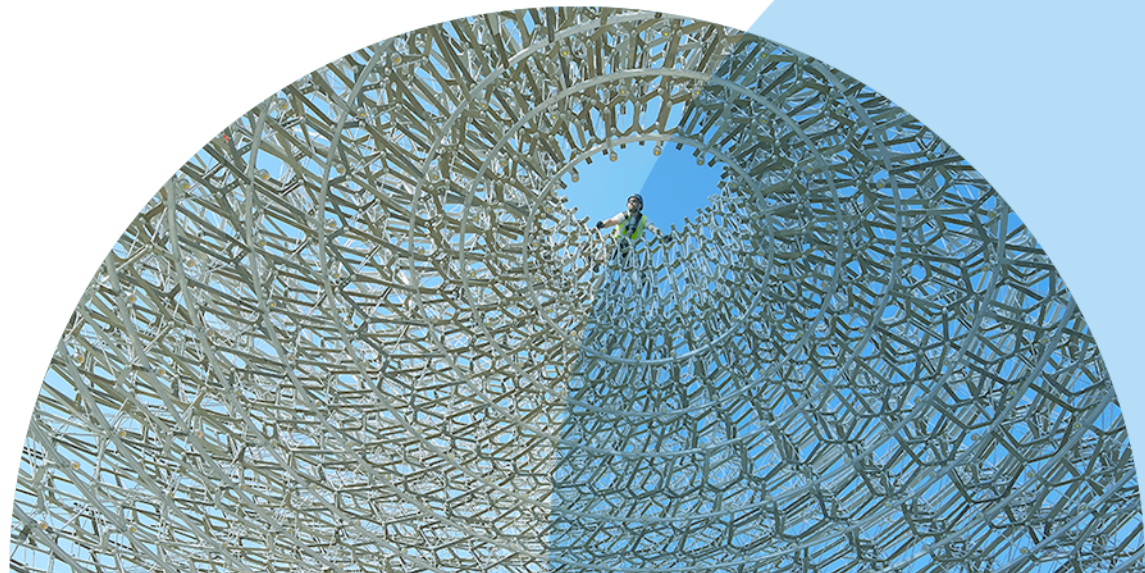


- **Optimising Concentrations of CRMs**

Non-reusable WEEE will be processed on a small WEEE processing line. Processes include, but are not limited to, crushing, magnetic separation, electrostatic separation and sensor separation of metals.

- The three fractions from the WEEE processing which have the highest concentrations of CRM will be identified and then further refined to increase the CRM content of these fractions.

# Key Lessons



# Key Lessons:

Suggested interventions to enhance the recovery of CRMs

- **Utilise your network, make the most of your partner's own marketing capabilities & keep in touch regularly**
  - Tendering process
- **Thus far, data suggests:**
  - Trusted brands offset security concerns
  - WEEE that is collected whole and in a less damaged condition is more suitable for re-use and manual disassembly
  - Whole PCBs are more suitable for the processing phase of the trial

# Get involved!

**Join the CRM Recovery newsletter for project updates**

[www.criticalrawmaterialrecovery.eu](http://www.criticalrawmaterialrecovery.eu)

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